Sustainable Remediation Forum (SURF)
November 28 and 29, 2007
Sacramento, California

This meeting marked the fifth time that various stakeholders in remediation—industry, government agencies, environmental groups, consultants, and academia—came together to develop the ability to use sustainability concepts in remedial decision-making. Those individuals that participated in the two-day meeting are listed in Attachment 1 along with their contact information.

Meeting Opening

The meeting began with Mike Rominger (meeting facilitator) welcoming all participants, thanking the California Department of Toxic Substances and Control (DTSC) for hosting the meeting, and thanking the Meeting Design Team. (Meeting Design Team members are noted by two asterisks in Attachment 1).

Mike read an anti-trust statement and discussed meeting logistics and ground rules (e.g., expectation that attendees will be active participants, show respect for others, appreciate and encourage divergent opinions, refrain from marketing, and be familiar with previous meeting minutes so the meeting can focus on new information). Mike also noted that it is assumed that nothing discussed or presented contains confidential information. Prior to the meeting, export control compliance was verified.

Maureen Gorsen (Director, California DTSC) kicked off the meeting, welcoming all SURF members and stating her strong support for applying sustainability concepts in remediation. She also highlighted her organization's efforts in this area, which are led by the Green Remediation Team.

Introductions were made, and attendees participated in an exercise that allowed them to get to know other SURF members. The meeting agenda was available in hard copy for those participants attending the meeting in person, and development of a web site to store documents (e.g., previous meeting notes) is in progress.

The draft mission statement from the February 2007 meeting was read as follows: "To establish a framework that incorporates sustainable concepts throughout the remedial action process that provides long-term protection of human health and the environment and achieves public and regulatory acceptance. Participants were reminded that this mission statement served as a starting point and could be revised as SURF develops and moves forward.

Presentations and Brainstorming

As noted on the agenda, the meeting was designed to answer the following question: "How might we integrate sustainability metrics into remediation planning?" Presentations and brainstorming discussions were designed to address this question. Each presentation, subsequent discussion, and brainstorming discussions are summarized briefly in the subsections below. Presentation slides and notes from the chart pad are provided in Attachments 2 through 12.

European SURF Activity Update

This presentation provided an update of the ongoing SURF work in Europe (see Attachment 2). Curt Stanley (Global Discipline Leader, Shell Global Solutions) reported that momentum for sustainability efforts is building, and significant interest and a willingness to contribute exist. As a result, SURF Europe has acquired limited start-up funds and currently is awaiting other budget approvals for upcoming activities and work.

Work packages (i.e., tasks) have been identified, and a Steering Group has been established by Contaminated Land: Applications in Real Environments (CL:AIRE). The Steering Group includes representatives from industry, the Environment Agency, one consulting company, and academia. The Steering Group will continue to work on work packages and initiated projects into 2008. One such project involves the group performing a pilot study of the United Kingdom benefits assessment approach to establish whether the approach is a workable base format to assess soil and groundwater management in a sustainable way. Pilot study results should be available by mid-2008.

Participants discussed the wide range between European countries of both environmental challenges that need to be addressed and existing regulations. In Eastern Europe, soil standards exist but no groundwater standards have been established. On the other hand, the Netherlands and the United Kingdom have standards for both soil and groundwater and seem to be the most forward-thinking regarding sustainability. Other countries, such as Germany, pump-and-treat systems are required as part of industrial designs, making it very difficult to consider and apply alternate remedial technologies. Curt stressed that the goal of SURF Europe's efforts is to create a solution that is workable for all sites and one that addresses challenges holistically rather than focusing only on one aspect (e.g., point sources).

California DTSC Green Remediation Team Briefing

The California DTSC chartered an initiative known as the Green Remediation Team in early 2007. This presentation by team members described how the team is evaluating ways to identify and characterize remediation technologies that provide benefits such as reduced energy consumption, increased reuse of materials and resources, and reduction of greenhouse gases. The team has reviewed available literature and enlisted the help of the DTSC's experts in life-cycle analysis. The presentation was aimed at stimulating discussion among participants as to efficient and straightforward ways of identifying and evaluating the "green" characteristics of remediation technologies. Presentation slides are provided in Attachment 3.

Discussions focused on how to keep the process simple, yet defensible. Some participants mentioned two key factors that add to the complexity of sustainable metrics: local vs. global scale, and time required vs. environmental impact. The need for case studies in which the state is the responsible party was cited as a useful way to begin addressing these challenges. One participant mentioned that the U.S. Environmental Protection Agency (USEPA) Region IX has requested to perform a sustainability pilot study at the Lorentz Barrel & Drum site in San Jose, California.

Green Cleanup Certification

By the year 2020, the USEPA and the authorized states plan to have largely completed the work of implementing final remedies at all facilities requiring Corrective Action. As a result, the amount of contaminated sites needing to be cleaned up has doubled (see quantification of "the numbers" in Attachment 4). With this in mind, Deb Goldblum (Project Manager, USEPA Region III) focused her presentation on how to consider sustainability as part of the cleanup process without slowing down cleanup.

One approach Deb discussed was promoting sustainable remediation by mimicking the Leadership in Energy and Environmental Design (LEED) certification approach and developing a prototype rating system for sustainable remediation. This rating system would evaluate the full environmental impact of a cleanup to maximize the net environmental benefit of engineered remedies. The system could guide and stimulate efficient, cost-effective, low-impact site remediation by encouraging property owners, developers, and communities to go beyond state and federal requirements in their cleanups and land revitalization projects.

Deb followed this proposal by asking participants how they would integrate the sustainability concept into remediation. Although the obvious answer to this question seemed to be to integrate sustainability into policy and force compliance, Deb reminded participants of the limitations of that approach when considering the USEPA 2020 goals. Many participants agreed that the solution should focus on incentives for responsible parties. Some approaches that were discussed are as follows:

- ❑ Consider certifying presumptive remedy (i.e., not necessary to evaluate a number of other technologies).
- ❑ Leverage capabilities of organizations such as the American Society for Testing and Materials (ASTM) or the American Academy of Environmental Engineers (AAEE) to develop training package, and then develop implementation strategy [perhaps through the Interstate Technology Remediation Council (ITRC)].
- ❑ Link sustainability to the nine criteria of the National Contingency Plan (NCP).
- ❑ Imitate the Risk-Based Corrective Action (RBCA) process.

Participants agreed that these ideas were starting points and that many challenges lay ahead. Regardless of the approach, participants agreed that open communication between all stakeholders would be the key to successfully integrating sustainable concepts in remediation.

Making SURF Carbon Neutral

Mike Rominger (meeting facilitator) led a brainstorming discussion to answer the following question: How might we make SURF carbon neutral? Although many participants mentioned that using teleconferencing, net meeting, web meeting, or video conferencing technologies would reduce the carbon emissions used to attend a SURF meeting, an equal amount of participants expressed a high value for face-to-face meetings. Other responses focused on collecting contributions to buy carbon credits to offset the carbon emissions, holding meetings near public transportation, implementing a remedy (as SURF) that reduces carbon emissions, and plant trees to offset the carbon used. Detailed responses are provided in Attachment 5.

All participants agreed to reuse name badges and tent cards at the next meeting, and plastic water bottles and trash were recycled during the meeting. The discussion of how to make SURF carbon neutral is ongoing and will continue at future meetings.

Net Environmental Benefit Analysis: Overview and Case Study

Joe Nicolette (Vice President, Director EcoValuation Practice, CH2MHill) provided a review of natural resource valuation metrics that can be used to demonstrate the benefits of land management, site remediation, and site restoration. Joe showed how the application of these approaches could be linked to demonstrating environmental sustainability and making overall land management decisions. Both ecological and human use service metrics were discussed, as well as the value of quantifying these metrics so that the ecological and human use values associated with actions can be used by regulatory and corporate entities in managing land assets and potential environmental liabilities. Joe presented several case studies where these valuation metrics were used to demonstrate the quantified benefits associated with selected actions. An overview of an ongoing USEPA pilot study was also presented. Presentation slides are provided in Attachment 6.

Discussions focused on the complexity of net environmental benefit analysis in a changing environmental footprint, where a benefit is provided to another location (i.e., offset) instead of cleaning up the contaminated location to a regulatory level. Human use can be a key factor in determining these offsets. Some participants expressed concern as to how to account for future changes in parameters such as exposure pathways and land use when developing offsets. All participants seemed to agree that if a project was implemented in different jurisdictions with different project teams, the vast range in cleanup goals and risk assessment practices combined with the variability of interpretation between agencies and individuals could lead to completely different results. With that in mind, one participant mentioned that additional analyses required by activities like net environmental benefit analysis might only add to that range and not reduce it.

Life-Cycle Analysis for Use in Evaluating Sustainable Remediation Metrics

Through this presentation, Mike Houlihan (Principal, Geosyntec) and Bob Boughton (Senior Hazardous Substance Engineer, California DTSC) introduced life-cycle analysis (LCA) as a tool for evaluating the metrics associated with sustainable remediation. LCA has been used for many years to evaluate the overall impacts of product development on the environment. More recently, the method has been used to evaluate the overall impacts of certain processes, including environmental remediation, on the environment. A key step in performing a LCA involves defining the impacts associated with the process; this step is analogous to the evaluation of sustainability metrics that has been discussed at previous SURF meetings. Moreover, LCA offers a framework for interpreting the evaluation of metrics so that the environmental impacts of different remediation alternatives can be compared; this framework might be useful in extending the work of previous SURF efforts. Presentation slides are provided in Attachment 7.

At the end of the presentation, participants discussed the need for a framework for interpreting sustainability metrics and the value of LCA methods for this purpose. While LCA results can be used to make decisions at sites, LCA can also be used as a tool to explore the impacts of changes to different variables (e.g., material changes). Participants agreed that the values applied in LCA are the crux of the analysis and the starting point. For sustainable remediation, these values could be existing regulatory screening levels or limits. All participants agreed that the LCA would need to be developed with regulators and property owners, considering site-specific factors. Some participants discussed that LCA could be an interesting tool to help define the process of what to do with metrics the team has developed thus far. Other participants mentioned that LCA could be used to drive innovation in technology methods, using the analysis as a tool to set targets (e.g., how can we do this with 20% less energy next time?).

Metrics: The Search for the Critical Few

This brainstorming session focused on answering the following two questions:

- What is holding you back from practicing more sustainable remediation practices right now?
- What two metrics are the most important to you?

Specific answers to these questions are provided in Attachment 8. The two most common answers to the first question were (1) inherent agency skepticism or lack of interest and (2) lack of time. The most common metrics that were important to participants were energy use, economic cost, greenhouse gas emissions, carbon emissions, and environmental benefit.

Discussions among participants focused on the skepticism about what a sustainable process is because there is no well-worn path to sustainable remediation. One participant noted that there is no baseline to prove that current remedial actions at sites are *not* sustainable vs. other actions. Another participant reiterated what had been said earlier that, in many cases, sustainable remediation would be just another box for busy regulators to check. Other participants emphasized the need to get restorative rather than just concentrating on offsets. Finally, all participants seemed to agree that the key to successful sustainable remediation involved the following: regulatory allowance, generic metrics, a framework to select or evaluate metrics, and guidance and training.

Participants looked to excerpts of the Carol Browner memo that was presented by Joe Nicolette (CH2MHill) (see Attachment 6) and saw that it was necessary to "maintain a level of reasonableness" in approaching sustainable remediation metrics. All agreed it is important to bring rationality to the remedial process rather than just creating more problems than the ones you are trying to solve.

A Cooperative Approach to a Remediation Solution with a Sustainability Component

This agenda item consisted of a presentation by Deb Goldblum (USEPA Region III), a panel discussion, two presentations by Brandt Butler (URS) and a skit.

- USEPA Region III/DuPont RCRA Pilot: How We Work Together
  Deb Goldblum (USEPA Region III) provided a brief overview of how USEPA Region III and DuPont worked together on a pilot for a Resource Conservation and Recovery Act (RCRA) Corrective Action site in Virginia. Instead of a traditional approach to remedial action decision-making that involves a long timeline and many report iterations, a remedial solution was identified using face-to-face meetings and a cooperative approach. The USEPA and DuPont held meetings every two months to develop a framework to assess sustainability and implement a remedial strategy for one area on-site. The remedy was required to meet the following three threshold criteria: protect human health and the environment, achieve media cleanup objectives, and control sources to the extent practicable. A

remedy was selected for the area within six months. Presentation slides are provided in Attachment 9.

- Panel Discussion
  Deb Goldblum (USEPA Region III), Dave Ellis (DuPont), and Brandt Butler (URS) serving as panel members. In response to what DuPont's motivation is for including sustainability in the remedy selection process, Dave stated that sustainability is a DuPont core value and that the company is always looking for ways to reduce its environmental footprint. Dave believes that the process of considering sustainability at DuPont sites has improved the quality of the remedies and subsequent reports. Deb said that sustainable remediation is something that the USEPA is exploring as a way to maximize the net environmental benefits from cleanup. Deb clarified that the USEPA would probably not be able to address sustainable remediation as an entire organization because of the "numbers issue" she had previously discussed (see Attachment 4). However, the approach could be used to help streamline projects and achieve site cleanup quicker. Participants noted that the USEPA Office of Solid Waste and Emergency Response (OSWER) currently has a greenhouse gas and climate change initiative that could be useful as SURF moves forward. One reference for this initiative is a document entitled *Green Remediation and the Use of Renewable Energy Sources for Remediation Projects* by Amanda Dellens (available at http://www.clu-in.org/download/ studentpapers/Green-Remediation-Renewables-A-Dellens.pdf).

  When asked to identify the greatest challenge of the pilot, Brandt responded that a significant amount of preparation time was required before each meeting with the agency so that anticipated questions from the agency could be addressed during the meeting. From an industry perspective, Dave thought the greatest challenge was introducing new team members into the relationship with agency personnel and stepping back from preconceived notions of how to address the contamination on-site. Deb believed that the challenge was slowing down the discussions during the meetings so that technical issues could be fully digested.

  Panel members agreed that the process was effective in addressing differences in opinion, allowing these differences to be resolved through full-day discussions versus back-and-forth correspondence of hard copy documents. Deb stressed that this approach allowed all involved to better understand the thought process behind thoughts and opinions. In response to further questions, Deb mentioned that the state agency and her supervisor were present at all meetings, and USEPA Headquarters reviewed the list of impacts prior to remedy selection. Brandt clarified that the stakeholders, not industry, chose the parameters that were important to this site (e.g., particulates).

- Sustainable Parameter Estimation Methodology
  Brandt Butler (URS) described the evaluation protocol that DuPont has developed to assess sustainability indicators [i.e., carbon dioxide (equivalents); energy; natural resource consumption; occupational risk; and local issues such as air quality parameters, traffic, or sound]. Brandt explained the step-wise process that is used during the remedial action selection phase using information available from the

remedial investigation phase. This process has been implemented in the aforementioned USEPA Region III pilot for a DuPont site in Virginia. The highlights of the process were reviewed and are summarized briefly below. Presentation slides are provided in Attachment 9.

- Understand site impacts
- Agree on remedial action objectives based on demonstrated migration pathways
- Brainstorm candidate remedial technologies and refine them based on their ability to achieve the threshold criteria mentioned earlier
- Based on source volume and mass, evaluate the short list of technologies for their sustainability indicators by assessing the impact of each task in technology implementation (e.g., mobilization, drilling, operation and maintenance)
- Assess remaining remedy selection criteria and sustainability indicators as an additional balancing criteria for each technology

Participant discussions focused on the debits and credits applied during the process, and one participant expressed concern that industry is getting potential monetary value (carbon credits) for cleaning up contaminants that they had released to the environment. Deb Goldblum (USEPA Region III) responded, stating that, at this Virginia site, DuPont could have selected a technology that did not destroy the contamination (i.e., dig and haul). Instead, source control (i.e., treatment in place) was selected and sustainability was the driver for this decision.

❑ Sustainable Parameter Sensitivity Analysis Methodology
Brandt Butler (URS) described the methodology for developing the sensitivity of the sustainability assessments for the Virginia site. Mass and volume were increased by 10 and 100 times compared with the base case, and constituent mix was varied. The change in estimated carbon dioxide equivalents was documented for five technologies: capping, excavation, in situ zero valent iron (ZVI)-clay treatment, in situ soil vapor extraction (SVE), and ex situ thermal treatment. Then, the assumptions (area, depth, concentration) associated with each permutation in site condition (mass, volume, constituent mix) were documented.

The sensitivity analysis showed that capping was largely proportional to area, excavation was largely proportional to volume, ZVI-clay treatment was largely proportional to volume, SVE was most influenced by area and treatment time, and ex situ thermal treatment was proportional to volume and vapor controls. Thus, no technology is always more sustainable than the other. The scale of the remedy (mass, volume, compositions) determines the remedy with the lowest (and highest) carbon dioxide footprint. Presentation slides are provided in Attachment 9.

Participant discussions focused on the fact that the sensitivity analysis described was not a “true” sensitivity analysis and that the goal is to use the analysis to help make better decisions.

- Skit
  Finally, Deb Goldblum (USEPA Region III), Dave Ellis (DuPont), Brandt Butler (URS), and Mike Rominger (meeting facilitator) acted in a light-hearted skit to illustrate how the collaborative approach on this project streamlined the remedy selection process and more effectively used resources.

A Revised Corrective Measures Study (CMS) Outline Based on Sustainability

DuPont and the USEPA Region III are developing an expedited CMS for the sustainability pilot project at the Virginia site discussed in the previous presentations. The standard highly documented and highly iterative process of developing a CMS is being replaced with a series of face-to-face discussions and collaborative decision-making. A streamlined document is produced in which the only technologies discussed in detail are those which are suitable for use on-site. The content of the meetings and off-line analyses is documented by a series of tables and matrices rather than detailed text. Both DuPont and USEPA Region III team members believe that this new CMS process is much more efficient and effective than its traditional counterpart. Presentation slides are provided in Attachment 10.

Preparing a White Paper about Sustainable Remediation

Paul Hadley (California DTSC) and Dave Ellis (DuPont) discussed a new effort within SURF to write a white paper about sustainable remediation. The draft title of the white paper is *Integrating Sustainability Principles, Practices, and Metrics into Remediation Projects*, and a draft outline of the paper was distributed to participants prior to the meeting and is provided in Attachment 11. The purpose of the white paper is to collect, clarify, and communicate the thoughts and experiences of SURF members on sustainability in remediation. SURF has raised the national awareness about sustainability practices in remediation, and the proposed white paper is intended to give depth and breadth to the discussion with other parties. Paul emphasized that the development of the paper should be a transparent process whereby issues do not need to be resolved, merely documented by a consensus process.

Facilitators for major chapters were assigned, and participants volunteered to help specific facilitators based on the chapter topic and their area of interest or expertise (see table on next page). Each group gathered together to discuss an action plan for their chapter. Participants agreed that at least one year would be needed to develop the white paper, with progress checks along the way.

Chapter Title	Facilitator	Volunteers
Description and Current Status of Sustainability in Remediation	Dick Raymond, TerraSystems	Carol Dona, Corps of Engineers Lowell Kessel, GEO Chuck Newell, GSI Environmental
Sustainability Concepts and Practices in Remediation	Stephanie Fiorenza, BP	Bob Boughton, California DTSC Catalina Espino Guerrero, Chevron David Hull, LFR Steve Koenigsberg, WSP Environmental Strategies Nick Lagos, Lagos George Leyva, California Region II Water Board Tiffany Swann, GSI Environmental Dave Woodward, EarthTech
A Vision for Sustainability	Paul Favara, CH2MHill	Louis Bull, Waste Management Mike Kavanaugh, Malcolm Pirnie Maryline Laugier, Malcolm Pirnie Gary Maier, EarthTech Maile Smith, Northgate Environmental
The Impediments and Barriers	David Major, Geosyntec	Mike Houlihan, Geosyntec Charlie So, Shaw Environmental & Infrastructure Curt Stanley, Shell Global Solutions Elizabeth Wells, San Francisco Water Board
Vignettes of Success	Brandt Butler, URS	Maile Smith, Northgate Environmental (Other SURF members ad hoc)

Applying Sustainability to Small Sites

Mike Rominger (meeting facilitator) led a brainstorming discussion about how to apply sustainability to smaller sites. This topic was discussed because, when developing metrics for sustainability, it will be important that the metrics are broadly applicable to a variety of site types. In the extreme cases, a comprehensive sustainable evaluation at a small site could be costlier than the remedy itself. This topic was aimed at initiating discussion among SURF members about how to address these issues. Participants defined small sites as those sites with a relatively small area of contamination, such as formerly used defense (FUD) sites, brownfield sites, gas stations, dry cleaners, manufactured gas plant (MGP) sites, abandoned mine sites, paint/print/body shops, fire training pits, car/truck washes, junkyards, metal salvage yards, and small municipal landfills. Participants also mentioned the need to include the issue of small sites in the white paper. The detailed notes from the brainstorming discussion are provided in Attachment 12.

News Items

Participants discussed the following news items at the meeting:

- Deb Goldblum mentioned that the editor of *Brownfield News* would like to include an article about SURF activities. The following participants volunteered to help write the article: Dave Woodward (EarthTech), Stephanie Fiorenza (BP), Dick Raymond (TerraSystems), Lowell Kessel (GEO), Mike Kavanaugh (Malcolm Pirnie), John Scandura (California DTSC), Paul Favara (CH2MHill), and Steve Koenigsburg (WSP Group). Dave Ellis (DuPont) will serve as the coordinator for this effort, and Deb Goldblum volunteered to serve as the liaison between the group and *Brownfield News*.
- Dave Ellis mentioned that SURF was the topic of a recent editorial for *Groundwater Monitoring and Remediation* (Volume 27, Issue 4, pages 47-49, Fall 2007). "Surf's Up Dude!" was authored by David Major (Geosyntec), a member of SURF.
- Erica Becvar (Air Force Center for Engineering and the Environment) asked if SURF members would like to speak at the upcoming Association of State and Territorial Solid Waste Management Officials (ASTSWMO) symposium in San Diego, California, on March 12 and 13, 2008. The theme of the symposium is "balancing sustainability concepts with remediation goals." Deb Goldblum, Curt Stanley, Stephanie Fiorenza, and members of the DTSC's Green Remediation Team expressed interest in speaking. These individuals were forwarded relevant symposium information via e-mail after the meeting.

Path Forward

The following path forward items were identified at the meeting:

1. Based on feedback at the meeting, volunteers for the design team are as follows: Maile Smith (Northgate Environmental), Dave Woodward (EarthTech), Gary Maier (EarthTech), and Chuck Newell (GSI Environmental). Additional members are welcome. Meeting Design Team members should expect to spend about eight hours on the effort between now and the next meeting.
2. Participants agreed that it would be helpful to discuss a test site at the next meeting. Dave Ellis (DuPont), Dick Raymond (TerraSystems), Chuck Newell (GSI Environmental), and Paul Favara (CH2MHill) volunteered to work as a team to develop the test site. The team will distribute the details of the test site to SURF members, who will perform their own sustainability analysis on the site prior to the next meeting. Results and key learnings will be discussed at the next meeting.
3. The next meeting will be hosted by SURF member Ralph Nichols at Savannah River National Laboratory in early March 2008. Additional meeting logistics will be forwarded as they become available. A draft agenda will be developed by the Meeting Design Team and will be circulated via e-mail. Active feedback and suggestions are encouraged.

Attachment 1
November 28 and 29, 2007 (SURF 5)
Participant Contact Information

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Participant Contact Information

Participant	Affiliation
Kathy Adams	Writing Unlimited
Erica Becvar*	Air Force Center for Engineering and the Environment
Bob Boughton	California DTSC
Louis Bull	Waste Management
Brandt Butler	URS Corporation
Deni Chambers	Northgate Environmental Management
Carol Dona	Corps of Engineers
Dave Ellis**	DuPont
Catalina Espino Guerrero	Chevron
Mikos Fabersunne	California DTSC
Paul Favara**	CH2M Hill
Stephanie Fiorenza	British Petroleum
Mike Gill	USEPA Region IX
Deb Goldblum	USEPA Region III
Maureen Gorsen	California DTSC
Paul Hadley**	California DTSC
Elizabeth Hawley	Malcolm Pirnie, Inc.
John Hawthorne	Locus Technologies
Mike Houlihan	Geosyntec Consultants
David Hull	LFR, Inc.
Mike Kavanaugh	Malcolm Pirnie, Inc.
Lowell Kessel	GEO Inc.
Stephen Koenigsberg	WSP Environmental Strategies
Nick Lagos**	Lagos
Maryline Laugier	Malcolm Pirnie, Inc.
Alana Lee	USEPA Region IX
George Leyva	California Region II Water Board
Tayseer Mahmoud	California DTSC
Gary Maier	EarthTech
Chuck Newell	GSI Environmental
Joe Nicolette	CH2M Hill
Ralph Nichols	Savannah River National Laboratory
Jenny Phillips	USEPA Region IX
Dick Raymond**	Terra Systems
Charlie Ridenour	California DTSC
Mike Rominger**	DuPont Retiree
John Scandura	California DTSC
Erich Simon	San Francisco Water Board
Maile Smith	Northgate Environmental Management
Charlie So	Shaw Environmental & Infrastructure
Susan Solger**	Chevron

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November 28 and 29, 2007 (SURF 5)
Participant Contact Information

Participant	Affiliation
Curt Stanley	Shell Global Solutions
Tiffany Swann	GSI Environmental
Carolyn Tatoian-Cain	California DTSC
Mike Vivas	California DTSC
Elizabeth Wells	San Francisco Water Board
John Wesnousky	California DTSC
Dave Woodward**	EarthTech

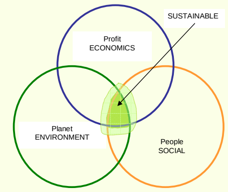
Notes:
* Individual participated via conference call
** Meeting design team member

Attachment 2
European SURF Activity Update

SUSTAINABLE REMEDIATION FORUM EUROPE Update

SURF 5
Sacramento November 2007

FORMAT



- Recap
- Progress
- Partners
- Profile
- Policy

RECAP 1 – Goals of SURF Europe

- Initiated 2007 after English Government request to:
  - develop the concepts of sustainable "remediation" decision making
  - Output to guide policy makers
- Co-ordinated by CL:AIRE* (currently UK focussed but European collaboration building) and linked to SURF USA
- Includes:
  - Business (national and multinational)
  - Regulators
  - Soil and groundwater practitioners (academics, consultants, and contractors)
  - NGOs
- To meet business needs - expanded remit and aim for globally applicable outputs

RECAP 2:To Achieve Goals Themes Identified

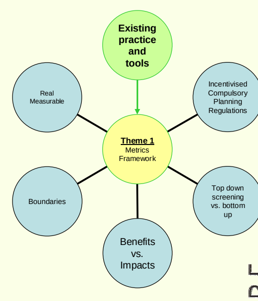
Theme 1. Metrics/Framework
Phase I

Initial work packages focused on existing tools and practice.

In parallel Shell and National Grid testing UK Environment Agency CBA methodology

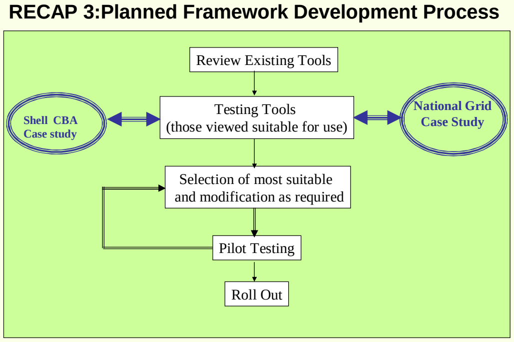
WP1 WP2

WP3 WP4



Theme 2. Carbon Trading
Theme 3. Affect on Design and Delivery

RECAP 3:Planned Framework Development Process



Progress

PHASE1 – Set up Steering Group and individual Work Packages
Regulators enthusiastic and supportive

$?	✓	✓	$?
WP1 Literature Survey	**WP2** Frame Work Testing existing tools e.g. CBA	**WP3** Existing tools outside industry	**WP4** Existing tools inside industry
Awaiting financial approval	**Progressing well *CBA test results Q1 08**	**Proposal received awaiting approval**	**Awaiting financial approval**

*cost benefits assessment to society P278/9

Partners

- Collaboration beginning in Europe new partners include:
  - BP / Shell linking USA and World outside USA
  - NICOLE* http://www.nicole.org who have been exploring the meaning and measurability of sustainability since 2002
  (*Network for Industrially Contaminated land in Europe)
  - SAGTA** http://www.sagta.org.uk
  (**Soil and Groundwater Technology Association UK)
- SURF Europe actively seeks partners with global interests willing to collaborate on framework development

PROFILE – SURF Europe

- **Special Sustainability Sessions** at:
  - Battelle 08 www.battelle.org/environment/er/conferences/
  - CONSOIL 08 **www.consoil.de** Milan, Italy 3 - 6 June 08
    - **The biggest contaminated land conference in Europe**
    - **with ~ 1000 delegates**
    - **invited speakers from UK & US SURF, European Industry Groups**
- SURF Europe involved in joint NICOLE/SAGTA Meeting March 08 "Measuring Sustainability in Remediation"

Policy – New Directions

- Groundwater Framework Directive – involves holistic catchment management not point source pollution
- Environmental Liability Directive – "offset penalty approach"
- EU Commission looking at resource equivalency methods for assessing environmental damage (REMEDE)
  - Remedy options include:

Primary	same site and same resource
Complementary	different site and or resource
Compensatory	Same and or different site, and Same and or different site resource

Will these new directions and sustainability accounting change the way contaminated soil and groundwater are managed in future?

Take home message

- Development of a globally applicable decision making framework underway
- If you would like to participate contact:
  Nicola.harries@claire.co.uk or
  Curtis.Stanley@Shell.com

Thank you

Any Questions?

Details of SURF Europe Work Packages

- WP1 – Output from literature survey – policy development, metrics/indicators, key learning, tools available and potential overlap.
- WP2 – Review the current CBA framework and assess how workable it is to sustainability. The current 3 volumes, (1 for soil and 2 for groundwater) need the individual tiers to be separated out more clearly and expanded to reflect on the wider environmental impacts and identify parameters that have greater applicability to sustainable remediation.
- WP3 – Review existing tools and identify what parameters are covered by other industry's sustainability assessment tools and could have applicability. This is to include Life Cycle Analysis.
- WP4 - Review existing tools and identify what parameters are covered by the different tools and identify potential overlaps.
  - Existing tools include: DuPont, National Grid, Atkins, Golders, Entec, Shell, BP, UK Environment Agency's Cost Benefit Assessment methodology.

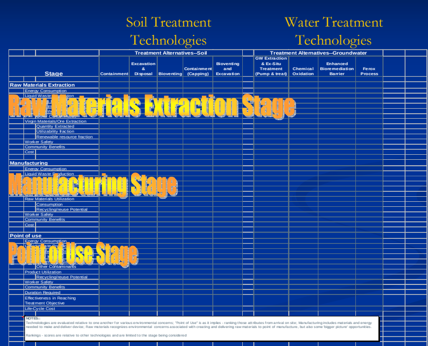
Attachment 3
California DTSC Green Remediation Team Briefing

DTSC's Green Remediation Team

An Expanded List of Topics Technologies/Remedies

- Energy Consumption
- Liquid Waste Production
- Solid Waste Production
- Air Quality Impacts (Greenhouse Gases and Other)
- Product utilization (Recycling/Reuse Potential)
- Worker Safety
- Community benefits
- Duration Required
- Effectiveness in Reaching Treatment Objective
- Life-Cycle Cost

Our First Attempt

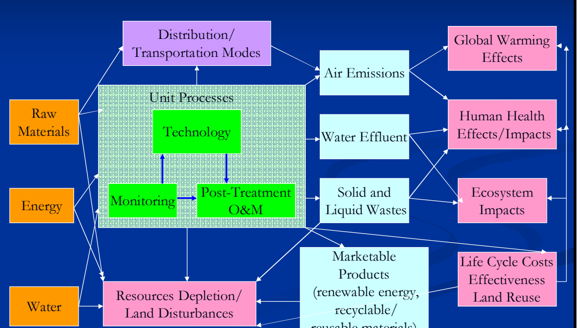


Life Cycle Framework

- Life Cycle Assessment (detailed/quantitative)
- Life Cycle Management (simple/qualitative)

M.L. Diamond, C.A. Page, et al.
Life-Cycle Framework for Assessment of Site Remediation Options: Method and Generic Survey, **Environmental Toxicology and Chemistry**, 18:4, p. 788-800, 1999.

Life-Cycle Evaluation Framework Diagram



Impact Factors

- Atmospheric Stressors
- Aqueous Stressors
- Thermal Stressors
- Physical Disturbances, Disruptions & Nuisances
- Resource Depletion

Atmospheric Stressors

- Airborne NOx & Sox (smog producers)
- Chloro-fluorocarbon vapors (ozone depleters)
- Greenhouse gas emissions
- Airborne particulates
- Toxic vapors/gases
- Water vapor (humidity)

Aqueous Stressors

- Non-toxic suspended solids (particulates)
- Toxic suspended solids (*bad* particulates)
- Non-toxic dissolved solids (minerals)
- Toxic dissolved solids (metals, organics)

Thermal Stressors

- Warm water (condensers)
- Warm water vapor (cooling towers)

Physical Disturbances/Disruptions & Nuisances

- Soil structure disruption
- Soil moisture removal/addition
- Noise
- Sub-toxic level, nuisance gas and vapor releases (odors)
- Traffic
- Visual landscape

Resource Depletion

- petroleum
- minerals
- land & space
- forest & grasslands
- surface water & groundwater
- atmospheric oxygen
- aqueous oxygen
- biological/microbiological organisms

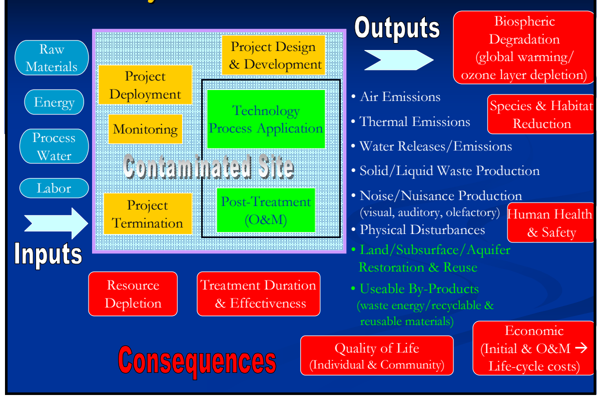
Candidate Soil Treatment Technologies

- Bioventing (Soil Venting)
- Cap Site
- Consolidate and Cap
- Construct Landfill Cell
- Enhanced Biodegradation
- Excavate and Dispose
- Excavate and Treat
- Passive Venting
- Soil Vapor Extraction with Vapor-phase treatment

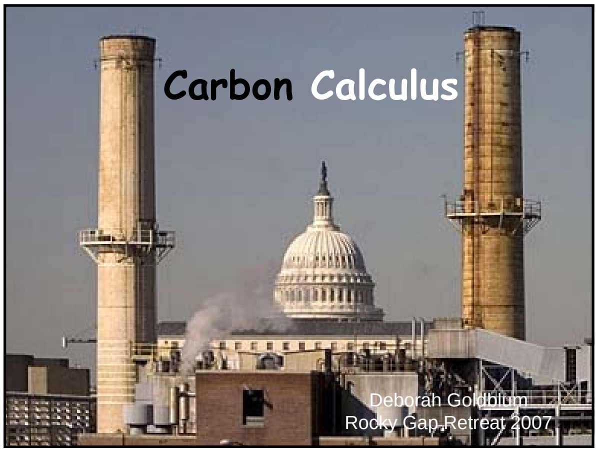
Candidate Water Treatment Technologies

- Air Sparging
- Chemical Oxidation, In Situ
- Containment Barrier
- Dual Phase Extraction
- Enhanced Biodegradation, In Situ
- Monitored Natural Attenuation
- Pump and Treat Groundwater
- Wellhead Treatment
- Zero Valent Iron (Permeable Reactive Barrier)

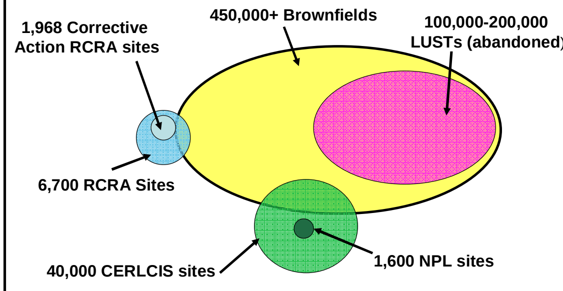
Life Cycle Evaluation Framework



Attachment 4
Green Cleanup Certification



Cleanup Sites



The Numbers

Program	Universe	Percent Construction Complete	Need Construction Complete
Superfund	1246	66%	424
RCRA 2008	1968	36%	1260
RCRA 2020	3746	19%	3038

Attachment 5
Making SURF Carbon Neutral

Attachment 5
How Might We Make SURF Carbon Neutral?
Brainstorming Discussion

How might we make SURF carbon neutral?

- Use teleconferencing, net meeting, webcast, and video conferencing technologies (8)
- Collect contributions to buy carbon credits that offset our carbon emissions (4)
- Hold meetings near public transportation (2)
- Implement a remedy that reduce carbon emissions (2)
- Plant trees to offset carbon used (2)
- Bring your own water bottle and coffee mug
- Recycle trash (e.g., water bottles) and reuse materials (e.g., tent cards, name badges)
- Minimize travel once at meeting location (e.g., use public transportation, carpool)
- Camp vs. hotel use
- Share hotel rooms
- Dissolve SURF organization
- Hook up exercise bikes to grid and pedal toward consensus
- Rent hybrid cars
- Do not eat meat

Attachment 6
Net Environmental Benefit Analysis: Overview and Case Study

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Use of a Net Environmental Benefit Analysis (NEBA) Approach in Demonstrating Environmental Sustainability and Incorporation Into Remedial decision-Making

Presentation to Sustainable Remediation Forum
November 28, 2007

Joseph Nicolette – Atlanta, GA
Paul Favara – Gainesville, FL

Agenda

- NEBA Overview
  - Origin and Evolution
  - Value in Risk Management Decision-Making
  - Demonstrating Environmental Sustainability
  - Metrics
- EPA's Need to Document and Maximize Benefits
  - Pilot Project Overview
- Consistency With Regulatory Guidance
- Integration of Remedial and NRDA Issues
- Case Study
- Discussion

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NEBA Origin and Evolution

- **NEBA Defined:** A Risk-Benefit Analysis Applied to Environmental Management Options
- Origin: Oil Spill Response
  - Evaluation of tradeoffs associated with response actions
    - Prince William Sound, Exxon Valdez
      - NOAA and EPA

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Recent Examples in Regulatory Process


Utilizing Net Environmental Benefit Analysis (NEBA) as a Tool for Evaluating Applied Response Technologies in Response to a Marine Oil Spill

Yvonne Najah Addassi, Staff Environmental Scientist, Office of Spill Prevention and Response, Department of Fish and Game

California

Introduction

Over the last several years, localized Ecological Risk Assessments (ERAs) have been conducted in the states of California, Washington and Texas. The purpose of these workshops was to provide response planners and other stakeholders with a forum for discussing oil spill response measures, with an emphasis on chemical dispersants. Many members of the Region IX Regional Team (RRT) participated in these workshops and decided to try and streamline the decision making process dispersant use in California. In 2000, the Region IX RRT requested that Area Committees within the state, utilizing local expertise, make recommendation for the use of dispersants into three zones; pre-approval; pre-approval with consultation, and RRT approval required. The first of the Dispersant-Use Zone recommendations was approved by the RRT in July 2002, for the North Coast Area Committee.

The RRT envisioned that the Dispersant-Use Zones Recommendations and subsequent Dispersant-Use Plans will be incorporated into the Federal Area Contingency Plans and will become an integral process of planning and preparedness for spill response. In development of the Dispersant-Use Plans, the area committees used a modified ERA process (best described as a NEBA) to identify concerns and prioritize risk so that sound and appropriate recommendations could be made. This process provided a mechanism to clearly identify species of concern, routes of exposure and trade-offs associated with each response option and begin to make determination regarding their appropriate use.

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What is a Net Environmental Benefit Analysis (NEBA)?

(In the Broader Context of Environmental Sustainability Including Remediation and Land Development Actions)

- A Risk-Benefit Analysis Applied to Environmental Management Options
  - Analytical framework to quantify and compare the ecosystem service benefits and/or losses associated with an environmental management option (e.g., remedial action, site re-development)
    - Uses *formally quantified* values
- Can be Used as a Method to Demonstrate Environmental Sustainability
- Potential uses under site cleanup/land development programs…
  - Use NEBA to help identify preferred alternatives: the break-point between remedial/development alternatives
    - Demonstrate and maximize benefits
  - Support feasibility studies and decision-making
- What are ecosystem services?

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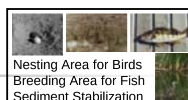
Ecosystem Services
"The functions a natural resource provide for other resources and for humans".



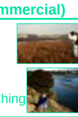
Nesting Area for Birds
Breeding Area for Fish
Sediment Stabilization
Water Quality Enhancement
Many Others

Ecological

Land/Habitat

Direct Human Uses
(e.g., Recreational, Commercial)

Bird watching
Fishing
Swimming
Hunting
Commercial Fishing



Passive Use

Existence value
Aesthetic value
Preservation of diversity
T&E species

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Why Formal Quantification is Important?

- Allows us to:
  - Demonstrate Environmental Sustainability: compare ecosystem benefits/costs between actions;
  - Document the ecosystem benefits/costs of an action;
  - Select/modify actions that maximize ecosystem benefits; and
  - Avoid/minimize actions that create natural resource liability
- Overall Goal:
  - Encourage the selection of actions that offer the greatest ecosystem service benefits to the environment and public.

8

Quantifying Services and Values

- Economic Methods to Determine the Present Discounted Value of Changes in Ecosystem Services Over Time
  - Ecological Services (Habitat Equivalency Analysis - HEA)
  - Direct Human Uses Such As Recreational Services (Economics Models: e.g., benefits/value transfer)

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HEA Metric

- The typical metric is a measure of *ecological services per acre per year* or SAYs (service acre years)
- A discounting factor is applied to standardize the measure of services using a common base year

  dSAYs (discounted service acre years)

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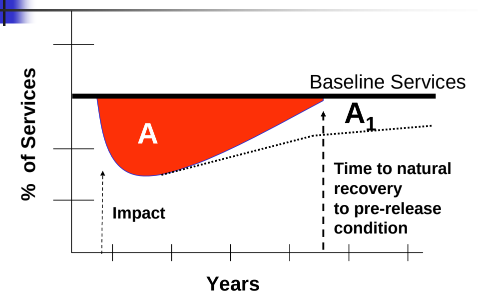
Quantifying Lost Ecological Services (Area A, "The Debit")



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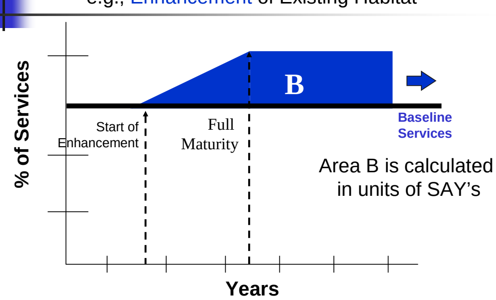
Providing Services: The "Credit"

e.g., Enhancement of Existing Habitat



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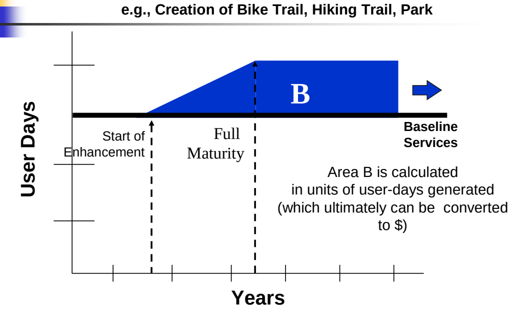
Metric: Providing Human Use Services: "Credit"

e.g., Creation of Bike Trail, Hiking Trail, Park



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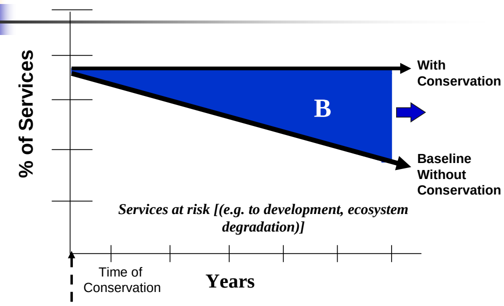
Conservation Value



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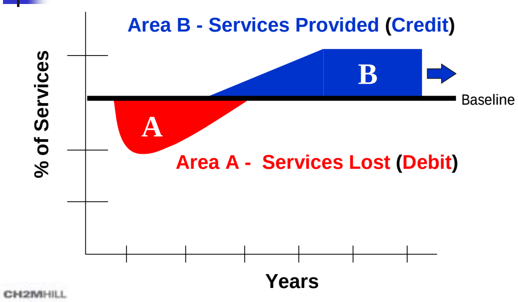
Demonstrating Environmental Sustainability

(Ecological and Human Use Values)



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HEA Application

- Applications are expanding
- Supported by Federal Agencies (NOAA, DOI, USFWS, NPS)
- Supported in Federal Court Rulings: Litigation Tested (USA vs M. Fisher et al. 1997)
- Origin (EPA Commissioned Paper, 1991, "*Scientifically Defensible Compensation Ratios for Wetland Mitigation*"
- Used with State Agencies (e.g., CA, TX, VA, SC, NJ, WA, ID, LA, FL, OR, others) and USACE
- Educated Stakeholders

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HEA Regulatory Applications

- Natural Resource Damage Assessment (NRDA) under the Oil Pollution Act (OPA)
- Corrective and remedial actions under (CERCLA) and (RCRA)
- Permitting and Environmental Documentation
- CWA Section 316(a)&(b) Demonstration
- Natural resource trustees are actively involved
  - Federal: DOI, DOC, FWS, NOAA, NPS, BLM
  - State: fish and game and natural resource agencies

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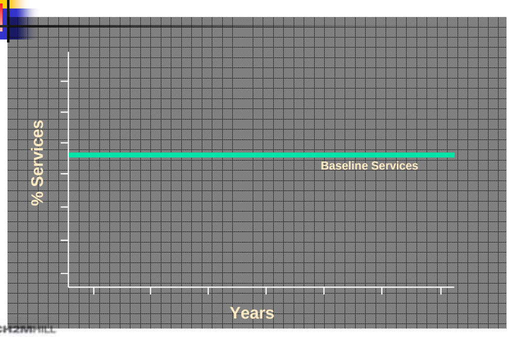
Comparing Environmental Values

(Cost Benefit Analysis of Design/Site Alternatives)



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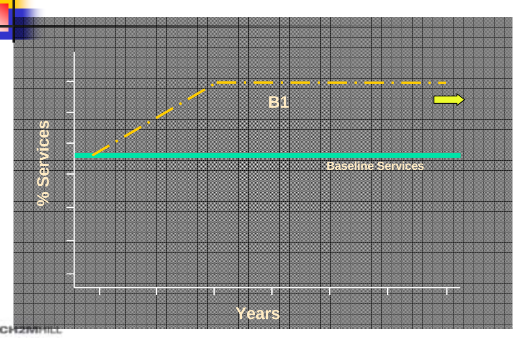
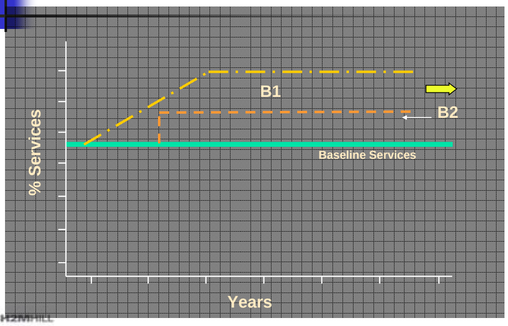
Comparing Environmental Values

(Cost Benefit Analysis of Design/Site Alternatives)



Comparing Environmental Values
(Cost Benefit Analysis of Design/Site Alternatives)



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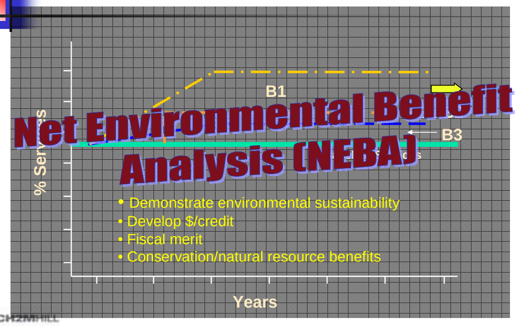
Comparing Environmental Values
(Cost Benefit Analysis of Design/Site Alternatives)



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Quantifying Ecosystem Services: Value in Risk Management Decision-Making

Trends for Transparency in Process

Recent Example UMRBA Report:

Net Environmental Benefits Analysis
Upper Mississippi River, Pool 12
March 8-9, 2006
Savanna, Illinois

REPORT

Contributors:

Sheila Calovich, U.S. Environmental Protection Agency, Region 5
Stuart Eddy, Great Lakes Commission
David Fritz, BP
Dave Hokanson, Upper Mississippi River Basin Association
Steve Lehmann, National Oceanic and Atmospheric Administration
Derek Martin, Upper Mississippi River Basin Association
Ginger Molitor, U.S. Fish & Wildlife Service
Ann Whelan, U.S. Environmental Protection Agency, Region 5

Prepared by the
Upper Mississippi River Basin Association

June 2006

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From the UMRBA Report:

"NEBA has the potential to assist resources managers in avoiding the possibility that the real-time removal alternative will provide no net environmental benefit over natural attenuation of contaminants and ecological recovery. A removal option may provide no net environmental benefit because:

1. The removal action is ineffective or inappropriate (the action does not substantially change the risk); or,
2. The removal alternative causes environmental injuries greater than the damage associated with the contamination because:
   - The need for remediation has been driven by human health risk, not ecological risk;
   - The ecological injury from contamination has been overestimated;
   - Injuries associated with removal were not properly addressed; or,
   - The need for remediation is driven by human considerations not related to health or ecologic concerns."

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Former EPA Administrator Carol Browner Memorandum Excerpts

MEMORANDUM

SUBJECT: EPA Risk Characterization Program

TO: Assistant Administrators
Associate Administrators
Regional Administrators
General Counsel
Inspector General

First, we must adopt as values **transparency** in our decisionmaking process and **clarity** in communication with each other and the public regarding environmental risk and the uncertainties associated with our assessments of environmental risk.

Second, because **transparency** in decisionmaking and **clarity** in communication will likely lead to more outside questioning of our assumptions and science policies, we must be more vigilant about ensuring that our core assumptions and science policies are **consistent** and comparable across programs, well grounded in science, and that they fall within a "zone of **reasonableness**."

While I believe that the American public expects us to err on the side of protection in the face of scientific uncertainty, I do not want our assessments to be unrealistically conservative. We cannot lead the fight for environmental protection into the next century unless we use common sense in all we do.

I recognize that as you develop your Program-specific policies and procedures you are likely to need additional tools to fully implement this policy.

Net Environmental Benefit Analysis (NEBA)

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"A Framework for Net Environmental Benefit Analysis For Remediation or Restoration of Contaminated Sites"

Rebecca A. Efroymson
Oak Ridge National Laboratory

Joseph P. Nicolette
CH2M HILL

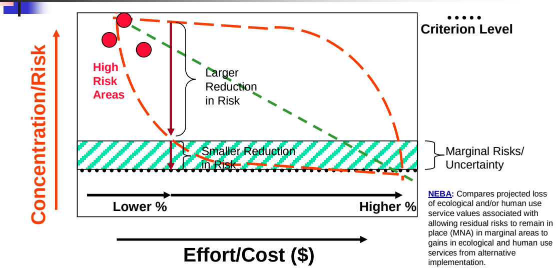
Glenn W. Suter II
USEPA National Center for Environmental Assessment

Published, *Environmental Management, August 2004*

Risk and Injury Issues

- Risk versus injury
- Conservatism and uncertainty
- Injury and/or benefits to ecosystem service values associated with remedies are rarely *formally quantified,* professional judgment is typically used
  - the potential exists for some remedial actions to:
    - 1) create more natural resource harm than that predicted by the risk assessment that drove the remedial action or
    - 2) provide a marginal benefit compared to the effort expended.
- NEBA provides collaborative framework to make risk management decisions

Cleanup to Criterion (Cost/Benefit)



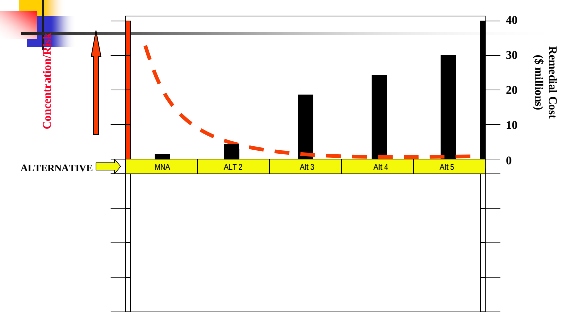
NEBA: Compares projected loss of ecological and/or human use service values associated with allowing residual risks to remain in place (MNA) in marginal areas to gains in ecological and human use services from alternative implementation.

Allows for **offsetting mitigation** (providing certain gains for uncertain losses): Maximizing benefits.

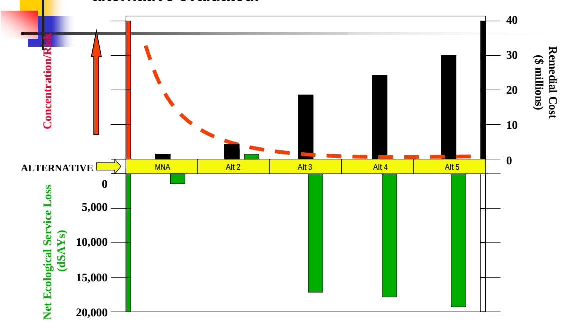
Table 1. The general effect of a remedial alternative can be evaluated.

Scenario #1					
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Remedial Actions	*Ecological Services (dSAYs)*	*Human Use Value ($)*	*Human Risk Profile*	*Ecological Risk Profile*	*Cost ($)*
ALT 1					
ALT 2					
ALT 3					
ALT 4					

NEBA Results: **Comparison of remedial costs and risk profile changes for each remedial alternative evaluated.**



NEBA Results: **Comparison of remedial costs to risk profile, and ecological service changes for each remedial alternative evaluated.**



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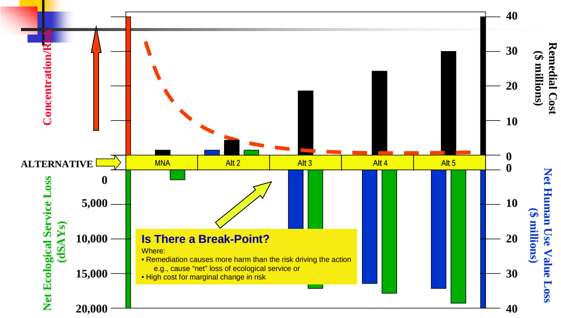
<u>NEBA Results:</u> Comparison of remedial costs to risk profile, ecological/human use service changes for each remedial alternative evaluated.



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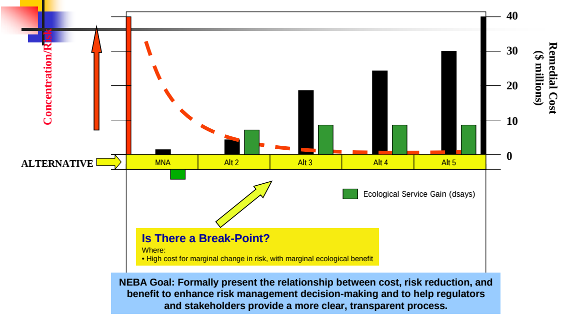
<u>NEBA Results:</u> Comparison of remedial costs to risk profile, ecological service changes for each remedial alternative evaluated.



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When to Consider a NEBA for Site Remedy Comparison?

- Remediation:
  - Alternatives being evaluated provide no unacceptable human health risks
  - Balance of risks and benefits of remediation are ambiguous
    - Site retains significant ecological value
    - Remediation will cause environmental damage
      - Creating NRD Liability?
    - Ecological risks are small, uncertain, or limited
    - Remediation or restoration may fail or not truly change risk scenario
    - Costs appear disproportionate to changes in the risk scenario

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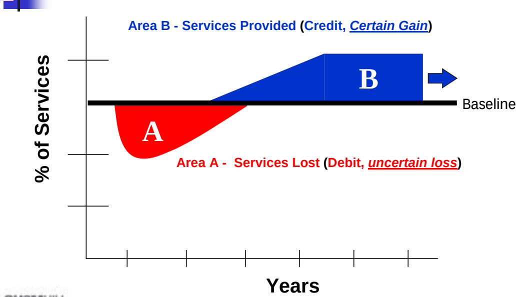
Offsetting Marginal Risk

(Ecological and Human Use Values)



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When to Consider a NEBA to Demonstrate Environmental Sustainability?

- Need to Balance the risks and benefits of action, especially when they are ambiguous
  - Need to maximize benefits and justify/compare between proposed actions
  - Refine actions
  - Site has significant natural resource value or site action will create natural resource value
  - Action will cause environmental damage
    - Creating NRD Liability?

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Documenting and Maximizing Benefits

Site Revitalization and Pilot Project

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The “Need” to Document Benefits

- EPA Cleanup program under attack
  - Is EPA running the least cost-effective public heath programs?
  - Enormous costs, marginal HH&E benefits
- Complete quantification of benefits and costs
  - Transparency for better accountability
  - priority setting, and
  - (possibly) more resources for cleanup programs
- SAB review of Superfund benefits report advised EPA to use case study approach to describe ecosystem beneficial impacts of cleanup
- Paradigm shifting

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EPA Benefits Quantification Pilot Study: Metrics

Benefits of Site Cleanup →

1. Increase in Human Use Value
2. Increase in Ecological Service Value
3. Increase in Economic Value to Society

Purpose of Pilot Study: Need to Express and Maximize Benefits: Evaluating Potential Metrics

Metrics Evaluated

2 Closed Sites

1 Active Site

Human Recreation Use Value - User-Days
Remediation resulted in a fish advisory being lifted; fishing user days increased.

Human Recreation Use Value - $$$; Willingness to pay in excess of cost of the good
The *quality of the fishery is increasing, along with the publics “willingness to pay to fish there.”*

Ecological Service Value – Services provided per acre/year (Service Acre Years-SAY’s)
Increases in the fish population increased habitat quality by 20% (measured in SAY’s).

Ecological Service Value – $$$ per acre
The $ value of provisioning services (food function) of the lake has increased by 50%.

Economic Measures – Property values, jobs, taxes, community benefits, secondary development effects
Economic welfare better because of enabled redevelopment, e.g., property values have increased as a result of lifting the fish advisory.

2 Closed Sites: Goal: ***Compare metrics of pre-cleanup projected baseline to post-cleanup projected condition***

***1 Active Site: Goal**: Use the NEBA approach* **within the remedial decision-making process to assist in evaluating and developing remedial alternative strategies using the ecological and human use metrics described above (dSAYs, user-days, human use in $). These results would subsequently support the selection of a preferred alternative and assist with documenting and maximizing the benefits associated with EPA’s actions.**

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Sites Being Evaluated

- Closed Sites
  - Homestead AFB, FL
  - Rocky Mountain Arsenal, CO
- Active Site
  - Under consideration

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NEBA Consistent With Regulatory Guidance

- ***Examples:***
  - Risk Management Objectives
  - EPA’s Ecological Benefits Assessment Strategic Plan
  - OSWER Directive 9285.7-28 P 1999
  - Interstate Technology and Regulatory Council (ITRC)
  - State rules (e.g., Texas risk reduction rules, ESA provision)
    - Port Arthur, Texas, Chevron RCRA Site
  - 1999 DOI-EPA Guidance

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Risk Management Objectives

- EPA Superfund ERA Guidance (Step 8):
  - “The risk manager must balance (1) residual risks posed by site contaminants before and after implementation of the selected remedy with (2) the potential impacts of the selected remedy on the environment independent of contaminant effects.”
  - “In instances where substantial ecological impact will result from the remedy (e.g., dredging a wetland), the risk manager will need to consider ways to mitigate the impact of the remedy and compare mitigated impacts to the threats posed by the site contamination.”

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OSWER Directive 9285.7-28 P 1999

- Guidance states:
  - ‘Even though an ecological risk assessment may demonstrate that adverse ecological effects have occurred or are expected to occur, it may not be in the best interest of the overall environment to actively remediate the site.
  - “At some sites, especially those that have rare or very sensitive habitats, removal or in-situ treatment of the contamination may cause more long-term ecological harm (often due to wide spread physical destruction of habitat) than leaving it in place.”

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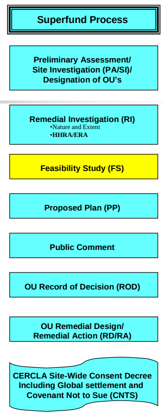
Where Does NEBA Fit?

NEBA:
1. Evaluate ecosystem cost/benefit associated with remedial alternatives
2. Supplement 9 Criteria
3. Maximize benefits and demonstrate environmental sustainability



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Integration of Remedial and NRDA Issues

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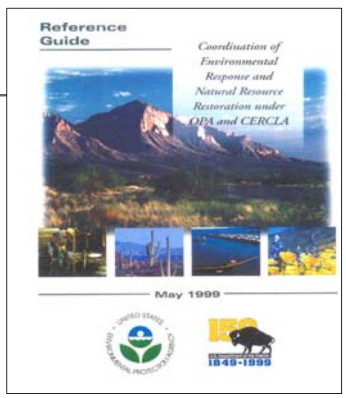

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Coordinated Approach to Assessment, Remediation and Restoration

Cleanup

Remedial Investigation
Health/Eco Risk Assessment
EE/CA, FS (NEBA)
ROD
Remedial Action
O&M

Parallel Track

NRDA

Pre-Assessment
Assessment (e.g., injuries)
Post Assessment (Restoration Options Analysis)
Restoration Plan (Consent Decree)
Restoration Implementation & Monitoring

Overall Goals
- Follow EPA/DOI Guidance (1999)
- Minimize NRI through remedial strategy
- Manage short and long-term risks
- Reduce time to resolution (transaction costs)
- Reduce study costs, improve design (e.g., eco-risk)

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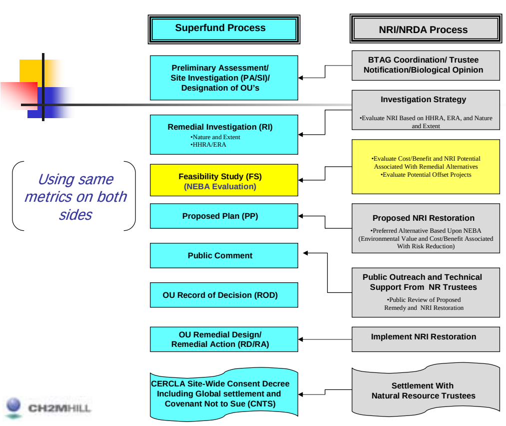

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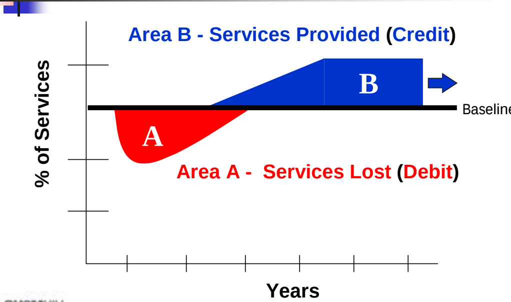
Demonstrating Environmental Sustainability

(Ecological and Human Use Values)



Benefits

- Basic way to demonstrate environmental sustainability using litigation tested methods
- Maximize and demonstrate benefits to public
- Reduce costs (private and public $)
- Expedite site closures
- Manage existing and potential long-term risks
- Enhance basis for land management decisions/actions

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Net Environmental Benefit Analysis (NEBA)

Edwards AFB ROD OU6

Groundwater Restoration

- TCE primary contaminant
- Restore groundwater to background conditions of 0.5 µg/L

Risk Assessment Process

- Human health and ecological risks identified
  - Ecological risks insignificant
  - Concentrations exceeded ARARs
- Sites N2, N3, and N7
  - Source areas for co-mingled plume
  - Chlorinated solvents and hydrocarbons

Draft Feasibility Study

- Four Alternatives developed
  - Alternative 1: Land Use Controls
  - Alternative 2: Groundwater Monitoring/Hydrologic Control
  - Alternative 3: : *In Situ* Chemical Oxidation of the Entire Plume
  - Alternative 4: No Action

Net Environmental Benefit Analysis

- Evaluate FS alternatives
- Formally quantify effects on natural resource services associated with the proposed remedial alternatives in relation to the incremental changes in risk

55

Revised Feasibility Study

- Evaluated ecological and human use service (GW yield) values
- NEBA results led to the addition of a 5th alternative (Alternative 3a)
  - a less aggressive version of Alternative 3, based on *In Situ* Chemical Oxidation

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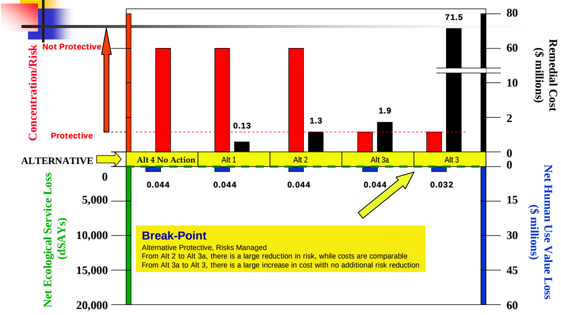
NEBA Results: Comparison of remedial costs to risk profile, ecological/human use service changes for each remedial alternative evaluated over a 30-year timeframe.



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NEBA Summary

		Human Use Service Loss (NPV)	Human Risk Profile	Ecological Risk Profile	Cost of Remedial Alternative (NPV)
	Alternative 4 No Action	$0.044 million	Not Protective	No Risk	$0
	Alternative 1	$0.044 million	Not Protective	No Risk	$0.13 million
	Alternative 2	$0.044 million	Not Protective	No Risk	$1.3 million
Chosen Alternative	Alternative 3a	$0.044 million	Protective	No Risk	$1.9 million
	Alternative 3	$0.032 million	Protective	No Risk	$71.5 million

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Record of Decision

- The Air Force and the USEPA selected Alternative 3a in concurrence with the California Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board (CRWQCB)
- ROD signed September 2006

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Discussion

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Attachment 7
Life-Cycle Analysis for Use in Evaluating Sustainable Remediation Metrics

Life-Cycle Analysis
for Use in Evaluating
Sustainable Remediation Metrics

Sustainable Remediation Forum Meeting 5
Sacramento, California
27 November 2007

Bob Boughton, DTSC, CalEPA, Sacramento CA
Mike Houlihan, Geosyntec Consultants, Washington DC

California Environmental Protection Agency
Department of Toxic Substances Control

Geosyntec consultants

1

Purpose of this Presentation

Introduce Life Cycle Analysis (LCA) as a tool for evaluating Sustainable Remediation Metrics

- Provide overview of LCA
- Discuss Case Histories of LCA, particularly LCA applied to environmental remediation projects
- Suggest a framework for incorporating LCA into SuRF's metrics discussions

2

Metrics for Sustainable Remediation

Many metrics have been considered for remediation at past SuRF meetings, for example:

- GHG and climate change
- Air particulate emissions
- Fossil fuel depletion
- Natural resource consumption or recycling
- Ozone depletion
- Occupational Health and Safety
- Acidification
- Eutrophication
- Photochemical smog formation
- Human carcinogenic effects
- Land use or reuse (Brownfields)
- Water use (groundwater depletion, recharge, etc.)
- Contribution to future sustainability
- Fuel Use
- Natural resource depletion (aggregate, lime, wood, etc.)

How do we manage all of these factors? Do we consider them all?

3

Past SuRF Discussions on Metrics

- Focused on a few, key metrics
  - GHG emissions
  - Energy Use
  - Resource Consumption
  - Human Safety
- Many other metrics have been suggested for inclusion in the analysis, but no methods suggested for how to quantitatively evaluate impacts or how to interpret impact assessments
  - Land use
  - Property value
  - Sequestration value
- LCA offers a method for defining which metrics to focus on and for performing an integrated interpretation of metrics

4

Life-Cycle Assessment - Overview

- A standardized tool for evaluating the overall impacts of a product ***or activity***
- Can be used to compare alternative waste management, site cleanup, and P2 options
- Theoretically, can account for all inputs and outputs
- Outputs are related to a suite of impact characteristics (including the commons)

➢ 'Metrics' are a key element of LCA – SuRF efforts to date actually constitute the key initial steps of a LCA

5

Why Use Life Cycle Analysis?

- Helps one consider the holistic environmental burdens resulting from products or processes
- Broadens the range of environmental issues considered when setting policies and making recommendations or decisions
- Inform consumers, industry, and government on the environmental tradeoffs of alternative products/services
- Accounts for temporal, spatial, and media impact shifts (more later on this topic)

6

History of LCA

- 1960's: Growing concerns over stocks of raw materials and energy resources. Example: Coca-Cola's evaluation of beverage containers.
- 1970's: Quantify resource use and environmental releases of products and alternatives to land disposal (recycling, composting)
  - USA - Resource and Environmental Profile Analysis (REPA)
  - Europe – Ecobalance
- 1990's: International Consensus
  - Society of Environmental Toxicology and Chemistry (SETAC) builds consensus on methodology
  - ISO develops LCA standards (14040-43 Environmental Management - Life Cycle Assessment)
  - Japan LCA Forum and the National LCA Project; US resurgence
  - Development of TRACI – USEPA's LCA tool

7

Elements of "Standard" LCA

i. Define the Product Life Cycle
ii. Gather Input and Output Data
iii. Create Inventory of Impacts
iv. Characterize Impacts
v. Interpret results (this is the tough part)

8

i. Define the 'Product' Life Cycle

<u>Standard LCA Stages</u>

- Raw materials acquisition
- Materials processing
- Product manufacture
- Product use
- Final Disposition

➢ Transportation, material resources and energy use included at each stage

<u>Remediation Project LCA Stages</u>

- Raw materials acquisition
- Site Processing
- Waste Management
- Transportation

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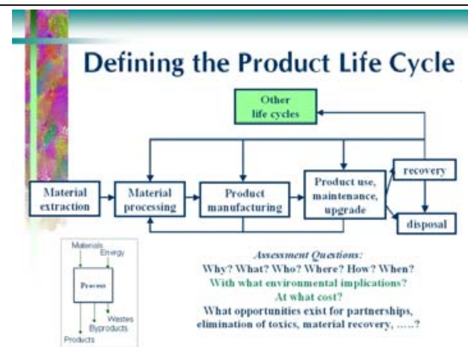
ii. Gather Input and Output Data



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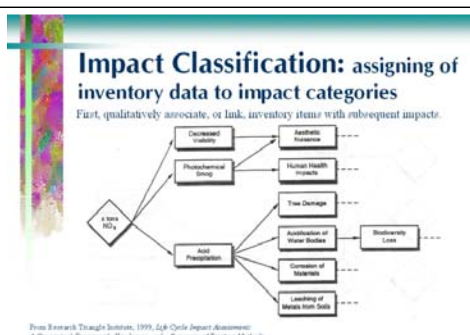
iii. Create Inventory of Impacts



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Example Inventory of Impacts: Remediation

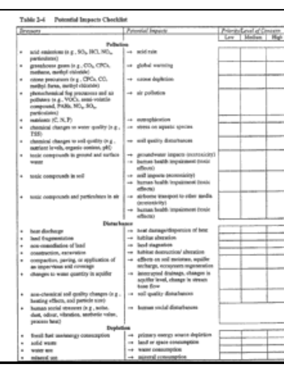

Table 2-1 Potential Impacts Checklist

Stressors	Potential Impacts	Priority/Level of Concern Low	Medium	High
Pollution				
• acid emissions (e.g., SO_2, HCl, NO_x, particulates)	→ acid rain			
• greenhouse gases (e.g., CO_2, CFCs, methane, methyl chloride)	→ global warming			
• ozone precursors (e.g., CFCs, CO, methyl furan, methyl chloride)	→ ozone depletion			
• photochemical fog precursors and air polluters (e.g., VOCs, semi-volatile compound, PAHs, NO_x, SO_x, particulates)	→ air pollution			
• nutrients (C, N, P)	→ eutrophication			
• chemical changes to water quality (e.g., TSS)	→ stress on aquatic species			
• chemical changes to soil quality (e.g., nutrient levels, organic content, pH)	→ soil quality disturbances			
• toxic compounds in ground and surface water	→ groundwater impacts (ecotoxicity) → human health impairment (toxic effects)			
• toxic compounds in soil	→ soil impacts (ecotoxicity) → human health impairment (toxic effects)			
• toxic compounds and particulates in air	→ airborne transport to other media (ecotoxicity) → human health impairment (toxic effects)			
Disturbance				
• heat discharge	→ heat damage/dispersion of heat			
• land fragmentation	→ habitat alteration			
• non-consolidation of land	→ land stagnation			
• construction, excavation	→ habitat destruction/ alteration			
• compaction, paving, or application of an impervious soil coverage	→ effects on soil moisture, aquifer recharge, ecosystem regeneration			
• changes to water quantity in aquifer	→ interrupted drainage, changes in aquifer level, change in stream base flow			
• non-chemical soil quality changes (e.g., heating effects, soil particle size)	→ soil quality disturbances			
• human social stressors (e.g., noise, dust, odour, vibration, aesthetic value, process heat)	→ human social disturbances			
Depletion				
• fossil fuel use/energy consumption	→ primary energy source depletion			
• solid waste	→ land or space consumption			
• water use	→ water consumption			
• mineral use	→ mineral consumption			

- Each stressor paired with a corresponding impact
- 'Screening level' evaluation can be performed to determine need for additional analysis
- Each impact can be quantified

(From Ontario Ministry of Environment, 1998)

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iv. Categorize Impacts (i)

Characterization: modeling of the inventory data within impact categories

- Use of Impact Potentials
  - global warming potential (kg CO_2 eqv.)
  - photochemical smog potentials (kg C_2H_4-eqv.)
  - acidification potentials (kg SO_2- eqv.)
  - eutrophication potentials (kg NO_3- eqv.)
  - toxicity potentials (???)

Characterization: Example

- Impact of each stressor is quantified
- Impacts quantified according to life-cycle stage
- Stressors are categorized for future interpretation by category

(From Ontario Ministry of Environment, 1998)

iv. Categorize Impacts (ii)

(From UNEP Life Cycle Initiative)

Example Impact Categories

- Global Concerns
  - Global Climate Change
  - Ozone depletion
  - Loss of Habitat and Reductions in Biodiversity
- Regional and Local Concerns
  - acidification
  - eutrophication
  - land use
  - photochemical smog
  - toxics in the environment

Alternative Impact Categorization

(after Cadotte, 2007)

- Global Warming Potential (GWP)
- Gross Energy Requirement (GER)
- Solid Waste Burden (SWB)
- Residual Toxicity Burden (RTB)
- Land Use Assessment (LUA)

➢ Each Category is a collection of several stressor/impact evaluations that are specific to environmental remediation

v. Interpret Results

➢ Perform comparative review of impacts and determine course of action.

➢ Interpretation depends largely on the value system of the Interpreter:
- Value development over conservation?
- Value personal freedoms over public benefit?
- Value human health over economic gain?
- Value short-term benefits over long-term benefits?

➢ Many of the values can't be quantified – this leaves many of the most important elements of the LCA (or any sustainability analysis) open to debate

LCA CASE STUDIES

I. Automotive Catalytic Converter

California Environmental Protection Agency
Department of Toxic Substances Control

Geosyntec consultants

LCA of Catalytic Converter

- Seminal case study of LCA
- Cars are one of the predominate sources of air emissions - the catalytic converter is very effective in reducing emissions
- A review of “end of pipe treatment” methods was performed to evaluate the environmental life-cycle benefits/impacts – published in ‘Journal of Cleaner Production’

  - ➢ This example is discussed today to illustrate LCA methodologies and outcomes

Inventory of Impacts and Benefits

- <u>Categorization of Impacts</u>: Mining and production processes require substantial energy and material resources
  - Energy resource use 86 kg
  - CO_2 emissions to air 390 kg
  - Solid waste (mining) 253 kg
  - Few other significant emissions
- <u>Benefits</u>: Air emissions reduction
  - CO 1500 kg
  - NO_x 290 kg
  - HC 140 kg
  - CH_4 11 kg

Interpretation Methods

<u>Environmental Priority Strategy (EPS).</u> Environmental impacts are ‘weighted’ according to willingness to pay to protect the resources in question. Long-term impacts of waste not considered.

<u>Eco-Scarcity</u>. ‘Weights’ environmental load based on critical load for an area versus actual load. This method tends to value solid waste generation as most important impact.

<u>Environmental Theme</u>. Groups loads by impact categories and ‘weights’ them according to assumed critical loads for that area over period of consideration.

Quantitative Results

Method	Benefits					Impacts				
	CO	NO_x	HC	CH_4	<u>Total</u>	Waste	Energy	Materials	Air Emissions	<u>Total</u>
EPS	290	114	96	17	**517**	--	38	831	26	**895**
Eco-Scarcity	--	137	144	--	**281**	892	0.3	--	1.8	**894**
Env. Theme	125	114	103	1	**343**	1	1	--	2	**4**

Interpretation

- Each arguably considered the most significant impacts and quantified them comparatively so that a decision could be made.
- The different evaluation methods show the sensitivity of the result to the qualitative “value” system used for interpretation.
- Each identified impacts that are important.
- Each identified the “hot spots” (especially manufacturing phase resource consumption).

Implications

- *<u>Temporal Shift.</u>* Benefits were gained *after* impacts were caused.
- *<u>Spatial Shift.</u>* Impacts occur far from the benefits.
- *<u>Media Shift.</u>* Air emissions reduction benefits vs. resource consumption and waste generation impacts.
- *<u>Unintended Consequences.</u>* Recent study has found platinum group metals (used in manufacture of catalytic converters) in soil along roadways

LCA CASE STUDIES

II. Environmental Remediation

i. Cadotte, 2007
ii. Other Publications
iii. SuRF Studies

California Environmental Protection Agency
Department of Toxic Substances Control

Geosyntec consultants

i. Cadotte, et. al. *"Selection of a Remediation scenario for a Diesel Contaminated Site using LCA"*

- A well-documented paper addressing specific contaminants and remedies
- Compared 4 in-situ and ex-situ scenarios to remove LNAPL and to treat soil and groundwater
  - 10,000 ppm diesel in soil
  - 0.1 to1-m thick layer of LNAPL on groundwater
  - Residual contamination in soil and groundwater
- Remediation Goal: Reduce diesel to 700ppm in soil and 0.1mg/l in waters

Technologies Considered

1. LNAPL Removal
   - Pumping
   - Bioslurping
2. Soil Treatment
   - Natural Attenuation
   - Bioventing
   - Excavation and On-Site Biopiles
3. Groundwater Treatment
   - Pump & Treat
   - Biosparging
   - Chemical Oxication
   - Natural Attenuation

Analysis and Interpretation (i)

- Classification and characterization of impacts performed using USEPA's TRACI method.
- Then, impacts were 'normalized' to roll primary (short-term) and secondary (long-term) impacts into one value that could be compared.
- "Normalization" performed using Impact 2000+ method…

Analysis and Interpretation (ii)

Table 9: Total average normalized impacts by impact categories for the groundwater treatment stage

Categories (person*year)	Media	Pump & Treat	Biosparging	Chemical Oxidation	Natural Attenuation
Global warming	Air	0.57	0.025	3.67	0.003
Ozone depletion	Air	1.07	0.026	27.1	0.003
Acidification	Air	30.1	2.76	2.5 E 2	0.34
Eutrophication	Air	45.7	4.84	2.7 E 2	0.65
	Water	20.2	0.69	6.6 E 2	0.08
	Soil	2.67	4.3 E-3	2.54	4.7 E-4
Photochemical smog	Air	85.7	4.68	2.4 E 2	0.61
Ecotoxicity	Air	31.6	1.44	4.9 E 2	0.13
	Water	3.8 E 5	2.8 E 4	9.7 E 5	1.9 E 3
	Soil	1.6 E 4	8.5 E 2	2.9 E 5	1.1 E 2
Human health cancer	Air	7.0 E-6	1.1 E-7	8.2 E-5	4.1 E-9
	Water	0.001	9.2 E-5	0.003	6.1 E-6
	Soil	5.2 E-5	2.8 E-6	9.5 E-4	3.5 E-7
Human health criteria	Air	2.2 E 2	8.78	6.1 E 2	0.7
Human health non cancer	Air	24.3	0.38	2.9 E 2	0.014
	Water	0.21	0.013	5.1	9.4 E-4
	Soil	7.1 E-3	4.0 E-4	0.13	4.8 E-5

- ➢ "Normalized" impacts are reported as "total human impact" values, which can be summed and compared

Cadotte: Results

Scenario	Remedy Description	Remedy Duration	Normalized Primary and Secondary "Impacts"
1	• Oil Removal (pumping) • Natural Attenuation • Pump and Treat	302 yrs	116
2	• Biosparging (oil removal) • Bioventing • Biosparging	38 yrs	8
3	• Bioslurping (oil removal) • Bioventing • Chemical Oxidation	11 yrs	20
4	• Bioslurping (oil removal) • Excavation • Biopiles	8 yrs	28

ii. 8 Other publications (1999-2002)

- Found a variety of best treatments, results are very site- and contaminant-specific.
- Energy consumption and transport off-site tend to be drivers.
- Methodology strongly influenced the outcomes.

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Findings Relative to SuRF

- Only a few categories tended to produce the greatest *quantifiable* impacts – resource acquisition, transportation, processing
- Some important impacts not quantifiable – land use/stagnation, residual waste, habitat alteration
- Even after analysis, remedy selection still depends on a *qualitative* value assessment, for which there is no generally accepted methodology
- Low-impact remedies require time, fast remedies have higher impacts.

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iii. Previous SuRF Discussions

- Metrics have included several key *quantifiable* stressors, such as atmospheric emissions (CO_2, NO_x, SO_x, PM_{10}), fuel use, residual waste
- Other metrics that cannot currently be quantified, such as land use, remedy efficiency, aesthetics (noise, visual impacts, etc.), social progress, etc., only addressed qualitatively
- A comprehensive methodology for performing integrated 'Interpretation' of the all relevant metrics has not been proposed/accepted yet

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Discussion

- How should one select which metrics to consider in sustainability evaluation?
- Is there a need to better define the 'Interpretation' step as a logical follow-up to the metrics discussions of past SuRF meetings?
- How should the 'Interpretation' step be conducted – subjectively or objectively? Highly quantitative or more qualitative?
- Can elements of LCA provide a framework for performing the 'Interpretation' step?

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Attachment 8
Metrics: The Search for the Critical Few

Attachment 8
Metrics: Search for the Critical Few
Brainstorming Discussion

1. What is holding you back from practicing more sustainable remediation practices right now?
    - Inherent agency skepticism or lack of interest (4)
    - Lack of time (remedial program managers, project managers) (4)
    - Lack of training or need for higher level of knowledge (3)
    - Lack of resources (especially for life-cycle analysis) (3)
    - Perception that sustainability evaluation involves high cost (3)
    - Lack of guidance (2)
    - Agency policy and regulations (e.g., antidegradation standards) (2)
    - Lack of easy-to-use and learn tool to measure and compare metrics quantitatively (2)
    - Lack of consensus on criteria that would be used to evaluate/approve remedy
    - Inexperience with analytical methods
    - Lack of understanding of whether the candidate remedy is among the most useful for making a difference
    - Lack of a definition of what "more sustainable" means
    - Regulatory/stakeholder preference for groundwater restoration

2. What two metrics are the most important to you?
    - Energy use (7)
    - Economic cost (4)
    - Greenhouse gas emissions (3)
    - Carbon emissions (3)
    - Environmental benefit (2)
    - Air emissions
    - Fuel use
    - Carbon footprint over project life cycle
    - Nonrenewable resource depletion
    - Resource impacts
    - Safety
    - Ecotox
    - Cost savings (costs used for something else or to restore something else)
    - Waste recycling
    - Contaminant destruction
    - Technology effectiveness
    - Time to meet cleanup objectives
    - Resource consumption (particularly water)

Attachment 9
A Cooperative Approach to a Remediation Solution with a Sustainability Component

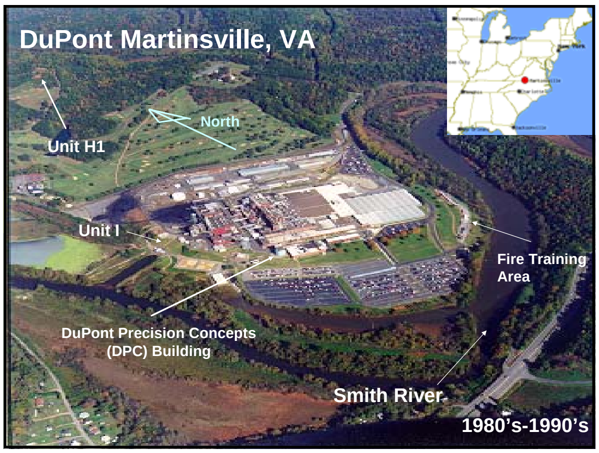
Region 3 RCRA/DuPont Pilot

How We Work Together

Dave Ellis, DuPont
Brandt Butler, URS
Deb Goldblum, EPA Region 3
Bob Greaves, EPA Region 3
Mike Jacobi, EPA Region 3
Bryan Ashby, DNREC

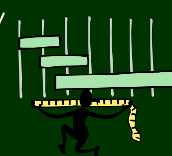
Background

- May 1998 - Region 3 and DuPont initiate semi-annual meetings for RCRA Corrective Action sites
- November 2006 – DuPont introduced the concept of sustainable remediation to Region 3 at semi-annual meeting
- February 2007 – Land Revitalization Office was tasked with developing clean energy and greenhouse reduction strategy for OSWER
- April 2007 – DuPont/Region 3 RCRA began to test sustainability criteria on Martinsville, VA site/

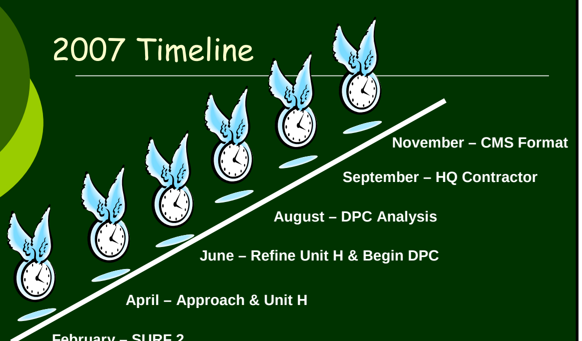


Integrating Sustainability into Cleanups

- Goals
- Framework to assess sustainability
  - Factors (common language)
  - Measures
- Implementation strategy



2007 Timeline



April Meeting

April 10
- Discuss credit/debit approach
- Define cleanup objectives
- Brainstorm options for Unit H1

April 26
- Revisit credit/debit approach
- Review Unit H1 initial calculations versus sustainability criteria

June Meeting

- Revisit credit/debit approach
- Identified data gaps in Unit H1 assessment
- Discussed credit for contaminant destruction
- Discussed merit of including efficiencies
- Agreed to capture technologies eliminated
- Initiated discussion on DPC

7

August Meeting

- DPC sustainability analysis
- H1 sustainability analysis for MNA
- Revisit debits and credits
- Initial discussions on CMS format

8

September Meeting

- Review for HQ contract support
- Discuss fitting sustainability criteria into CMS

9

November Meeting

- Agree upon remedy for Unit H1
- Review options for DPC
- Finalize remedy selection matrix
- Detailed discussion on CMS format

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Measuring Sustainability

• land use
• water use
• noise
• air impacts
• energy
• odor
• PM-10
• human exposure hours
• NO_X
• CO_2
• local issues
•treatment vs. containment
•SO_X
• occupational risk
•recycled materials

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Sustainability Credits and Debits (April)

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gas (CO_2 equivalents)	❑ Sequestration	❑ Generated by fuel consumed during activity ❑ Generated by manufacture of consumables
Resource Use		
Soil	❑ Reused-recycled soil or soil-substitute (e.g. crushed concrete)	❑ All soil required ❑ Off-site disposal
Land	❑ Beneficially reused (brownfields, wind field, solar field) ❑ Wetlands created or upgraded	❑ Permanently deed restricted
Water	❑ Reused-recycled	❑ All water used or captured for treatment ❑ Water for dust control
Energy	❑ Renewable energy generated on-site	❑ Required by remediation activity ❑ Required for manufacture of consumables
Occupational Risk	❑ Controls or measures to reduce hazardous exposure	❑ Exposure hours on-site ❑ Exposure hours for travel and delivery ❑ Road miles traveled for personnel and consumables

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Sustainability Credits and Debits (June)

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gas (CO_2 equivalents)	❑ Sequestration in-situ ❑ Sequestration by plants ❑ Destroying GWP equivalents	❑ Generated by fuel consumed during activity ❑ Generated by manufacture of consumables ❑ Vegetation removed ❑ Ex-situ contaminant destruction
Resource Use		
Soil	❑ Reused-recycled soil or soil-substitute ❑ Improved soil usability	❑ All soil required ❑ Off-site disposal ❑ Sterilized
Land	❑ Unrestricted reuse ❑ Restricted reuse – i.e. renewable energy or brownfield ❑ Wetlands created or upgraded	❑ Permanently deed restricted ❑ Permanent access restriction
Water	❑ Restored aquifer or surface water body ❑ Reused-recycled	❑ All water used or captured for treatment ❑ Water for dust control ❑ Ongoing O&M (i.e. growing grass on caps)
Air	❑ Odor control	❑ Contaminant emissions ❑ PM10 and PM 2.5 ❑ Acid rain compounds
Energy Use	❑ Renewable energy used for remedial action ❑ Renewable energy production	❑ Required by remediation activity ❑ Required for manufacture of consumables
Occupational Risk	❑ Controls or measures to reduce hazardous exposure	❑ Exposure hours on-site ❑ Exposure hours for travel and delivery ❑ Road miles traveled for personnel and consumables

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Sustainability Credits and Debits (August)

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gas (CO_2 equivalents)	❑ Sequestration in-situ ❑ Sequestration by plants ❑ Destroying GWP equivalents ❑ Immobilization of contaminants	❑ Generated by manufacture of consumables ❑ Sequestration loss by permanent vegetation removal ❑ Generated by fuel consumed during activity ❑ Ex-situ, on-site air emissions treatment ❑ Generated by off-site management of residuals ❑ Future release of contaminants (e.g. ??)
Resource Use		
Soil/Solids	❑ Reused-recycled soil or soil-substitute ❑ Improved soil usability	❑ All off-site soil required for remedy ❑ Off-site disposal
Land	❑ Unrestricted reuse ❑ Restricted reuse – i.e. renewable energy or brownfield ❑ Wetlands created or upgraded ❑ Conservation easement for preserving trees/ecological resource	❑ Permanently deed restricted ❑ Permanent access restriction
Water – address/assess where a critical (local) issue	❑ Restored aquifer or surface water body ❑ Reused-recycled ❑ Re-injected groundwater	❑ Public or surface water use e.g. Water for dust control or ongoing O&M (i.e. growing grass on caps) ❑ Groundwater captured for remediation – where critical
Air^^	❑ Odor control	❑ Contaminant emissions ❑ PM10 and PM 2.5 ❑ Acid rain compounds
Energy Use	❑ Avoided energy from recovery of energy-rich waste materials ❑ Renewable energy created and used by remedy	❑ Energy use by remediation activity ❑ Required for manufacture of consumables ❑ Ex-situ, on-site air emissions treatment ❑ Consumption by off-site management of residuals
Occupational Risk ^^	❑ Controls or measures to reduce hazardous exposure	❑ Exposure hours on-site ❑ Exposure hours for travel and delivery ❑ Road miles traveled for personnel and consumables
^^ Potential for addressing/quantifying as part other balancing criteria		

Sustainability Credits and Debits (September)

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gases and Energy		
○ Greenhouse Gases (CO_2 equivalents)	❑ Sequestration in-situ ❑ Sequestration by plants ❑ Destroying/immobilizing GWP equivalents	❑ Generated by fuel used ❑ Generated by manufacture of consumables ❑ Generated by on-site air emissions treatment ❑ Generated by off-site management of residuals ❑ Sequestration loss by permanent vegetation removal
○ Energy (kWh)	❑ Avoided energy use through reuse of energy-rich waste materials ❑ Renewable energy created and used by remedy	❑ Used for remediation activity ❑ Used for manufacture of consumables ❑ Used for on-site air emissions treatment ❑ Used for off-site management of residuals
Resources		
○ Soil/Solid Material (tons)	❑ Reused-recycled soil or soil-substitute ❑ Improved soil usability	❑ All off-site soil required for remedy ❑ Off-site disposal
○ Land (acres)	❑ Cleanup supports options for use/reuse ❑ Wetlands created or upgraded ❑ Conservation easement for preserving trees/ecological resource	❑ Permanent deed and access restrictions severely limit use/reuse
○ Water (gallons)	❑ Reused-recycled ❑ Re-injected groundwater	❑ Public or surface water use e.g. Water for dust control or ongoing O&M (i.e. growing grass on caps) ❑ Groundwater captured for remediation – where groundwater resources are critical
Site Specific Issues		
○ Noise	❑ Noise Control	❑ Noise
○ Odor	❑ Odor Control	❑ Odors
○ Light	❑ Light Control	❑ Light

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Sustainability Credit and Debits (Nov – Deb G.)

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gases & Energy		
○ **Carbon Dioxide** (CO_2 equivalents)	❑ Sequestered by plants ❑ Sequestered in-situ ❑ Destroyed GWP equivalents	❑ generated by fuel used during remediation ❑ generated by manufacturing of consumables
○ **Energy** (kWh)	❑ Renewable energy generated on-site	❑ Required by remediation ❑ Required for manufacturing of consumables
Resources		
○ **Soil / Solid Material** (tons)	❑ Reused-recycled soil or soil-substitute (crushed concrete)	❑ Off-site soil required ❑ Off-site disposal
○ **Land** (acres)	❑ No limitations to anticipated use ❑ Wetlands created or upgraded ❑ Conservations easement	❑ Permanent limited use
○ **Water** (gallons)	❑ Reused-recycled	❑ public or surface water used ❑ groundwater for remedy – where resource is critical

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Sustainable Parameter Estimation Methodology

Martinsville Unit H1

Sustainable Remediation Forum

November 29, 2007

DuPont The miracles of science

Overview

Sustainable Parameter Estimation Methodology
- Assessment Flow Chart

DuPont Martinsville Unit H1
- Source Area
- Migration Pathway

Technology Assessment
- Technology Options
- Task Analysis
- Estimation Spreadsheet
- Summary of Technology Assessments

Remedy Selection Matrix

Assessment Flow Chart

- RI and Other Reports → **Assess soil and ground water impacts** ← Project Team; Sustainability Resources
  - Aerial and vertical extent
  - Groundwater: volume, flow, constituents (concentration and mass)
  - Soil: volume, constituent mass

Assessment Flow Chart

- RI and Other Reports → **Assess soil and ground water impacts** ← Project Team; Sustainability Resources
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- Regulations; Business needs → **Identify remedial action objectives** ← Project Team; Sustainability Resources; Regulators, community
- ITRC; Technology Forums → **Identify candidate technologies** ← Project Team; Sustainability Resources; Technology Specialists; Regulators

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Assessment Flow Chart

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- ITRC; Technology Forums → **Identify candidate technologies** ← Project Team; Sustainability Resources; Technology Specialists; Regulators
- Prior Assessments → **Scope remedial option tasks** ← Project Team; Sustainability Resources; Technology Specialists; Regulators
  - Duration
  - Staff
  - Materials
  - Equipment
- Life Cycle Analysis → **Sustainability assessment worksheet** ← Project Team; Sustainability Resources; Technology Specialists
  - Structure templates to reflect technologies

Assessment Flow Chart

- RI and Other Reports → **Assess soil and ground water impacts** ← Project Team; Sustainability Resources
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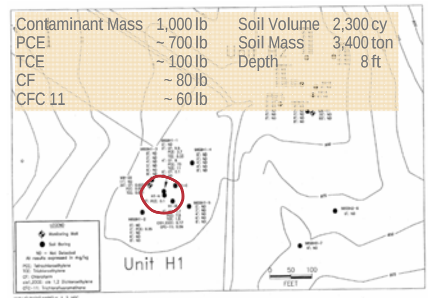
  - Duration
  - Staff
  - Materials
  - Equipment
- Life Cycle Analysis → **Sustainability assessment worksheet** ← Project Team; Sustainability Resources; Technology Specialists
  - Structure templates to reflect technologies
- Regulatory Framework → **Remedial alternatives analysis** ← Project Team; Sustainability Resources; Peer Review; Regulators
  - Include with balancing criteria

Martinsville Unit H1

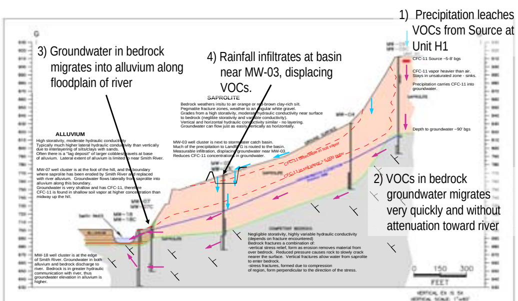
Source Area

Migration Pathways

Unit H1 Source Area



Conceptual Migration of VOCs



Technology Assessment

Technology Options

Task Analysis

Estimation Spreadsheet

Summary of Technology Assessments

Technology Options

Source - Soil

- **Excavation and landfill**
- **Geomembrane Cap**
- **In-situ Soil Vapor Extraction**
- In-situ Stabilize (no treatment)
- **In-situ ZVI/Clay (optimized)**
- In-situ Enhanced Bioremediation (tight formation – difficult to place)
- In-situ thermal & vapor capture (low concentration levels)
- In-situ Chemical-oxidation (matrix demand)
- **Ex-situ thermal treatment**
- Ex-situ soil wash (not proven)

Groundwater (source area or river)

- **MNA**
- Permeable Reactive Barrier (source + MNA preferred)
- In-situ Enhanced Bioremediation (source + MNA preferred)
- Pump and treat (air stripping and carbon adsorption) (source + MNA preferred)
- In-situ Air sparge w/vapor capture– option w/windmills (diffuse plume)
- In-situ chemical-oxidation (diffuse plume)
- In-well stripping (diffuse plume)

Technology Assessment

Capping

Excavation

In-situ ZVI-Clay Treatment

In-situ Soil Vapor Extraction

Ex-situ Thermal Treatment

Task analysis – In-Situ ZVI-Clay Treatment

Task	Item	Quantities
Mobilization, Site Prep and Demobilization	Time Staff Equipment	15 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Man lift, forklifts (2), crane, mix head, others
Shallow Soil Mixing	Time Staff Equipment Materials	17 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Mix head/crane, fork lifts(2), excavator, batch plant 70 ton ZVI, 50 ton bentonite, 200 ton kiln dust 130,000 gal water
Deliver Materials	Materials	Soil – 25 miles ZVI, Clay, Kiln Dust – 150 miles
Soil Cover	Time Staff Material Equipment	2 days 6 - 1 Super, 1 Eng'r, 4 Operators & Laborers 400 ton (1 ft cover) Dozer, roller

Task Evaluation – In-situ ZVI Treatment – Soil Mixing

Soil Mixing & Re-grading							
	Cubic Feet	68000	Water, gal	130,000		Total On-Site Mileage	
Days	17						2550
Hours per Day	9						
	Total Gasoline						**255**
Gasoline Vehicle	Support	gal/day	Avg MPG	Site Mileage	Days	Hours	Gallons
	3	5	10	2550	17	459	255
	Total Diesel						**3,740**
Diesel Equipment	Batch Plant	gal/day			Days	Hours	Gallons
	1	40			17	153	680
Diesel Equipment	Excavator	gal/day			Days	Hours	Gallons
	1	50			17	153	850
Diesel Equipment	Crane	gal/day			Days	Hours	Gallons
	1	50			17	153	850
Diesel Equipment	Mix Head	gal/day			Days	Hours	Gallons
	1	50			17	153	850
Diesel Equipment	Forklift	gal/day			Days	Hours	Gallons
	2	15			17	306	510
	Total Labor						**1,683**
	Operators and Supervisors				Days	Hours	
	11				17	1,683	
	Additional Field Crew				Days	Hours	
	0				17	0	

Consumables – ZVI Clay Treatment

Resource/Material	Units	Quantity	CO_2 Conversion	Units	Total CO_2 (lbs)
Gasoline	Gallons	530	20.17	lbs	10,690
Diesel	Gallons	5,358	25.80	lbs	138,245
Contaminant Degradation	lbs	940	0.52	lbs	487
GWP Change	lb-CO_2/lb-X	940	-299.66	lbs	-281,680.0
PVC	lb	0	2.58	lbs	0
Steel	lb-CO2	0	2.02	lbs	0
HDPE	lb-CO2	0	2.47	lbs	0
Cement	lbs	0	571	lbs	0
ZVI	lbs	140,000	1.3	lbs	184,800
Bentonite	lbs	100,000	0.00	lbs	0
Kiln Dust	lbs	400,000	0.00	lbs	0
Potable Water	Gallons	130,000	0.00	lbs	0
Total Groundwater	Gallons	0	0.0000	lbs	0
Groundwater Retained in River/Aquifer	Gallons	0	0.0000	lbs	0
Soil	lbs	800,000	0.00	lbs	0

Technology Summary – ZVI Clay Treatment

Carbon Dioxide Equivalents (Tons)		*Resource Usage*		*Consumables*	
Gasoline	5	Potable Water (gal)	130,000	Gasoline (gal)	530
Diesel	69	Total Groundwater (gal)	0	Diesel (gal)	5,358
Contaminant Degradation	0.24	Groundwater Retained in River/Aquifer (gal)	0	PVC (Total lb)	0
PVC	0	Soil (tons)	400	Steel	0
Steel	0	Landfill Space (ac-ft)	0	HDPE	0
HDPE	0	Land (Acre)	0.25	Cement	0
GranulatedCarbon	0	Air	0	Concrete	0
Cement	0			ZVI	70
Concrete	0			Bentonite	50
ZVI	92			Kiln Dust	200
TOTAL	**167**			Asphalt	0
lb-Contaminant/lb-CO2	0.0028125			Grid Energy	0
GWP Change	-140.8			Propane	0
ADJUSTED TOTAL	**26**			Propane	0

Summary of Technology Assessments

	Parameters	ZVI-Clay In-Situ Treatment	Excavation & Off-Site Disposal	Ex-Situ Thermal Desorption	Soil Vapor Extraction	Capping	MNA
Greenhouse Gas (ton - CO_2)		170	250	590	160	24	5
Adjusted Greenhouse Gas (ton - CO_2 Equivalents)		26	250	450	19	24	0
Efficiency (lb-contaminant destroyed/lb CO2)		0.003	0.000	0.0008	0.003	0.000	0.088
Energy Usage (kWh)		790,000	910,00	2,400,000	390,000	58,000	21,000
Occupational Risk	*Exposure Hours*	3,300	4,400	7,100	4,500	820	1,000
	Mileage	8,500	110,000	12,000	23,000	1,600	8,600
	Groundwater (gal)	130,000	0	0	0	0	0
	Soil (ton)	400	3,400	400	170	1,200	0
	Landfill Space (acre-ft))	0	2	0	0	0	0
	Land (Acre)	0.3	0	0.3	0.3	0.3	0
	PM_{10} (ton)	8	66	0	0	2	5

Unit H1 – Remedy Selection Matrix

	Protect HH &E	Control Sources	Meet Cleanup Objectives	Long-term reliability	Reduction of T, M, V	Short-term effectiveness	Ease of implementation	Cost	Community acceptance	State acceptance	Sustainability
Source Area Remedies											
ZVI-Clay In-Situ Treatment	Yes, when combined with MNA	Yes, by treatment	Yes	High	High due to treatment	32 days 3,300 hours 8,500 miles	Moderate	$$	Acceptable, pending public notice	Acceptable, pending review	CO_2 170 ton Adj. CO_2 26 ton Efficiency: 0.003 Water 130,000 gal
Excavation & Off-Site Disposal	Yes, when combined with MNA	Yes, by removal	Yes	High	None	25 days 4,400 hours 110,000 miles	Simple	$$	Acceptable, pending public notice	Acceptable, pending review	CO_2 250 ton Adj. CO_2 250 ton Efficiency: 0.000 Water 0 gal
Ex-Situ Thermal Desorption	Yes, when combined with MNA	Yes, by treatment	Yes	High	High due to treatment	53 days 7,100 hours 11,800 miles	Complex	$$	Acceptable, pending public notice	Acceptable, pending review	CO_2 5909 ton Adj. CO_2 450 ton Efficiency: 0.008 Water 0 gal
Soil Vapor Extraction	Yes, when combined with MNA	Yes, by treatment	Yes	High	Moderate	2 years 6,700 hours 17,000 miles	Moderate	$$	Acceptable, pending public notice	Acceptable, pending review	CO_2 160 ton Adj. CO_2 19 ton Efficiency: 0.003 Water 0 gal
Capping	Yes, when combined with MNA	Yes, by cover	Yes	Moderate	Moderate, eliminate mobility	13 days 820 hours 1,600 miles	Simple	$	Acceptable, pending public notice	Acceptable, pending review	CO_2 24 ton Adj. CO_2 24 ton Efficiency: 0.000 Water 0 gal

Sustainable Parameter Methodology Sensitivity Analysis

SURF 5

November 28, 2007

The miracles of science

Agenda

Sensitivity Analysis

Technology Sensitivity Analysis

- Capping
- Excavation
- In-situ ZVI-Clay Treatment
- In-situ Soil-vapor Extraction Treatment
- Ex-situ Thermal Treatment

Summary of Technology Sensitivity

Sensitivity Analysis

Evaluate effect of Inputs on Parameter Estimates

- Volume: 10X, 100X
- Mass: 10X, 100X
- Chemical Mix: All PCE, All Freon 11

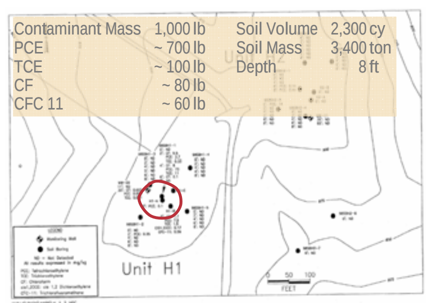
Compare Carbon Dioxide Estimates

- Surrogate and trends with other parameters

(Evaluate sensitivity, not suitability of technology)

Unit H1 Source Area

Contaminant Mass	1,000 lb	Soil Volume	2,300 cy
PCE	~ 700 lb	Soil Mass	3,400 ton
TCE	~ 100 lb	Depth	8 ft
CF	~ 80 lb		
CFC 11	~ 60 lb		



Technology Sensitivity Analysis

Capping

Excavation

In-situ ZVI-Clay Treatment

In-situ Soil Vapor Extraction

Ex-situ Thermal Treatment

Base Case Assumptions

Technology	Base Case
Capping	• 3 ft soil cap with geomembrane and geotextile • 0.18 acre
Excavation	• 3,400 tons • Replace with clean fill
ZVI-Clay	• 3,400 cy (100' dia x 8' deep) • 130,000 gallons water • ZVI – 70 tons • Bentonite – 50 tons • Kiln dust - 300 tons
Soil-Vapor Extraction	• 25 points • Carbon treatment • 2 years operation
Thermal Treatment	• 3,400 tons • 75 tons/day

Summary of Base-Case Technology Assessments

	Parameters	Capping	Excavation & Off-Site Disposal	ZVI-Clay In-Situ Treatment	Soil Vapor Extraction	Ex-Situ Thermal Desorption
Greenhouse Gas (ton - CO_2)		24	250	170	160	590
Adjusted Greenhouse Gas (ton - CO_2 Equivalents)		24	250	26	19	450
Efficiency (lb-contaminant destroyed/lb CO2)		0.000	0.000	0.003	0.003	0.0008
Energy Usage (kWh)		58,000	910,000	790,000	390,000	2,400,000
Occupational Risk	*Exposure Hours*	820	4,400	3,300	4,500	7,100
	Mileage	1,600	110,000	8,500	23,000	12,000
	Groundwater (gal)	0	0	130,000	0	0
	Soil (ton)	1,200	3,400	400	170	400
	Landfill Space (acre-ft))	0	2	0	0	0
	Land (Acre)	0.3	0	0.3	0.3	0.3
	PM_{10} (ton)	2	66	8	20	12

Sensitivity Assumptions

10X Increase in Source Area Volume
- Double Depth
- Increase area by factor of 5
- Constant soil concentration of COCs
- 10X increase in total mass of COCs

100X Increase in Source Area Volume
- Double Depth
- Increase area by factor of 50
- Constant soil concentration of COCs
- 100X increase in total mass of COCs

10X Increase in COC Mass
- Base Case Depth
- Base Case Area
- 10X increase soil concentration of COCs
- 10X increase in total mass of COCs

100X Increase in COC Mass
- Base Case Depth
- Base Case Area
- 100X increase soil concentration of COCs
- 100X increase in total mass of COCs

All COC is PCE
- Base Case Depth
- Base Case Area
- Total Soil Concentration is PCE
- Original mass of COCs, but exclusively PCE

All COC is Freon (CFC-11)
- Base Case Depth
- Base Case Area
- Total Soil Concentration is CFC-11
- Original mass of COCs, but exclusively CFC-11

ZVI-Clay Technology Sensitivity

Measures	Base Case	10X Soil Volume	100X Soil Volume	10X COC Mass	100X COC Mass	100% PCE	100% CFC-11
GHG, ton	170	1,500	15,000	170	190	170	170
Adjusted GHG, ton	26	67	500	-1,200	-14,000	170	-2,000
Energy Usage (kWh)	790,000	7,200,000	71,000,000	790,000	790,000	790,000	790,000
Water (gallons)	130,000	1,300,000	13,000,000	130,000	130,000	130,000	130,000
Soil (tons)	400	2,000	20,000	400	400	400	400
Exposure Hours	3,300	19,000	180,000	3,300	3,300	3,300	3,300
Total Mileage	8,500	35,000	300,000	8,500	8,500	8,500	8,500
PM_{10} (ton)	7.6	38	340	7.6	7.6	7.6	7.6
NOx (ton)	1.7	13	120	1.7	1.7	1.7	1.7
SOx (ton)	0.14	1.1	11	0.14	0.14	0.14	0.14

Capping

Measures	Base Case	10X Soil Volume	100X Soil Volume	10X COC Mass	100X COC Mass	100% PCE	100% CFC-11
GHG, ton	24	120	1,200	24	24	24	24
Adjusted GHG, ton	24	120	1,200	24	24	24	24

~ Area

Excavation

Measures	Base Case	10X Soil Volume	100X Soil Volume	10X COC Mass	100X COC Mass	100% PCE	100% CFC-11
GHG, ton	250	2,700	26,000	250	250	250	250
Adjusted GHG, ton	250	2,700	26,000	250	250	250	250

~ Volume

In-situ ZVI-Clay Treatment

Measures	Base Case	10X Soil Volume	100X Soil Volume	10X COC Mass	100X COC Mass	100% PCE	100% CFC-11
GHG, ton	170	1,500	15,000	170	190	170	170
Adjusted GHG, ton	26	67	500	-1,200	-14,000	170	-2,000

~ Volume

In-situ Soil Vapor Extraction

Measures	Base Case	10X Soil Volume	100X Soil Volume	10X COC Mass	100X COC Mass	100% PCE	100% CFC-11
GHG, ton	160	700	1,200	250	950	160	160
Adjusted GHG, ton	23	-700	-13,000	-1,200	-13,000	160	-2,000

Treatment time and vapor controls are significant factors

Ex-situ Thermal Treatment

Measures	Base Case	10X Soil Volume	100X Soil Volume	10X COC Mass	100X COC Mass	100% PCE	100% CFC-11
GHG, ton	121	1,200	12,000	190	880	120	120
Adjusted GHG, ton	-20	210	2,100	-1,200	-13,000	120	-2,100

Treatment time and vapor controls are significant factors

Greenhouse Gas Sensitivity

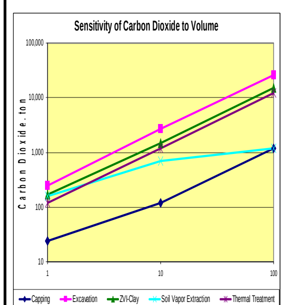
Technology	Base Case	10X Soil Volume	100X Soil Volume	10X COC Mass	100X COC Mass	100% PCE	100% CFC-11
Capping	24	120	1,200	24	24	24	24
Excavation	250	2,700	26,000	250	250	250	250
ZVI-Clay	170	1,500	15,000	170	190	170	-2,000
Soil Vapor Extraction	160	700	1,200	250	950	160	-2,000
Thermal Treatment	120	1,200	12,000	190	880	120	-2,100

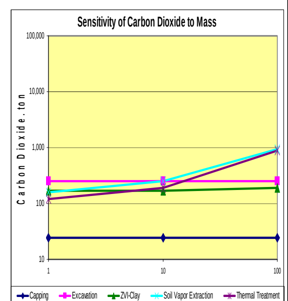
Values are Total Carbon Dioxide, except 100% CFC-11 Case (Adjusted Carbon Dioxide)

No one clear winner - scale of remedy determines minimal footprint

- Capping – area
- Excavation – volume
- ZVI-Clay - volume
- SVE – area, mass
- Thermal – area, mass

Sensitivity of Carbon Dioxide to Scale





Attachment 10
A Revised Corrective Measures Study Outline
based on Sustainability

Remedial Action Objectives

- Source Area
  - Mitigate/Reduce source mass to best of ability – future releases
  - Allow for continued current use of building
  - Institutional controls to preclude exposure
- Groundwater
  - MCLs throughout plume
  - Institutional controls to preclude exposure
- Surface Water
  - Meet SW quality standards – river/channel

Expedited Corrective Measure Study (CMS) - AOC DPC

- 1st Meeting at DuPont – April 10, 2007
- Review of RFI conditions at AOC DPC.
- State, EPA, DuPont, consultants brainstorming on technologies that might be applicable to VOC contaminated soil and groundwater.

Potential Remedial Measures

Soil

- Excavation and landfill – can't access
- Geomembrane Cap – already "capped"
- **SVE – horizontal delivery or removal**
  - Dual-phase – too deep to gw table
- In-situ Stabilization – can't access source, not applicable to contaminants
- ZVI/Clay – not implementable – no access to source
- **Enhanced bioremediation – bio-sweep substrate carried into formation – horizontal delivery**
- In-situ thermal & vapor capture – not implementable, too dry and no direct access to source
- Ex-situ thermal treatment – can't excavate
- Ex-situ Chem-ox – can't excavate
- **In-situ Chem-ox – horizontal delivery**
- Excavate and soil wash – can't access

Groundwater

- Monitored natural attenuation – if coupled with source remedy - revisit existing data to see if possible
- Iron PRB
  - Parking lot-shallower, wider and lower concentration or
  - Source-deeper, narrower and higher concentration
- Enhanced bioremediation – essentially the same as enhanced MNA – need carbon and microbes to implement
- Pump and treat – plume centerline or outfall channel
- Air sparge w/vapor capture
- In-situ chem-ox – large plume size and collateral impact of gw – purple seep?
- In-well stripping
- Phyto-remediation to transpire groundwater and contaminants
- Constructed Wetlands - outlet canal

Conventional Outline for a CMS

1. OBJECTIVES
    1.A. Establish Corrective Action Objectives (CAO)
2. DEVELOPMENT OF CORRECTIVE ACTION ALTERNATIVES
    2.A. Description of Remedial Actions
    2.B. Screening of Corrective Measure Technologies
        2.B.1. Site Characteristics and History
        2.B.2. Waste Characteristics
        2.B.3. Technology Limitations
    2.C. Identification of Corrective Measure Alternatives
3. EVALUATION OF THE CORRECTIVE MEASURE ALTERNATIVES
    3.A. Technical/Environmental/Human Health/Institutional
        3.A.1. Technical
        3.A.2. Environmental
        3.A.3. Human Health
        3.A.4. Institutional
    3.B. Cost Estimate
4. RECOMMENDATION OF A CORRECTIVE MEASURE AND PREPARATION OF THE CMS REPORT
    4.A. Technical
        1. Performance
        2. Reliability
        3. Implementability
        4. Safety
    4.B. Human Health
    4.C. Environmental
    4.D. Other Pertinent Factors

After the CMS outlined here, there is a Corrective Measures Implementation Work Plan

Proposed Streamlined Outline - Martinsville CMS

TABLE OF CONTENTS

1.0 Introduction
  1.1 Objective (of report)
  1.2 Establish Corrective Action Objectives (CAO)
  1.3 CMS Approach
  1.4 Report Organization
2.0 Summary of RFI
3.0 Corrective Measures Study - Unit H1
  3.1 Development of Corrective Action Alternatives
    3.1.1 Description of Corrective Action Objective
  3.2 Screening of Corrective Measure Technologies (against primary performance standards)
    3.2.1 Identification of Potential Corrective Measure Alternatives
  3.3 Evaluation of the Corrective Measure Alternatives (against balancing criteria)
  3.4 Recommended Corrective Measure
4.0 Corrective Measures Study - AOC DPC
  similar to section 3.0
5.0 Corrective Measures Study - Fire Training Area
  similar to section 3.0
6.0 Summary

Outline for CMS – Detail Look at Section 3

3.0 CORRECTIVE MEASURES STUDY – UNIT H1
Site Characteristics and History of Unit
- 3.1 Development of Corrective Action Alternatives
  - 3.1.1 Description of Corrective Action Objective
    identify the exposure pathways that should be addressed by CMS
- 3.2 Screening of Corrective Measure Technologies (against primary performance standards)
  identify technologies, which are appropriate.
  - 3.2.1 Identification of Potential Corrective Measure Alternatives
    determine which technologies appear suitable for the site.
    (See Example Table 1 – Technology Screening)
- 3.3 Evaluation of the Corrective Measure Alternatives (against balancing criteria)
  evaluate each corrective measure alternative that is suitable (from Section 3.2.1)
  balancing factors
  - Long-term Effectiveness
  - Short-term effectiveness
  - Long-term reliability
  - Reduction of toxicity, mobility, or volume of waste
  - Implementability
  - Sustainability
  - Cost
  - Institutional (State and community) acceptance
  (See Example Table 2 – Remedy Selection Matrix)
- 3.4 Recommended Corrective Measure
  (See Example Table 3 – Summary of Selection)

Example Table 1 – Technology Screening

Source Area Remedies	Protect HH &E	Control Sources	Meet Cleanup Objectives	Selection
Bio-barrier	Unlikely	Unlikely, source concentrations high (bio not very effective at high concentrations)	Unlikely	**Poor**
Bioventing	Unlikely	Uncertain, oxygen demand will be very high due to waste oil in source	Uncertain. Reduces some constituents, but source concentrations likely inhibit degradation.	**Poor**
Capping	Yes, when combined with MNA	Yes, by eliminating migration	Yes (constituents remain)	**Good**
Chemical Oxidation (In Situ)	Unlikely	Uncertain, oxygen demand will be very high due to waste oil in source. CFC-11 expected to be highly resistant to oxidation	Uncertain. Other constituents, including waste oils may interfere with reaction	**Poor**
Chemical Reduction	Unlikely	Source is already highly reduced. CFC-11 appears resistant to reduction.	Uncertain. Other constituents, including waste oils may interfere with reaction.	**Poor**
Excavation & Off-Site Disposal	Yes, when combined with MNA	Yes, by removal	Yes (complete removal)	**Good**
Ex-Situ Thermal Desorption	Yes, when combined with MNA	Yes, by treatment	Yes (some constituents remain, metals)	**Good**
In Situ Bioremediation	Unlikely	Unlikely, No evidence of degradation to CFC-11	Unlikely	**Poor**
Options graded "**Good**" are considered adequate treatment options and are passed onto the selection screening, which factors in balancing criteria.				
Options graded "**Fair**" are not recommended and would only be considered in the absence of more effective options.				
Options graded "**Poor**" are either not applicable to the treatment of the constituents present or there is such great uncertainty regarding the effectiveness of the option at this location				

DPC Selection Matrix – Source Area

	Protect HH &E	Control Sources	Meet Cleanup Objectives	Long-term reliability	Reduction of T, M, V	Short-term effectiveness	Ease of implementation	Cost	Community acceptance	State acceptance	Sustainability
Chemical Oxidation	Yes, when combined with plume treatment	Yes	Moderate	Moderate	High due to treatment	(strong reagents) 502 Hrs 2,700 miles	Moderate	$$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 101 ton Adj. CO_2 101 ton Efficiency: 0.0008
Soil Vapor Extraction	Yes, when combined with plume treatment	Yes	Yes	High	High due to treatment	(high exp hrs) 3,000 Hrs 4,500 miles	Moderate	$$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 105 ton Adj. CO_2 105 ton Efficiency: 0.0008
Bio Sweep	Yes, when combined with plume treatment	Yes	No	Low	High due to treatment	(high exp hrs, inert material handling) 1,200 Hrs 6,800 miles	Simple	$$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 16 ton Adj. CO_2 16 ton Efficiency: 0.005

DPC Selection Matrix – Groundwater

	Protect HH &E	Control Sources	Meet Cleanup Objectives	Long-term reliability	Reduction of T, M, V	Short-term effectiveness	Ease of implementation	Cost	Community acceptance	State acceptance	Sustainability
Outfall Pump & Treat	Yes	NA	Yes	High	High due to treatment	Exposure 8,500 Hrs Highway 25,000 mi	Simple	$$$$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 1,037 ton Adj. CO_2 1,034 ton Efficiency: 0.0002
Groundwater Pump & Treat	Yes	NA	Yes	High	High due to treatment	Exposure 12,000 Hr Highway 14,000 mi	Moderate	$$$$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 996 ton Adj. CO_2 994 ton Efficiency: 0.0002
Constructed Wetlands	Yes	NA	Yes	Moderate	Moderate	Exposure 2,900 Hrs Highway 34,000 mi	Complex	$$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 89 ton Adj. CO_2 87 ton Efficiency: 0.002
Phyto Remediation	Yes	NA	Yes	Low	Low	Exposure 3,600 Hr Highway 11,000 mi	Simple	$$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 22 ton Adj. CO_2 22 ton Efficiency: 0.008
Bio Treatment	Yes	NA	Yes	High	High due to treatment	Exposure 1,700 Hr Highway 10,000 mi	Moderate	$	Acceptable, pending Public Comment	Acceptable, pending Public Comment	CO_2 18 ton Adj. CO_2 16 ton Efficiency: 0.009

Example Table 3 – CMS Summary

Area	Media	Selected Technology	Comment
H1	Soil	Zero-Valent Iron/Clay	• Source treatment destroys chlorinated VOCs and stabilizes others • Cap reduces infiltration • Clay reduces soil permeability • Future source leaching eliminated • Balancing criteria best met
H1	Groundwater	Monitored Natural Attenuation	• Coupled with source treatment • Little plume mass in bedrock aquifer or sorbed to formation

Similarities and Differences between Conventional and Streamlined CMS

Similarities:
Both approaches. . . .
- Define the problem and set remedial objectives
- Present a list of potential options and perform two screens (first screen eliminates options that will not work, second screen selects the "best" option)

Differences:
- Conventional approach describes potential options in greater detail in first screen. Streamlined approach does not spend time describing options that are expected to be ineffective.
- Streamlined approach focuses on second screen and considers a larger number of balancing criteria.

Summary:
- When the initial technology screening is collaboratively developed with EPA/State agency, the CMS effort becomes more focused and quickly shifts to selecting the optimal remedy.
- Collaborative development with agencies ahead of the CMS on the most critical or sensitive balancing criteria facilitates selection of the optimal remedy.

Wrap -Up

- Mutual Interests
  - Streamline remedial action selection
- Face to Face Meeting
- List of Potential Cleanup Options
- Discussion on Remedial Technologies

Attachment 11
Preparing a White Paper about Sustainable Remediation

Attachment 11
Draft White Paper Outline

Title: *Integrating Sustainability Principles, Practices, and Metrics into Remediation Projects*

General Outline:
Executive Summary
Introduction and Scope
Background
Description and Current Status of Sustainability in Remediation
Sustainability Concepts and Practices in Remediation
A Vision for Sustainability
The Impediments and Barriers
Vignettes of Success
Summary, Conclusions, and Recommendations
Acknowledgements
References

Acronym List
Glossary

Figures, tables, and appendices will be included as needed.

Attachment 12
Applying Sustainability to Small Sites

Attachment 12
Applying Sustainability to Small Sites
Brainstorming Discussion

How can we apply sustainability to smaller sites?

- Categorize by function/business
- Scale
- Limit the number of impacts
- Use sensitivity modeling approach
- Stakeholder characteristics (diversity)
- Re-development opportunities
- Potential indoor air issues
- More state involvement (local) vs. federal agencies
- Funding availability low
- After categorizing, identify key technologies for those sites
- PRP knowledge
- Raise general awareness
- Will have to be driven by regulators or LSP
- If it becomes accepted practice of regulatory approval process (already happening in counties in California), leverage what is already being done
- Focus on low-hanging fruit
- Guidance to allow them to shut off with short-term monitoring
- Leverage small site evaluation in Europe
- Include section in white paper—need to include
- Different rules in different locations—air emissions
- Include/exclude sites with groundwater contamination?