

Clark University

**Clark Digital Commons**

---

International Institute for Indigenous Resource  
Management, Inc. (IIIRM)

MTA Fund Collection

---

12-23-2002

**Identifying the Burdens and Opportunities for Tribes and  
Communities in Federal Facility Cleanup Activities: Environmental  
Remediation Technology Assessment Matrix For Tribal and  
Community Decision-Makers**

International Institute for Indigenous Resource Management, Inc. (IIIRM)

Mervyn L. Tano

Jeanne M. Rubin

Kacey C. Denham

Follow this and additional works at: <https://commons.clarku.edu/iiirm>

---

**Identifying the Burdens and Opportunities for Tribes and Communities  
in Federal Facility Cleanup Activities:  
Environmental Remediation Technology Assessment Matrix  
For Tribal and Community Decision-Makers**

*Supported by a grant from the Citizens' Monitoring and Technical Assessment Fund*

Mervyn L. Tano, President  
Jeanne M. Rubin, General Counsel  
Kacey C. Denham, Research Assistant

**International Institute for Indigenous Resource Management**  
444 South Emerson Street, Denver, CO 80209  
www.iiirm.org

December 23, 2002

**ABSTRACT**

*The cleanup of this country's federal facilities can affect a wide range of tribal and community interests and concerns. The technologies now in use, or being proposed by the Department of Energy, Department of Defense and other federal agencies can affect tribal treaty protected fishing, hunting and other rights, affect air and water quality thereby requiring the tribe to bear the burden of increased environmental regulation. The International Institute for Indigenous Resource Management developed a tribal and community decision-maker's Environmental Remediation Technology Assessment Matrix that will permit tribes and communities to array technical information about environmental remediation technologies against a backdrop of tribal and community environmental, health and safety, cultural, religious, treaty and other concerns and interests. Ultimately, the matrix will allow tribes and communities to assess the impact of proposed technologies on the wide range of tribal and community interests and will promote more informed participation in federal facility cleanup activities.*

**PURPOSE**

The purpose of the project was to develop an analytical tool to help tribal and community decision-makers and stakeholders identify the wide range of tribal and community interests that may be affected by environmental remediation projects; assess the impact certain environmental technologies may have on this wide range of tribal and community interests; and participate in federal facility environmental restoration projects in a knowing and informed manner.

## I. INTRODUCTION

### BACKGROUND

The impact of government pollution is so severe and widespread that every region of the country is affected in some way. Federal agencies such as the Department of Energy (DOE), Department of Defense (DOD), Department of the Interior (DOI), Department of Agriculture (USDA) and National Aeronautics and Space Administration (NASA) contaminated more than 60,000 sites across the country.<sup>1</sup> The majority of federal facility contamination is the result of defining moments in history such as nuclear weapons production and manufacturing during WWII and the Cold War. According to a study by a task force of governors and attorneys general, the DOE alone produces 750,000 tons of hazardous waste each year. It is estimated that the DOD, the Nation's largest employer, has roughly 21,400 sites contaminated with fuels, solvents, industrial waste and unexploded ordnance. The production of missiles and bombs that occurred at weapons plants operated by the DOE is responsible for the contamination of 475 billion gallons of ground water. Contamination associated with the roughly 10,000 DOE sites includes radioactive waste, hazardous waste, mixed waste and fissile material.<sup>2</sup> Currently, the DOE and other federal agencies are in the process of implementing environmental remediation projects at several contaminated government sites. For example, the DOE is facing the largest (in acreage) and most expensive environmental cleanup project in United States history. This cleanup includes 113 installations including 10,000 sites within these installations in 30 states across the country<sup>3</sup> and will take roughly 75 years to complete with an estimated cost of \$147 billion.<sup>4</sup>

Indian lands and the toxic legacy of the DOE and other federal agencies are often inextricably tied. The DOE sited parts of the United States nuclear weapons complex in areas on or adjacent to Indian lands. In other instances, these facilities were sited on lands in which Indian tribes retain treaty-protected rights, or lands on which tribes have statutorily protected rights to exercise their religion. Several of the sites are, or will be, subjected to remediation in the future.

### UNDERPINNINGS OF TRIBAL PARTICIPATION – THE FEDERAL TRUST OBLIGATION

The obligation of the federal government to provide Indian tribes meaningful participation in federal facilities remediation activities affecting their interests derives from the trust obligation owed by the United States to American Indian tribes. This obligation originated in the course of dealings between the government and the Indians

---

<sup>1</sup> Armstrong, David. "The Nation's Dirty, Big Secret." [Online] *The Boston Globe*. 14 November 1999. <http://www.boston.com/globe/nation/packages/pollution/day1.htm> (11 June 2002).

<sup>2</sup> Armstrong, "http://www.boston.com/globe/nation/packages/pollution/day1.htm"

<sup>3</sup> Lapachin, Larry and Mervyn L. Tano. "Developing the Environmental Remediation Technology Matrix for Tribal Decision-Makers to Assess and Evaluate Tribal Implications and Opportunities Throughout the Department of Energy's Cleanup Activities." *International Institute for Indigenous Resource Management*. <http://www.iiirm.org/publications/pubs.htm> (11 June 2002).

<sup>4</sup> Armstrong, "http://www.boston.com/globe/nation/packages/pollution/day1.htm"

and is reflected in the treaties, agreements, and statutes pertaining to Indian tribes. In order to understand the federal trust obligation, one must understand the original sovereign status of Indian tribes, the course of dealing between the federal government and Indian tribes resulting in the conclusion of more than 800 treaties, and the nature of the promises embedded in those treaties.

### **Origins of the Trust Obligation**

The fiduciary relationship of the United States to Indian tribes is independent of any specific statute, treaty or agreement. The trust relationship between the federal government and Indian tribes originated in the course of dealings between the “discovering” European nations (later the original states and the United States) and the native Americans who occupied the continent. The interactions between these peoples resulted in the conclusion by this country of treaties and agreements recognizing the quasi-sovereign status of Indian tribes.

The sovereign status of Indian tribes was first addressed by the U. S. Supreme Court in *Cherokee Nation v. Georgia*.<sup>5</sup> In *Cherokee Nation* the Court found that the Tribe, though a “distinct political community” and thus a “state,” was neither a State of the United States nor a foreign state. Chief Justice Marshall concluded that Indian tribes “may, more correctly, perhaps, be denominated domestic dependent nations . . . in a state of pupilage” and that “their relation to the United States resembles that of a ward to his guardian.”<sup>6</sup> *Cherokee Nation* was the first judicial articulation of the fiduciary nature of the relationship between the United States and Indian tribes. Chief Justice Marshall’s subsequent decision in *Worcester v. Georgia*<sup>7</sup> reaffirmed the status of Indian tribes as self-governing entities without, however, elaborating on the specific obligations of the United States inherent in the guardian-ward relationship.

In *Worcester*, the Court invalidated a Georgia law, which, among other things, prohibited all white persons from residing in Cherokee territory without a license from the Governor. The case was brought by a missionary residing in Cherokee territory with the permission of the Tribe, but without a state license in violation of the Georgia law. The Court invalidated the Georgia law, finding that Cherokee Territory was subject to the control and dominion of the Cherokee Nation of Indians, and not within the territorial jurisdiction of Georgia. In reaching its decision, the Court addressed at length the course of dealing between Europeans (later Americans) and the Indian tribes that recognized the sovereignty of Indian tribes, and the nature of the ensuing relationship.

As recounted by the Court, prior to its “discovery” by Europeans, America was “inhabited by a distinct people, divided into separate nations, independent of each other and of the rest of the world, having institutions of their own, and governing themselves

---

<sup>5</sup> 30 U.S. (5 Pet.) 1 (1831).

<sup>6</sup> *Cherokee Nation*, 30 U.S. (5 Pet.) at 17

<sup>7</sup> 31 U.S. (6 Pet.) 515 (1832).

by their own laws.”<sup>8</sup> The Court dismissed the notion that inhabitants of either continent could have “rightful original claims of dominion over the inhabitants of the other, or over the lands they occupied; or that the discovery of either by the other should give the discoverer rights in the country discovered, which annulled the pre-existing rights of its ancient possessors.”<sup>9</sup> While the European nations found it expedient to agree among themselves that the nation “discovering” a particular territory enjoyed the sole right of acquiring the land and making settlements upon it, this principle “regulated the right given by discovery among the European discoverers; but could not affect the rights of those already in possession, either as aboriginal occupants, or as occupants by virtue of a discovery made before the memory of man.”<sup>10</sup> The relationship between the Europeans and the native Americans was determined in each instance by the particular government which asserted this preemptive privilege in a particular place, the United States eventually succeeding to the claims of Great Britain.<sup>11</sup>

Although the European nations had agreed in theory that discovery by one excluded all claims of the others, the extent of each nation’s discovery was the subject of “unceasing contest.”<sup>12</sup> As bloody conflicts arose among the European nations over territorial claims in America, the Indian nations took on new importance to the settlers, for they could be formidable enemies or effective friends. “Instead of rousing their resentments, by asserting claims to their lands, or to dominion over their persons, their alliance was sought by flattering professions, and purchased by rich presents. The English, the French, and the Spaniards, were equally competitors for their friendship and their aid.”<sup>13</sup> The English did not, however, attempt to interfere with the internal affairs or self-government of the Indians.<sup>14</sup> In 1763 the King of Great Britain issued a royal proclamation decreeing that Indian lands were owned by the Crown, reserved for the tribes under its “sovereignty, protection, and dominion” and forbidding the colonies to acquire such lands. The Indian nations were thus bound to the Crown as dependent allies, claiming the protection of a powerful friend and neighbor, and receiving the advantages of that protection without involving a surrender of their national character.”<sup>15</sup> When the Revolutionary War commenced, the Colonies, apprehensive that the Indian nations would join with the British army, did not assert dominion over them, but rather sought to secure and preserve their friendship. Three Indian departments were established “to treat with the Indians . . . in the name and on the behalf of the United Colonies, in order to preserve peace and friendship with the said Indians, and to prevent their taking any part in the present commotions.”<sup>16</sup>

---

<sup>8</sup> *Worcester*, 31 U.S. (6 Pet.) at 542-3.

<sup>9</sup> *Worcester*, 31 U.S. (6 Pet.) at 543.

<sup>10</sup> *Worcester*, 31 U.S. (6 Pet.) at 543-4.

<sup>11</sup> *Worcester*, 31 U.S. (6 Pet.) at 544.

<sup>12</sup> *Worcester*, 31 U.S. (6 Pet.) at 546.

<sup>13</sup> *Worcester*, 31 U.S. (6 Pet.) at 546.

<sup>14</sup> *Worcester*, 31 U.S. (6 Pet.) at 546.

<sup>15</sup> *Worcester*, 31 U.S. (6 Pet.) at 552.

<sup>16</sup> *Worcester*, 31 U.S. (6 Pet.) at 549.

Throughout the course of dealing between the Indian tribes and the succession of governments from the British Crown through the revolutionary United Colonies and eventually the United States, “the Indian nations had always been considered as distinct, independent political communities, retaining their original natural rights, as the undisputed possessors of the soil, from time immemorial.”<sup>17</sup> The Indian tribes were recognized as nations, and the law of nations is that a weaker power does not surrender its independence – its right to self-government – by associating with a stronger and taking its protection. A weak state may place itself under the protection of one more powerful without stripping itself of the right of government and ceasing to be a state.<sup>18</sup> At issue in *Worcester* was the sovereign status of the Cherokee Nation, not the extent of the trust obligations of the United States. Nevertheless, implicit in *Worcester* is the principle that the association of a weak state with a stronger one necessarily places obligations and responsibilities on the more powerful, protecting state.

The trust obligation of the United States is also embedded in the U.S. Constitution. Originally, Great Britain claimed for itself sovereignty over all Indian lands in the English colonies. As noted above, in 1763 the King issued a Royal Proclamation (the precursor of the federal Non-Intercourse Act) that decreed Indian lands were owned by the Crown and that no person or government could acquire such lands without the consent of the Crown. This policy reflected the practical need of the Crown to assert its control over the land and wealth of the colonies and to preserve peace among the colonists and the Indians. Notably, the 1763 Proclamation applied to all Indians without regard to the presence or absence of specific treaties or agreements. When the United States acquired sovereignty from Great Britain, it succeeded to all the incidents of the prior sovereign’s powers. The United States not only did not renounce the peculiar power and duty assumed by Great Britain over Indians, but endorsed it by specific reference in Article I of the Constitution, which authorizes Congress to regulate commerce with foreign nations, and among the several states, and with the Indian tribes.<sup>19</sup>

From the beginning, the Congress was a full partner in the establishment of the federal trust responsibility to Indians. Article III of the Northwest Ordinance of 1787, which was ratified by the first Congress assembled under the new Constitution in 1789,<sup>20</sup> declared:

The utmost good faith shall always be observed toward the Indians; their lands and property shall never be taken from them without their consent; and in their property, rights and liberty they shall never be invaded or disturbed, unless in just and lawful wars authorized by Congress; but laws founded in justice and humanity shall, from time to time, be made, for preventing wrongs being done to them, and for preserving peace and friendship with them.

---

<sup>17</sup> *Worcester*, 31 U.S. (6 Pet.) at 559.

<sup>18</sup> *Worcester*, 31 U.S. (6 Pet.) at 559-60.

<sup>19</sup> Constitution of the United States, Art. I, Sec. 8, cl. 3.

<sup>20</sup> 1 Stat. 50, 52.

In 1790, Congress enacted the Non-Intercourse Act<sup>21</sup> which itself established a fiduciary obligation on the part of the United States to protect Indian property rights.

### **Judicial Interpretation of the Trust Obligation**

As judicial interpretation of the federal trust obligation developed, the courts continued to look at the course of history in which Indian tribes concluded treaties of alliance or—after military conquest—peace and reconciliation with the United States. In virtually all these treaties, the United States promised to extend its protection to the tribes. Consequently, the trust responsibility to Indian tribes has its roots for the most part in solemn contracts and agreements with the tribes. The tribes ceded vast acreages of land and concluded conflicts on the basis of the agreement of the United States to protect them from persons who might try to take advantage of their weakened position. No comparable duty is owed to other United States citizens.

A comprehensive review of judicial interpretation of the federal trust obligation to Indian tribes is beyond the scope of this report. However, a few cases that help define the scope of that obligation are summarized below. Although the U.S. Congress has broad powers over Indian tribes, its actions on behalf of Indians are subject to constitutional limitations. In *Delaware Tribal Council v. Weeks*,<sup>22</sup> for example, the Court held that the trust responsibility is subject to due process limitations. The case stands for the proposition that the Congress is not free to legislate with respect to Indians in any manner it chooses; rather, Congressional action with respect to Indians is subject to judicial review and will be sustained only so long as it can be “tied rationally to the fulfillment of Congress’ unique obligation toward the Indians.”

Other opinions shed further light on what is meant by the “unique obligation toward the Indians.” In *Morton v. Ruiz*,<sup>23</sup> the Court, in holding that the Bureau of Indian Affairs erred in excluding a certain category of Indians from the benefits of its welfare program spoke of the “overriding duty of our Federal Government to deal fairly with Indians.” This statement appears as part of the procedural rights of Indians, and in this connection, the Court cited *Seminole Nation v. United State*,<sup>24</sup> which says governmental action must be judged by the “strictest fiduciary standards.”

The “unique obligation” mentioned in *Weeks* and the “overriding duty” of fairness discussed in *Ruiz* exist apart from any specific statute, treaty or agreement, and impose substantive constraints on the Congress and the executive branch. These decisions reinforce the principle that the government’s trust responsibility to Indian tribes has an independent legal basis and is not limited to the specific language of statutes, treaties and agreements. At the same time, the content of the trust obligation—apart from specific

---

<sup>21</sup> 1 Stat. 137, 138, now codified as 25 U.S.C. §177.

<sup>22</sup> 430 U.S. 73 (1977).

<sup>23</sup> 415 U.S. 199, 236 (1977).

<sup>24</sup> 316 U.S. 286, 296 (1942).

statutes, treaties and agreements—is limited to dealing fairly with Indian tribes. The standard of fairness is necessarily vague and allows considerable room for discretion, but these independently based duties do not stand alone. They must be read together with a host of statutory and treaty provisions designed to protect tribal interests.

The notions of the “unique obligations” and “overriding duty” of fairness form a backdrop for the construction and interpretation of the statutes, treaties and agreements respecting Indian tribes. This means that provisions for the benefit of Indians must be read to give full effect to their protective purposes and also must be given a broad construction consistent with the trust relationship between the government and the Indians.

### **Recent Executive Branch Policies**

In recognition of its unique relationship with Indian tribes, the Executive Branch has issued policy directives on implementation of its trust responsibility to Indian tribes. These directives have taken the form of Executive Orders and memoranda from the White House, and formal policy statements from the executive departments. A consistent theme in all of these directives is the requirement for meaningful tribal participation in federal programs and policies that affect tribal resources and interests.

### **Presidential Directives**

On April 29, 1994, President Clinton issued a memorandum to all Executive Departments and Agencies on “Government-to-Government Relations with Native American Tribal Governments.”<sup>25</sup> The memorandum reaffirms the unique legal relationship between the United States and Native American Tribal governments and outlines principles for all executive departments and agencies to follow in their interactions with tribal governments. The purpose of the memorandum is to clarify the federal responsibility to deal with federally-recognized Indian tribes on a government-to-government basis, and insure that tribes’ sovereign rights of self-government are fully respected. It calls upon all executive departments to consult with federally recognized tribal governments prior to taking actions that affect them; to assess the impact of their plans, projects, programs, and activities on tribal trust resources and assure that tribal government rights and concerns are considered during the development of such plans, projects and activities; and to remove any procedural impediments to working directly and effectively with tribal governments on activities that affect the trust property and/or governmental rights of the tribes.<sup>26</sup>

On May 24, 1996, President Clinton issued Executive Order 13007<sup>27</sup> designed to protect and preserve Indian religious practices by requiring federal agencies to accommodate

---

<sup>25</sup> William Clinton. “Government-to-Government Relations with Native American Tribal Governments,” Memorandum, April 29, 1994, 59 *Fed. Reg.* 22951, 1994 Westlaw 163120 (Pres.).

<sup>26</sup> Clinton. “Government-to-Government Relations with Native American Tribal Governments.”

<sup>27</sup> William Clinton. “Indian Sacred Sites,” Executive Order 13007, May 24, 1996, 61 *Fed. Reg.* 26771, 1996 Westlaw 285380 (Pres.).



access to and ceremonial use of Indian sacred sites and avoid adversely affecting the physical integrity of such sites. The Executive Order recognizes the importance of tribal government participation by expressly requiring compliance with Executive memorandum of April 29, 1994 (“Government-to-Government Relations with Native American Tribal Governments”). In addition, it mandates a report to the President from each executive branch agency with responsibility for the management of federal lands addressing, among other things, procedures implemented or proposed to facilitate consultation with appropriate Indian tribes and religious leaders and the expeditious resolution of disputes relating to agency action on federal lands that may adversely affect access to, ceremonial use of, or the physical integrity of sacred sites.

Executive Order 13175 (“Consultation and Coordination with Indian Tribal Governments”),<sup>28</sup> issued by President Clinton on November 6, 2000, reaffirms the responsibility of the United States government for continued collaboration and consultation with tribal governments in the development of federal policies that have tribal implications, to strengthen the government-to-government relationship between the federal government and Indian tribes, and reduce the imposition of un-funded mandates upon Indian tribes. Again, meaningful tribal participation in agency decision-making is a linchpin of the policy. The Executive Order provides that when undertaking to formulate and implement policies that have tribal implications, agencies will encourage Indian tribes to develop their own policies to achieve program objectives and, where possible, defer to Indian tribes to establish standards.<sup>29</sup> It also mandates that each agency will have “an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.”<sup>30</sup> On issues relating to tribal self-government, tribal trust resources, or Indian tribal treaty and other rights, each agency is mandated to “explore and where appropriate, use consensual mechanisms for developing regulations, including negotiated rulemaking.”<sup>31</sup>

### **Executive Department Indian Policies**

In 1984, the Environmental Protection Agency (EPA) became the first federal agency to adopt a formal Indian Policy. That policy acknowledged tribal governments as sovereign entities with primary authority and responsibility for the reservation populace and affirmed the Agency’s trust responsibility to protect the environmental interests of Indian tribes. The Policy pledges EPA’s support to assist Indian Tribes assume regulatory and program responsibilities for reservation lands, and to remove existing legal and procedural impediments to working directly and effectively with Indian tribes. By Memorandum dated July 11, 2001, EPA Administrator Christine Whitman reaffirmed the Agency’s commitment to the Indian Policy and the principles therein to build a stronger partnership with Tribal governments to protect the human health and environment of Indian communities.

---

<sup>28</sup> William Clinton. “Consultation and Coordination with Indian Tribal Governments,” Executive Order 13175, November 6, 2000, 65 *Fed. Reg.* 67249, 2000 Westlaw 1675460 (Pres.).

<sup>29</sup> Clinton. “Consultation and Coordination with Indian Tribal Governments,” Sec. 3.

<sup>30</sup> Clinton. “Consultation and Coordination with Indian Tribal Governments,” Sec. 5(c).

<sup>31</sup> Clinton. “Consultation and Coordination with Indian Tribal Governments,” Sec. 5(d).

The Department of Energy has also adopted an American Indian & Alaska Native Tribal Government Policy (“DOE Indian Policy”),<sup>32</sup> which sets forth the principles to be followed by DOE to ensure an effective implementation of a government-to-government relationship with American Indian and Alaska Native tribal governments. The DOE Indian Policy provides direction to the Department regarding fulfillment of its trust obligations and other responsibilities, noting in particular the trust responsibility of the United States to protect tribal sovereignty and self-determination, tribal lands, assets, resources, and treaty and other federally recognized and reserved rights. The DOE Indian Policy explicitly recognizes that some tribes possess treaty-protected and other federally recognized rights to resources and resource interests located within reservation boundaries, aboriginal territories, and outside reservation and jurisdictional boundaries. The DOE Indian Policy commits the Department to consult with tribes to assure rights and concerns are considered prior to taking actions, making decisions or implementing programs; consult with tribes about potential impacts of proposed DOE actions on cultural resources or religious concerns to avoid unnecessary interference with traditional religious practices, and remove impediments to working directly and effectively with tribal governments on DOE programs.

In 1998, the Department of Defense (DOD) adopted an American Indian and Alaska Native Policy<sup>33</sup> for interacting and working with federally-recognized tribes. The policy supports tribal self-governance and government-to-government relations between the federal government and the tribes. Although the policy is intended to provide general guidance, it is noteworthy in that it exhorts DOD personnel to consider the unique qualities of individual tribes when applying those principles. Among other things, the DOD Indian Policy recognizes the “unique and distinctive political relationship [that] exists between the United States and the tribes that mandates that, whenever DOD actions may have the potential to significantly affect protected tribal resources, tribal rights, or Indian lands, DOD must provide affected tribes an opportunity to participate in the decision-making process that will ensure these tribal interests are given due consideration in a manner consistent with tribal sovereign authority.”<sup>34</sup> The policy specifically acknowledges the cultural and religious significance to Indian tribes of certain natural resources and properties by providing for the conservation of protected tribal resources on DOD lands; enhancing tribal capabilities to effectively protect and manage natural and cultural tribal trust resources whenever DOD actions have the potential to significantly affect them, accommodating tribal member access to sacred off-reservation treaty sites located on military installations, and developing tribal specific protocols to protect tribal information regarding protected tribal resources.

The federal trust obligation to Indian tribes requires that tribes be given a meaningful voice in the remediation of federal facilities that will impact tribal resources and interests.

---

<sup>32</sup> U.S. Department of Energy. “American Indian & Alaska Native Tribal Government Policy.” *Office of Congressional & Intergovernmental Affairs*. Washington, DC. October 2000.

<sup>33</sup> U.S. Department of Defense. “American Indian and Alaska Native Policy.” October 20, 1998. <http://www.denix.osd.mil/denix/Public/Native/Outreach/policy.html>. (December 2, 2002).

<sup>34</sup> U.S. Department of Defense. “American Indian and Alaska Native Policy,” at Sec. III.

Translating the principle of the trust obligation into concrete agency actions that result in meaningful and effective tribal participation has often posed a challenge for federal personnel.

## **TRIBAL AND COMMUNITY PARTICIPATION IN FEDERAL FACILITIES' ENVIRONMENTAL REMEDIATION PROJECTS**

### **The Federal Facilities Environmental Restoration Dialogue Committee Recommendations**

The Federal Facilities Environmental Restoration Dialogue Committee (FFERDC) was an advisory committee federally chartered by the U.S. Environmental Protection Agency. The FFERDC also included members from the U.S. Departments of Agriculture, Defense (and its Military Services), Energy, and the Interior, the National Oceanic and Atmospheric Administration, and the Agency for Toxic Substances and Disease Registry; state, tribal, and local governments; and numerous national, regional, and local environmental, community, environmental justice, and labor organizations.

The FFERDC's 1993 Interim Report and 1996 Final Report both stressed the importance of adequate and meaningful stakeholder involvement in all aspects of federal facilities cleanup. But the FFERDC also recognized that such cleanup efforts would place significant demands on the regulatory, administrative, and management infrastructure of Indian tribes. The FFERDC cited DOE and EPA policies that acknowledge that treaties, statutes, and federal Indian policy obligate those agencies to consult and work on cleanup issues with Indian tribes on a government-to-government basis and recognized that these obligations extend to all agencies of the federal government and that federal agencies should negotiate agreements with affected Indian tribes to build tribal capacity.

### **Federal Strategies**

The federal government has adopted various strategies to obtain tribal and community participation in federal facility environmental remediation projects through the utilization of boards, cooperative agreements and national advisory panels. In the early 1990's, the DOE established local site-specific advisory boards (SSABs) at twelve DOE environmental remediation sites across the country including Fernald, Hanford, Idaho, Los Alamos, Monticello, Nevada, Oak Ridge, Pantex, Paducah, Rocky Flats, Sandia, and Savannah River.<sup>35</sup> The effort reflected the intent of DOE to involve community stakeholders in decisions that would affect them and their communities. Therefore, the local site boards comprise primarily people who are directly affected by site cleanup activities. Board members communicate to DOE the diverse community views on issues such as future use, economic development and cleanup levels. In addition, the SSABs keep the surrounding public informed on key issues and make technology

---

<sup>35</sup> U.S. Department of Energy: Office of Environmental Management. "Site Specific Advisory Boards." *U.S. Department of Energy: Office of Environmental Management*. 13 August 2001. <http://www.em.doe.gov/Public/ssab/brochure.html> (11 June 2002).

recommendations to the DOE. The Department of Defense created restoration advisory boards (RABs) that are similar to the DOE's SSABs. The RAB is composed of representatives from DOD, EPA, state government agencies, tribal governments and local community members. A properly functioning RAB will provide a forum where representatives from the installation, EPA, government and community can discuss the issues pertaining to environmental remediation projects.<sup>36</sup>

Another mechanism federal agencies use to encourage tribal and community participation in cleanup decisions and site-activities is to enter into cooperative agreements with the tribes and communities. The federal agency involved in the cooperative agreement provides funds to support various activities. For example, cooperative agreements between the DOE and tribes have allowed tribes to establish tribal environmental programs for particular sites and facilities, hire tribal staff and scientific experts to inform the tribe of cleanup efforts, examine cleanup efforts at the site, comment on the cleanup activities and preserve tribal cultural resources located at the sites.<sup>37</sup>

Lastly, federal agencies provide and participate in national advisory panels as another means to facilitate tribal and community participation. National advisory panels are composed of a variety of individuals from different backgrounds, such as technical advisors, government officials and lay citizens that meet together to exchange information and knowledge regarding site cleanup activities. The U.S. Department of Energy Office of Environmental Management formed the State and Tribal Government Working Group (STGWG) to help ensure DOE facilities are operated and cleaned up in accordance with Tribal rights, federal and state laws and regulations, and in a manner that protects human health, safety and the environment. STGWG originated in April 1989 with a letter written by ten governors addressed to then-Secretary of Energy Watkins expressing their concerns regarding the management, cleanup, and disposal of radioactive and hazardous wastes at DOE facilities within or adjacent to their state boundaries. Secretary Watkins responded in May 1989 with the formation of STGWG. The first meeting was held in June 1989 including representatives from various states, tribes and associations.<sup>38</sup> STGWG members represent the affected states of Colorado, Nevada, South Carolina, Idaho, Ohio, Tennessee, Missouri and Oregon<sup>39</sup> and tribes such as the Shoshone-Bannock, Yakama Indian Nation, Confederated Tribes of the Umatilla Indian Reservation, Seneca Indian Nation, Nez Perce Tribe, Pueblo de San Ildefonso, Isleta

---

<sup>36</sup> Defense Technical Information Center: Information for the Defense Community. "Restoration Advisory Boards." *Defense Technical Information Center: Information for the Defense Community*. May 2002. <http://www.dtic.mil/Envirodad/derpreport96/vol2/rab/rab.html> (12 June 2002).

<sup>37</sup> U.S. Department of Energy: Office of Environmental Management. "EM Tribal Programs/Special Initiatives." *U.S. Department of Energy: Office of Environmental Management*. 23 July 2001. <http://www.em.doe.gov/Public/tribal/initiatives.html> (12 June 2002).

<sup>38</sup> U.S. Department of Energy: Office of Environmental Management. "STGWG History." *U.S. Department of Energy: Office of Environmental Management*. 27 September 2000. <http://www.em.doe.gov/stgwg/history.html> (12 June 2002).

<sup>39</sup> U.S. Department of Energy: Office of Environmental Management. "State Participation." *U.S. Department of Defense: Office of Environmental Management*. 3 May 2001. <http://www.em.doe.gov/stgwg/statpart.html> (13 June 2002).

Pueblo, Santa Clara Pueblo and the Navajo Nation.<sup>40</sup> Organizations such as the Colorado Attorney General, National Governors Association and National Conference of State Legislatures are also participating members of STGWG.<sup>41</sup> The DOE is funding STGWG support and participation through a cooperative agreement with the National Conference of State Legislatures.

Another national advisory panel, the National Environmental Justice Advisory Council (NEJAC) of the U.S. Environmental Protection Agency, was established by charter on September 30, 1993. The purpose of NEJAC is to provide independent advice, consultation, and recommendations to the Administrator of the EPA on matters related to environmental justice. Membership in NEJAC comprises individuals from academia, community groups, environmental organizations, state and local governments, tribal governments, non-government organizations, and industry.<sup>42</sup> The Defense Environmental Response Task Force (DERTF) under the Office of the Deputy Under Secretary of Defense, provides yet another example. The DERTF examines environmental issues related to the restoration and reuse of closing military installations and identifies and recommends ways to expedite and improve environmental restoration at those installations. Membership in DERTF includes representatives from DOD, EPA, the Department of Justice, the General Services Administration, the National Governors' Association, the National Association of Attorneys General, and various public interest groups.<sup>43</sup>

### **Tribal and Community Disagreement with Federal Agencies' Environmental Remediation Decisions, Including the Choice of Remediation Technologies**

Indian tribes and other communities have not always agreed with the environmental remediation decisions, including the proposed remediation technologies, of the federal agencies. During the Second World War, the DOE was involved in plutonium production to supply America's first nuclear weapons in an area known as the Hanford Site located near Richland, Washington. All weapons production at Hanford ceased in the late 1980's and the Site is now engaged in the world's largest environmental cleanup project. This cleanup project concerns many governments, interest groups, and private citizens<sup>44</sup> including Tribal governments such as the Confederated Tribes of the Umatilla

---

<sup>40</sup> U.S. Department of Energy: Office of Environmental Management. "Tribal Participation." *U.S. Department of Defense: Office of Environmental Management*. 7 September 2001. <http://www.em.doe.gov/stgwg/tribpart.html> (13 June 2002).

<sup>41</sup> U.S. Department of Energy: Office of Environmental Management. "Organizations." *U.S. Department of Defense: Office of Environmental Management*. 8 November 1999. <http://www.em.doe.gov/stgwg/orgs.html> (13 June 2002).

<sup>42</sup> U.S. Environmental Protection Agency. "National Environmental Justice Advisory Council Overview." *U.S. Environmental Protection Agency*. 27 April 2000. <http://es.epa.gov/oeca/main/ej/nejac/over1.html> (13 June 2002).

<sup>43</sup> U.S. Department of Defense. "Defense Environmental Response Task Force." *Department of Defense Environmental Cleanup*. [http://www.dtic.mil/enviroDOD/derpreport95/vol\\_1/dertf.html](http://www.dtic.mil/enviroDOD/derpreport95/vol_1/dertf.html) (12 June 2002).

<sup>44</sup> U.S. Department of Energy. "Program Summary, Mission and Goals." *U.S. Department of Energy*. 9 July 2001. <http://www.hanford.gov/doe/inp/progsum.htm> (12 June 2002).

Indian Reservation, The Nez Perce Tribe, Wanapum and the Yakama Indian Nation.<sup>45</sup> The Treaties of 1855 reserved the rights of the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, and the Yakama Indian Nation to use land now part of the Hanford Site for economic and subsistence fishing, hunting, gathering and grazing cattle.<sup>46</sup> The Wanapum, who still live adjacent to the Site, are a non-federally recognized tribe that has strong cultural ties to the land within the Hanford site. Early DOE cleanup efforts failed to communicate with the tribes regarding tribal interests and concerns related to remediation efforts. Environmental remediation technologies were chosen and implemented by the DOE without the consideration of tribal interests or the support of tribal communities. As a result, the technologies adversely affected tribal burial sites, natural vegetation and important native cultural resources.<sup>47</sup>

Remediation of the Umatilla Army Depot presents another example of tribal disagreement with a federal agency's choice of an environmental remediation technology. The DOD proposed a chemical weapons incinerator for remediation of the Umatilla Army Depot Site located in Oregon on land that was ceded to the U.S. in 1855 by the Confederated Tribes of the Umatilla Indian Reservation in exchange for treaty rights. At the time of the proposal, then-Chairman of the Board of Trustees of the Confederated Tribes of the Umatilla Indian Reservation made the following statement regarding incineration:

The Umatilla Army Depot is located within our Tribe's ceded lands, an area within which our tribal members retain treaty rights, including the right to fish and to gather plants and medicines. Resources, such as our Wanaket Wildlife Refuge, located a few miles east of the town of Umatilla, are directly threatened by the incinerators...The Army has failed to consult with us on a government-to-government basis about its incinerator plans...This is unacceptable. The Army cannot pretend to protect us if it remains ignorant of what our interests are.<sup>48</sup>

Prior to selecting proposed technologies, the DOD failed to consult with the Confederated Tribes of the Umatilla Indian Reservation to understand their interests and concerns regarding remediation of the Umatilla Army Depot Site. Consequently, the DOD proposed incineration as a cleanup method, which the tribes adamantly opposed arguing that incineration threatened tribal treaty rights, health, and the environment.

---

<sup>45</sup> U.S. Department of Energy. "Indian Nations Program: Tribes Involved with the Program." *U.S. Department of Energy*. 9 July 2001. <http://www.hanford.gov/doe/inp/tribes.htm> (12 June 2002).

<sup>46</sup> Oregon Office of Energy. "Oregon Native American Interests at Hanford." *Oregon Office of Energy*. 9 January 2002. <http://www.energy.state.or.us/nucsaf/native.htm> (12 June 2002).

<sup>47</sup> Nez Perce. "The Basis for the Nez Perce Tribe Involvement at the Hanford Nuclear Reservation." *Nez Perce*. <http://www.nezperce.org/~erwm/hanfordinfo.html> (13 June 2002).

<sup>48</sup> Chemical Weapons Working Group. "Oregon." *Chemical Weapons Working Group*. <http://www.cwwg.org/Oregon.html> (11 June 2002).

## **Federal Agencies' Efforts to Include Tribal and Community Input in Environmental Remediation Technology Development and Deployment**

Federal agencies have made attempts to obtain tribal participation in the development and deployment of environmental remediation technologies. One such attempt was made by the Department of Energy under the Office of Science and Technology with the establishment of the Community Leaders Network (CLN). Since dissolved, it was the intent of the CLN to enhance technology development and deployment activities through stakeholder involvement. Members of CLN included individuals representing public interest and civic groups; business; education interests and local, state and tribal governments. CLN members reviewed various DOE proposed technologies and identified relevant citizen issues and concerns that needed to be addressed by the DOE prior to implementation.<sup>49</sup>

## **Federal Agencies Efforts to Involve Tribes and Communities in Federal Facility Cleanup Projects is Still Wanting**

Although the Department of Energy, Department of Defense and other federal agencies have made efforts to include tribal and community involvement in environmental remediation projects and environmental technology decisions, the way in which this is accomplished is still wanting. A major impediment for Indian tribes and other communities is that they usually do not have the technical resources to assess tribal and community implications resulting from federal facility cleanup activities. To participate knowingly in cleanup decisions, tribes and communities must have a context for the massive amounts of technical information that the federal facilities disseminate about cleanup activities. Tribal and community decision-makers will benefit significantly from an analytical tool that arrays technical information about environmental remediation technologies against a backdrop of tribal and community environmental, health and safety, cultural, religious, treaty and other concerns and interests. The International Institute for Indigenous Resource Management developed just such a tool: the Environmental Remediation Technology Matrix.

## **II. DISCUSSION**

### **ENVIRONMENTAL REMEDIATION TECHNOLOGY MATRIX: WHAT IS IT?**

The Environmental Remediation Technology Matrix is an analytical tool designed to assist tribes and communities with limited technical resources assess proposed environmental remediation technologies against the backdrop of environmental, social and cultural impacts including regulatory capability; health and safety; environment; future land-use; economic conditions; education and research; environmental justice;

---

<sup>49</sup> Initiatives Online In Environmental Technology Investment. "Community Leaders and OST Collaborate." *Initiatives Online In Environmental Technology Investment*. Volume 3, April 1996. <http://www.wpi.org/Initiatives/init/apr96/leaders.html> (12 June 2002).

religion and culture; tribal sovereignty and treaty rights; and the federal/tribal trust relationship and federal Indian policies. In its simplest terms, the matrix arrays the environmental remediation technology choices on one axis and the tribal interests on the other axis. Each cell will then assess the impact of a particular technology on a particular subset of tribal interests. For example, the assessment of a particular remediation technology may reveal potentially detrimental impacts on culturally significant resources, such as traditional foods and medicines. Conversely, the deployment of certain technologies may present the community with educational, employment, business, and other economic development opportunities.

The matrix facilitates more knowledgeable tribal and community participation in federal facilities environmental cleanup decision-making by establishing the context for the massive amounts of technical information that federal agencies disseminate regarding cleanup activities and a framework for setting out the tribal responses thereto.

### **III. PROJECT HISTORY**

This project had its beginning approximately ten years ago. At that time, Mervyn L. Tano, now president of the International Institute for Indigenous Resource Management was a member of the DOE Office of Science and Technology's Community Leaders Network (CLN). The CLN was an attempt by the DOE to get tribal and community input in decisions relating to the development and deployment of environmental remediation technologies. The Office of Science and Technology was then proposing the use of the Technology Investment Decision Model ("Gates Model") to manage technology development and to link technology development activities with cleanup operations. The Gates Model identified six research and development stages from basic research through implementation of a technology. At each stage, specific criteria, requirements, and deliverables form a common basis for technology assessment. Each stage is separated by "gates"—decision points at which projects are evaluated for funding of the next stage. This "stage-gate" process was meant to provide for evaluation of projects at all stages of development by end users and a wide range of state, local, and tribal governments and other stakeholders.<sup>50</sup>

The Gates Model worked well if the various stakeholders were aware of the vast universe of interests at stake, and were knowledgeable as to how these interests could be affected at any of the stages of the technology development process. However, there was nothing inherent within the Gates Model that assured or fostered such awareness and knowledge.

Realizing the Gates Model, absent additional analytical tools, excluded effective tribal and community participation, and concerned about the lack of early tribal and community involvement with the development of environmental remediation technologies, Mr. Tano devised a set of principles that were meant to capture the spirit of the tribal and

---

<sup>50</sup> Peer Review in Environmental Technology Development Programs, National Academy Press, <http://www.nap.edu/openbook/0309063388/html>, (1999), p.97.



community interests in the technology development process. Some of these guiding principles were seemingly self-evident, such as discontinuing technologies that are not needed or that create more waste than they eliminate, and supporting the development of technologies that create a final waste form over those that require a series of interim treatments or waste forms. Other, more complex, social and legal principles underlying technology development process were identified.

The impacts these social and legal principles engendered were first identified, described, and categorized in the paper “Environmental Remediation Technology Matrix for Tribal Decision-Makers.”<sup>51</sup> The implication categories included environmental regulation; emergency response; economic opportunities; education and research; treaty rights; trust relationship and DOE Indian policy; religious and cultural resources. In addition, the paper outlined the initial framework of the matrix that called for proposed remediation technologies to be arrayed along the vertical axis and tribal and community implication categories along the horizontal axis. The Citizens’ Monitoring and Technical Assessment Fund administered by Resolve provided an opportunity to develop the initial concept and rudimentary matrix into a more comprehensive and more useful tool and to expand its scope to include non-Indian communities. The research yielded information on representative examples of environmental remediation technologies that was then condensed into a set of technology summaries. An extensive glossary of scientific terminology was compiled to assist the lay reader.<sup>52</sup> The original implication categories were refined and new ones were added to the matrix in order to reflect more thoroughly the interests and concerns of tribes and communities. Finally, a series of questions was developed to guide the communities and their decision-makers through the process of identifying their concerns and interests potentially impacted by each remediation technology proposed for local cleanup.

#### **ENVIRONMENTAL REMEDIATION TECHNOLOGY MATRIX: HOW DOES IT WORK?**

The matrix arrays the remediation technologies being considered by federal agencies for facility decommissioning and waste characterization, retrieval, treatment and containment/stabilization along the vertical axis, and the implications for tribes and communities from such technologies along the horizontal axis. In order to inform and enhance the understanding of tribal and community members regarding specific technologies, the Institute has developed a brief, yet thorough summary of each of the proposed technologies that is easily understood by a lay audience. Each summary includes information on:

- ? Whether the remediation technology is in situ, ex situ, or both.

---

<sup>51</sup> Baptiste, Kristie L., TallBear, Kimberly and Mervyn L. Tano. “Environmental Remediation Technology Matrix for Tribal Decision-Makers.” *International Institute for Indigenous Resource Management*. <http://www.iiirm.org/publications/pubs.htm> (12 June 2002).

<sup>52</sup> Lapachin, Larry and Mervyn L. Tano. “Developing the ‘Environmental Remediation Technology Matrix for Tribal Decision-Makers’ to Assess and Evaluate Tribal Implications and Opportunities Throughout the Department of Energy’s Cleanup Activities.” *International Institute for Indigenous Resource Management*. <http://www.iiirm.org/publications/pubs.htm> (12 June 2002).

- ? Whether the technology treats contaminants in the soil, sediment, sludges, or water.
- ? A concise description of the remediation technology.
- ? Optimal situations in which to deploy the remediation technology.
- ? Unfavorable situations in which to deploy the remediation technology.
- ? The contaminants treated, removed or destroyed.
- ? Possible tribal and/or community implications.

Within the technology summaries, the section committed to possible tribal and/or community implications provides a detailed account of potential implications to consider when deploying that particular technology. It will serve as a useful reference guide for tribal and community decision-makers when completing the implication category questions. In addition to the technology summaries, the Institute has provided a glossary that defines potentially difficult scientific terminology. The technology summaries and glossary are attached hereto as Appendices 1 and 2. Finally, the horizontal axis includes the implications categories for tribes and communities from such technologies. Implications for tribes and communities include both burdens and opportunities resulting from the implementation of remediation technologies. The implications have been identified and organized into the following ten categories:

- ? Regulatory Capability
- ? Health and Safety
- ? Environment
- ? Future Land-Use
- ? Economic Conditions
- ? Education and Research
- ? Environmental Justice
- ? Religion and Culture
- ? Tribal Sovereignty and Treaty Rights
- ? Federal/Tribal Trust Relationship and Federal Indian Policies

This report includes a brief overview of how each implication category is potentially impacted by remediation processes. Questions designed to elicit specific information on how each proposed technology impacts each implication category are included in the Matrix (Figure 1, below) and in Appendix 3. It is through the discussion of these questions with tribal (or community) members representing a broad range of tribal (or community) interests that each proposed technology is assessed based on the issues of importance to the tribe (community).

The sample Environmental Remediation Technology Matrix at Figure 1, below, has been completed for the proposed remediation technology “AIR SPARGING” to illustrate the various components of the Matrix framework.

In actual field use of the Matrix, tribal and community decision-makers will include within their assessment each technology potentially applicable in their situation,

subjecting each to the same ten sets of categorical questions. As each set of questions is discussed, the community will develop a written assessment of the impacts of each proposed technology on each implication category. The Matrix includes space for a summary “impact narrative” under each impact category. These summary impact narratives are a condensed version of the information derived from the community discussion of the implication category questions and will provide a quick and easy reference for tribal and community leaders implementing the Matrix as a decision-making tool.

**Figure 1: ENVIRONMENTAL REMEDIATION TECHNOLOGY MATRIX (Air Sparging)**

Proposed Environmental Remediation Technologies	Regulatory Capability	Health and Safety	Environment	Future Land-Use	Economic Conditions	Education and Research	Environmental Justice	Religion and Culture	Tribal Sovereignty and Treaty Rights	Federal/Tribal Trust Relationship and Federal Indian Policies
<p>AIR SPARGING</p> <p>In situ – groundwater</p> <p><i>Summary:</i> The air sparging process injects air and/or other gases directly into the groundwater to remove contaminants. The air sparging system uses vertical wells and often a compressor to introduce pressurized air below the surface. The air increases the subsurface oxygen levels and helps remove the contaminants through volatilization. During the volatilization process, the contaminants dissolved in the groundwater are changed into a vaporized phase. The vaporized contaminants will move upward from the groundwater and toward the surface. The air sparging system uses vertical extraction wells to “capture” the volatilized contaminants. Often, an additional remediation technology, a soil vapor extraction system, is used in conjunction with the air sparging remediation technology to remove vaporized contaminants from the subsurface. The extracted vapors may require additional treatment to meet air emission standards (NRC, 1999). The increased subsurface oxygen levels also dissolve in the groundwater enhancing bioremediation, a process that detoxifies, or breaks down, certain contaminants (EPA, 1996). Biosparging is sometimes</p>	<p>What, if any, process residuals, or by-products, are associated with the implementation of the technology?</p> <p>Through what media will the process residuals travel, therefore affect (groundwater, soil, etc.)?</p> <p>To what extent will the tribal regulatory regime have to be established, expanded, or enhanced in order to accommodate the technology and the associated process residuals?</p> <p>What specific regulations have to be established, expanded or enhanced?</p> <p>How much will it cost to establish, or improve Tribal regulatory capacity?</p> <p>How long will it</p>	<p>How will the technology address site contamination?</p> <p>What, if any, is the possibility of an accidental release?</p> <p>What, if any, tribal emergency procedures are needed in order to prevent, alert and address a harmful accidental release?</p> <p>What is the cost of developing and implementing the needed emergency response procedures?</p> <p>Will the technology require the transportation of wastes?</p> <p>If so, how will the wastes be transported?</p> <p>What is the proposed transportation route?</p>	<p>What, if any, affects will the technology have on natural resources including: Air Soil Surface water Groundwater Plants Animals Fish?</p> <p>What affects, if any, will the technology have on the sensory attributes of surrounding areas such as sound, smell and visual aesthetics?</p> <p>To what extent can the technology restore current environmental damages?</p> <p>To what extent can the technology create additional environmental damages?</p> <p>Does the technology provide some degree of reversibility in the event that geological and climatic changes and human disruption require</p>	<p>Considering contamination levels, what, if any, future land-use options are available after the implementation of the technology: Residential Business District Agriculture Industrial Open Space Manicured Parks?</p> <p>What, if any, land use restrictions and prohibitions are associated with the technology?</p> <p>If there are land use restrictions and prohibitions, how long will they be in place and what areas are affected?</p> <p>Are the future land-use option/s associated with the technology acceptable to the tribe, or community?</p> <p>If applicable, what opportunities, if any, will the technology have to restore on-site facilities?</p>	<p>What job opportunities, if any, will the technology provide to tribal and local community members?</p> <p>How many tribal and local community members can expect employment at any given time?</p> <p>What is the expected duration of employment?</p> <p>What, if any, profitable opportunities are available to the tribe and community through technology implementation?</p> <p>What is the possibility of manufacturing the technology, or components of the technology, in Indian Country?</p> <p>Can the technology be installed and/or operated by Indian/community owned businesses?</p> <p>What external costs, if any, are</p>	<p>What opportunities, if any, are available to collaborate with the federal agency and contractor associated with the technology to provide for, or assist in developing training and technical assistance programs to establish or improve the capability of environmental justice organizations, Historically Black Colleges and Universities and tribal colleges to conduct health, scientific, technical, policy and regulatory analyses and studies?</p> <p>What opportunities, if any, are available for Tribal/community participation in the actual research, development and/or demonstration of the technology?</p> <p>What opportunities, if any, are available to establish education programs including internships,</p>	<p>What opportunities, if any, are available to collaborate with the federal agency and contractor associated with the technology to provide funds for retaining independent technical consultants to advise on the design, engineering and operations of the technology?</p> <p>What opportunities, if any, will be available for tribes and communities to monitor air, surface water and ground water as well as direct prompt remediation facility closure when emissions exceed standards?</p> <p>What opportunities, if any, will be provided to Tribes and communities to independently monitor technology inspection?</p> <p>How will exposure to persons living, working and traveling along transportation corridors be</p>	<p>Will construction and operation of the technology prevent, or limit tribal access to religious sites and adversely affect the right of Indian people to practice their religion?</p> <p>What specific religious sites will be impacted?</p> <p>What affects, if any, will construction and operation of the technology have on the habitat of religious and/or cultural sites?</p> <p>What affects, if any, will the construction and operation of the technology have on culturally significant artifacts and archeological sites?</p> <p>Will the technology require an outside workforce for construction and operation?</p> <p>What affects, if any, will an influx of outsiders have on Indian culture, traditions, spiritual beliefs and language?</p>	<p>What affects, if any, will the technology have on tribal sovereignty?</p> <p>How will tribal sovereignty be affected if tribal regulatory capacity and emergency response capabilities required by the technology are not achieved?</p> <p>What, if any, limitations will the technology have on the exercise of treaty rights?</p> <p>Will the technology prevent access to tribal hunting, gathering, fishing and other sites where traditional activities occur?</p> <p>Will implementation of the technology prevent the safe consumption of various natural resources?</p> <p>Will the technology impair habitats and cause harm to treaty protected fish, game, plant and other</p>	<p>How will the Federal/Tribal trust relationship and Federal Indian policy commitment to tribes be maintained with the implementation of the technology?</p> <p>How will the technology advance tribal interests?</p> <p>How will the technology advance tribal self-government?</p> <p>How will the technology protect Indian lands, resources, economy and social conditions?</p>

Proposed Environmental Remediation Technologies	Regulatory Capability	Health and Safety	Environment	Future Land-Use	Economic Conditions	Education and Research	Environmental Justice	Religion and Culture	Tribal Sovereignty and Treaty Rights	Federal/Tribal Trust Relationship and Federal Indian Policies
<p>used interchangeably with air sparging to highlight the biodegradation process that occurs. Air sparging is also known as in situ aeration (Tech Tree, 2001).</p> <p>Ideal: Air sparging is used ideally in coarse, permeable soils, such as sand or gravel. This allows the injected air to flow easily through the contaminated zone. The high air flow rates deliver the air to the subsurface and extract contaminated vapors. This technology has been primarily used for the cleanup of fuel spills (Marley and Bruell, 1995). A mixture of contaminants may pose volatilization problems for the air sparging technology.</p> <p>Not ideal: Air sparging is not used in soils that are impermeable or have low flow rates, including clay and silt soils. The low flow rate decreases the likelihood of air reaching the contaminated zone and volatilizing the contaminants. Heterogeneous soils, or a mixture of soil types, allow the air sparging system to reach some contaminated area, while not remediating others. This often produces “pockets” of contaminants within the target area. Because of the complexity of the soil types in the subsurface, achieving uniform air flow rates to reach contaminants is difficult.</p> <p><i>Contaminants Treated:</i> Volatile and semi-volatile contaminants</p>	<p>take to establish, or improve Tribal regulatory capacity?</p>	<p>Is it through populated areas and well traveled roadways/rail lines?</p> <p>What is the total distance of the transportation route?</p> <p>Are current tribal emergency response procedures capable of addressing accidents along the transportation route?</p> <p>If not, what needs to be established, or improved?</p> <p>What, if any, site safety concerns and hazards are associated with the technology?</p> <p>What, if any, site safety standards and procedures need to be implemented (fencing, sign postings, security measures, containment structures, etc.)?</p> <p>What considerations need to be made</p>	<p>the relocation of the waste or, new technologies are developed that increase the levels of human health and safety, and environmental protection?</p> <p>How much total land will be used by the implementation of the technology?</p>		<p>inflicted on the tribe, or community due to technology implementation (noxious smoke, polluted water, decreased tourism and property values)?</p> <p>Will the technology require long-term monitoring which might provide future economic opportunities that Indian tribes can perform?</p> <p>How can the Tribe/community participate in the transfer of the technology within the U.S. and internationally?</p> <p>How do the expenditures for regulation of the technology and associated process residuals affect public moneys available for other social welfare programs?</p> <p>Does the technology have the potential to be applied toward the restoration of other contamination problems affecting the tribe, or</p>	<p>fellowships and scholarships for Tribal and community students in mathematics, engineering and science at environmental justice organizations, federal research institutes and laboratories?</p> <p>What educational opportunities, if any, are available for Tribal and community students ages K-12 (field trips, demonstration of technology implementation)?</p>	<p>minimized?</p> <p>According to the “No Net Risk Gain Model” what, if any, additional community risks are associated with the technology?</p> <p>How will the community be compensated for taking on those additional risks?</p> <p>What existing risks can be minimized, or eliminated?</p> <p>What beneficial community resource can be increased or added?</p>		<p>resources?</p> <p>Is the participating federal agency relating to the tribe on a government-to-government basis in their dealings with the tribe in matters pertaining to the technology?</p>	

Proposed Environmental Remediation Technologies	Regulatory Capability	Health and Safety	Environment	Future Land-Use	Economic Conditions	Education and Research	Environmental Justice	Religion and Culture	Tribal Sovereignty and Treaty Rights	Federal/Tribal Trust Relationship and Federal Indian Policies
<p>(VOCs and SVOCs), including gasoline (BTEX) components, chlorinated solvents (PCE, TCE, DCE, etc.), NAPLs</p> <p><i>Possible Tribal and/or Community Implications:</i> Air emission standards/treatment</p> <p>Process involves drilling of injection wells (how land intensive/invasive to ecosystem?) Air monitoring must be performed (by tribal members?)</p> <p>Water and soil monitoring must be performed to document contaminant levels</p> <p>Some areas may have residual contamination because of low permeable soil makeup</p> <p>May be difficult to meet drinking water (or other water-based) standards</p> <p>How will residual contamination affect a tribe's cultural/natural resources</p> <p>Contaminated zones may experience a reduction of contaminants but are rarely completely cleaned up</p>		<p>in order to ensure the life-long process of health screening and monitoring of workers?</p> <p>Will the technology transfer danger to human health and safety to other populations outside the surrounding area?</p> <p>Will the technology affect local food resources?</p> <p>If so, how will it affect the nutritional balance and health of the Tribe, or community?</p>			<p>community?</p> <p>If so, what are the potential areas?</p>					
<p><i>Summary Impact Narrative</i></p>										

## **IMPLICATION CATEGORIES AND QUESTIONS: A CLOSER LOOK**

Within the matrix, implication categories and affiliated questions serve to inform tribal and community decision-makers how technologies affect their specific interests and concerns. The implication category headings are broad, making it possible to identify a wide range of interests and concerns relating to that category. The purpose of the implication category questions is to clarify, in detail, how the implementation of a technology can affect tribal and community interests and concerns. The ten categories and question sets were derived from a combination of archival research and consultation with tribal and community representatives and other experts. The responses elicited from affected tribes and communities will yield a community-specific assessment of interests and concerns. There are no right, or wrong answers to the questions. The Matrix is a neutral tool allowing various tribes and communities to identify the potential impacts of remediation technologies and assess the potential opportunities and burdens which they present, thereby yielding more informed participation in DOE cleanup activities and more environmentally sound and just cleanup decisions.

Following is a brief description of the ten implication categories. The order in which the categories appear below is not attributable to the significance of any particular category.

### **Regulatory Capability**

Regulatory Capability is the relative degree of difficulty or ease in securing regulatory oversight of the installation and operation of a remediation technology. Process residuals, waste-stream by-products, and noise, traffic and other nuisances associated with the construction, transportation, and closure are often created with the deployment of a remediation technology. Residuals need additional handling and may require a combination of additional treatment, internment, or removal from the site.<sup>53</sup> While some tribes have the legal authority to establish and maintain a tribal regulatory regime, the costs of establishing the regulatory capability sufficient to address these concerns can be expensive and time consuming. Tribes should consider all these factors when assessing environmental remediation technologies.

### **Health and Safety**

Health and safety concerns are identified through the assessment of risks associated with exposure to contaminants, transportation of contaminants and site safety. Exposure to hazardous contaminants can lead to injury, illness, or death of the recipients.<sup>54</sup> Therefore, tribes and communities will want to consider the principal contaminants associated with the site, human risks associated with exposure to the contaminants, how the technology will address site contamination, the possibility of an accidental release, tribal emergency procedures needed to prevent, alert and address a harmful accidental release and the cost of developing and implementing such procedures. Additionally, tribes will want to consider the extent to which the technology requires the transportation of wastes, how the

---

<sup>53</sup> Regens, James L., et al. *An Integrated Framework For Environmental Technology Evaluation*, n.p., The Medical University of South Carolina, 1999, 27.

<sup>54</sup> Regens, et al. *An Integrated Framework For Environmental Technology Evaluation*, 46.

wastes will be transported, whether the transportation route is through populated areas and the capability of emergency response procedures to address accidents along the transportation route. Immediate and long-term site safety concerns and hazards associated with the technology also need to be assessed, including safety standards and procedures such as fencing, sign postings, security measures, containment structures, etc. The need for procedures and facilities to insure the life-long process of health screening and monitoring of workers should be considered.

Finally, it is important to assess the extent to which the proposed technology transfers the identified risks of contamination to another population or substitutes one risk for another, either impacting the contemplated population or another population. For example, removal of contaminated soil from a site may be beneficial to the neighboring community, but may increase exposure to the labor force or people living close to the new repository. The technology may substitute risk to the contemplated population such as increased truck traffic due to technology implementation. Or, the technology may transform one danger to human health and safety into another danger for another population. For example, a technology to restore contaminated water may lessen the risk to the downstream population while the nature of the technology increases risk to the downwind population from air emissions.

## **Environment**

The general components of the natural environment include air, soil, surface water, groundwater, plants, animals, fish, etc. These natural resources all contribute to the functioning of the natural world. The natural environment that is within or outside the geographical boundaries of a tribe or community is valuable in many ways. The environment produces resources used by tribes and communities and can often promote economic viability. For example, the harvesting of a forest provides employment and income. Or, the pristine waters of a near-by river will attract fly-fishing enthusiasts and other forms of tourism that can increase the profitability of local businesses. In addition, the environment is valuable in ways that cannot be measured by economic tools. The beauty of a landscape, or the presence of wildlife can contribute to an individual's quality of life along with the knowledge that an unaltered environment will exist for future generations to enjoy. Certain technologies will affect the environment in more ways than others. During the selection of a remediation technology, it is important that tribes and communities consider the impacts each technology will have on natural resources, including the sensory attributes of surrounding areas such as sound, smell and visual aesthetics. The potential of the technology to remediate current environmental damages, or impose additional environmental insults will also need to be assessed.

## **Future Land-Use**

The extent and nature of future land-use depends on the level of site contamination, the remediation technology implemented and the desires of the tribe and community. Plans for future land-use of restored sites can include residential, business, agriculture, industrial, open-space and manicured parks. However, in some cases implementation of a remediation technology can restrict or even prohibit access to land. Considering contamination levels, a tribe and community will want to assess future land-use options,



including desirable or necessary land-use restrictions and prohibitions dictated by each technology. In addition, tribes and communities will want to consider whether the future land-use options associated with the technology are acceptable. Finally, if land use restrictions and prohibitions are required, consideration of the long-term stewardship of the site will be necessary.

### **Economic Conditions**

While there are potential negative implications for tribes and communities from the implementation of remediation technologies, tribes and communities may also derive economic benefits from the development and implementation of technologies. Improvements in the economy include opportunities such as an increase in the profitability of tribal and locally owned businesses and the attraction of additional jobs that provide employment to tribal and community members.

Certain remediation technologies will be more economically viable for a tribe or community than others. Careful attention must be paid to the economic opportunities and burdens associated with each proposed technology. Tribes and communities will want to consider the job opportunities the technology will provide to tribal and local community members and the duration of employment. In addition, it is important to assess the profitable opportunities available to the tribe through technology implementation such as manufacturing the technology, or components of the technology, in Indian country and whether the technology can be installed and/or operated by tribal or community owned businesses. Also, tribes and communities will need to consider external costs imposed on the tribe or community due to technology implementation. Economists define external costs as additional costs resulting from the production outlays of the technology. “External” costs do not accrue to the federal agency or contractor responsible for the technology, but are imposed on all of society, or at least on a subset of the households and businesses. Noxious smoke, polluted water, decreased tourism and decreased property values are examples of external costs.

Finally, it is important to consider whether the remediation technology will require long-term monitoring that could be performed by the Indian tribe or community, thereby providing future economic opportunities.

### **Education and Research**

Tribal and community technical capacity can be improved through participation in educational programs such as tribal and community college internships with a federal agency, or research and design opportunities with an environmental remediation technology contractor. The direct experience of educational programs will increase tribal and community understanding of specific technologies, the remediation process, effects the technology will exhibit on tribal and community environment and social values, and will develop the technical capacity of tribal and community educational institutions. Ultimately, tribes and communities can integrate their technical capability and expertise into the federal system of government through participating on their own terms in future research, design, development and implementation of remediation technologies. Therefore, in selecting a remediation technology tribes and communities will want to

consider collaborating with the federal agency and contractor associated with the technology to provide for, or assist in developing, training and technical assistance programs to establish or improve the capability of environmental justice organizations, Historically Black Colleges and Universities and tribal colleges to conduct health, scientific, technical, policy and regulatory analyses and studies. Opportunities for Historically Black Colleges and Universities and tribal colleges in environmental remediation technology research and development may include robotics, sensor technologies and materials science, or establishing education programs including internships, fellowships and scholarships for students in mathematics, engineering and science at environmental justice organizations, federal research institutes and laboratories.

## **Environmental Justice**

Numerous studies conducted in the 1980s revealed that low-income, minority and Indian neighborhoods generally suffered worse air quality, worse water quality, more landfills, more sources of toxic pollution, more hazardous waste sites, and weaker enforcement of environmental regulations than did wealthier, predominantly white neighborhoods.<sup>55</sup> Ultimately, the recognition that exposure to pollutants is not distributed equally and that low-income, minority and Indian communities share disproportionately high levels of environmental risk gave rise to the concept of environmental justice.

Some advocates argue that environmental justice is accomplished through the equitable distribution of environmental risks from one community to another. For example, all states, cities or communities will have an equal number of polluting facilities or, pollution facilities will be divided proportionately among income classes, racial groups, or even individuals. However, this broad and simplified approach to environmental justice fails to recognize the reality of the cleanup situation facing affected tribes and communities, and the need to define when and how a federal facility cleanup site will satisfy environmental justice criteria. The International Institute for Indigenous Resource Management developed a new, comprehensive definition of environmental justice, termed the “No Net Risk Gain Model,” based on a holistic risk assessment philosophy that will ultimately meet tribal and community environmental justice criteria. Under this model, environmental justice is achieved when there is a zero net increase in risk to a tribe or a community.<sup>56</sup> All communities have a pre-existing level of risk prior to implementation of a remediation technology. If the pre-existing level of risk increases through the introduction of another risk to the tribe and community, that added risk would be environmentally unjust. The best way to achieve environmental justice is to insure that if a risk is added then a risk must be removed, yielding a zero net increase in risk.

---

<sup>55</sup> Ringquist, Evan J. “Environmental Justice: Normative Concerns and Empirical Evidence.” *Environmental Policy in the 1990s: Third Edition*. Ed. Norman J. Vig and Michael E. Kraft. 231. Washington, D.C.: Congressional Quarterly Inc., 1997, 231.

<sup>56</sup> Lapachin, Larry and Mervyn L. Tano. “Developing the Taxonomy of Community Risk Variables Under the “No Net Risk Gain Model” to Satisfy Quality of Life Objectives During Federal Facility Environmental Cleanup Efforts.” *International Institute for Indigenous Resource Management*. <http://www.iiirm.org/publications/pubs.htm> (11 June 2002).

Ultimately, a zero net increase in risk is achieved through negotiation that results in either minimizing or eliminating an existing risk, or increasing or introducing a benefit. Additionally, most of the environmental injustice experienced in Indian country and other communities is based on the failure to involve the public in the planning, development, implementation and oversight of neighborhood environmental remediation programs. Therefore, when evaluating technologies, tribes and communities will want to consider retaining independent technical consultants to advise them on the design, engineering and operations of the technology, and exercising their right to monitor air, surface water and ground water as well as direct prompt remediation facility closure when emissions exceed standards. Consideration must also be given to minimizing exposure to persons living, working and traveling along transportation corridors. In addition, tribes and communities will want to assess the additional community risks associated with the technology and determine how the community will be compensated through either minimizing, or eliminating existing risks, or introducing a beneficial community resource. For example, if a tribe's pre-existing bundle of risk increases with the decision to incinerate contaminants on-site, the tribe will want to identify pre-existing risk burdens such as the absence of an adequate local healthcare facility, and negotiate a deal to fund its construction with the federal agency and/or contractor.

### **Religion and Culture**

Common history, traditions, language and spiritual beliefs all combine to define a group of people. It is imperative that a tribe and community maintain their identity and pass it along to future generations. Part of maintaining an identity is the preservation of sacred and culturally significant sites. In evaluating technologies, tribes and communities will want to assess the possibility that construction and operation of remediation technologies will prevent or limit tribal access to religious sites and otherwise adversely affect the right of Indian people to practice their religion. Tribes and communities must also assess how construction and operation of a technology will impair the habitat of religious and/or cultural resources and how it might disturb culturally significant sites.

Finally, the tribe will want to consider the religious and cultural impacts associated with a technology requiring an outside workforce. For example, individuals comprising an outside workforce may disrespect Indian spiritual beliefs and traditions, and introduce culturally inappropriate practices.

### **Tribal Sovereignty and Treaty Rights**

The key attributes of tribal sovereignty include the inherent governmental power that Indian tribes possess over all internal affairs; the exclusion of states from interfering with the tribes in their self-government; and the plenary power of Congress to limit tribal sovereignty.<sup>57</sup> By treating the tribes as sovereign nations and by leaving them to regulate their own internal affairs, the colonial powers and later the federal government recognized the sovereign status of tribes. Treaties between Indian tribes and the colonial government, and later the United States, reaffirmed tribal sovereignty. Under treaties,

---

<sup>57</sup> Canby, William C, Jr. *American Indian Law: In A Nutshell*. St. Paul, MN: West Publishing Co., 1981, 66.

tribes ceded specific lands to the federal government in exchange for perpetual rights to perform certain activities on those lands such as access to hunt, gather, fish and engage in other traditional activities. The protection and retention of Indian sovereignty requires the utmost vigilance on the part of tribal leaders. In assessing environmental remediation technologies, tribal decision-makers will want to consider how the technology impacts tribal sovereignty. For example, tribes may experience negative repercussions if tribal regulatory and emergency response capabilities required by the technology are not achieved. Additionally, it is important to consider what limitations the technology will impose on the exercise of treaty rights such as preventing access to tribal hunting, gathering, fishing and other sites where traditional activities occur; whether the technology will prevent the safe consumption of various natural resources; and whether it will impair habitats or harm treaty protected fish, game, plant and other resources. Finally, it is important to consider whether the federal agency is relating to the tribe on a government-to-government basis. Federal decisions regarding tribal lands, resources and people should not be made without consulting with the tribal government.

### **Federal/Tribal Trust Relationship and Federal Indian Policies**

The trust relationship between the federal government and Indian tribes is best explained as that of trustee and beneficiary, with the trustee (the United States) subject in some degree to legally enforceable responsibilities. The first judicial articulation of the fiduciary nature of the relationship between the United States and Indian tribes occurred in *Cherokee Nation v. Georgia*, in which the Court found that the Tribe, though a “distinct political community” and thus a “state,” was neither a State of the United States nor a foreign state. Chief Justice Marshall concluded that Indian tribes “may, more correctly, perhaps, be denominated domestic dependent nations . . . in a state of pupillage” and that “their relation to the United States resembles that of a ward to his guardian.”<sup>58</sup> The special relationship includes the federal government’s obligation to provide services required to protect and enhance Indian lands, resources, self- government, and also economic and social programs which are necessary to raise the standard of living and social well being of the Indian people to a level comparable to the non-Indian society.<sup>59</sup> However, Indian policies of the federal government have not always served the best interests of the tribes. Tribal leaders, in dealings with the federal government, must continue to press government officials to live up to the promises encompassed in the trust responsibility doctrine. In evaluating proposed remediation technologies, tribes will want to assess how the Federal/Tribal trust relationship and Federal Indian policy commitments to tribes will be maintained with the implementation of the technology. For example, if the proposed technology is part of efforts by DOE to privatize operations, tribes must assess how DOE’s trust and Indian policy obligations might be impaired if private companies were to implement technologies within DOE sites. Tribes will want to consider whether technology will advance tribal interests and self-government, and protect Indian lands, resources, economy and social conditions.

---

<sup>58</sup> *Cherokee Nation*, 30 U.S. (5 Pet.) at 17.

<sup>59</sup> Tribal Environmental Program, Council of Energy Resource Tribes. “Environmental Technology in Indian Country.” Presented at U.S. EPA Region IX 5<sup>th</sup> Annual Tribal Environmental Conference, 4-6 November 1997. San Francisco, CA. Golden Gate College Campus.

## **Weighing the Technological Affects on Tribal and Community Interests**

The completed matrix does not automatically generate a series of numbers that can be aggregated so that the technology options can be placed in rank order. Each tribe or community will have a unique set of interests and will look at the impacts of each environmental remediation technology on those interests in a uniquely different way. What the matrix and the process that supports it do then is first, help the tribe or community decide what interests are really important to tribal or community members; second, help the tribe or community understand exactly what is at stake; and third, strengthen the tribe's or the community's participation in the federal facilities environmental remediation decision-making by providing the information needed to move from a binary, "go -- no go" mode of decision-making to one that allows nuanced decision-making.

It is important to also understand what the matrix and the process that supports it is not. The matrix is not a decision-making model based on cost-benefit analysis. It is one thing to say that the federal facility manager will sweeten the benefit pot so that the tribe or community will bear whatever costs a particular environmental technology may engender, and a very different thing to understand that someone benefits from the installation, operation, and closure of a particular environmental technology and that Indian law and policy strongly suggest that the someone ought be the tribe. Similarly, it is one thing to acknowledge that environmental remediation technologies can generate process residuals, emissions, noise and other nuisances, but it is not cost-benefit decision-making when the cognizant federal agency provides the financial support to build the tribal regulatory systems and institutions required to abate nuisances and to protect the tribe. What the matrix and the process that supports it do is to provide the tribe or the community with the information they require to justify the need for these systems and institutions and the rationale for the tribe's or the community's primary role in operating these systems and institutions.

### **IV. CONCLUSION AND RECOMMENDATIONS**

The International Institute for Indigenous Resource Management consulted with members of tribes and communities affected by environmentally contaminated federal facilities at its own and other conferences and workshops. Tribal and community members from the Tanana Chiefs Conference, Inc. in Alaska, from the Confederated Tribes of the Umatilla Indian Reservation in Oregon, from Anniston, Alabama and other places have asked the Institute to brief community members and to field test the matrix in their communities. At present the Tribal and Community Decision-Makers Environmental Remediation Technology Assessment Matrix is a framework. It is a very good framework, but it can be improved.

There are two follow-up activities that should be undertaken. The first is to continue the dissemination effort to take the matrix to an even broader audience of tribal and community decision-makers, federal facilities environmental remediation managers and regulators, and tribal and community-based non-governmental organizations. This information dissemination effort should include:

- ? Continued distribution of the Tribal and Community Decision-Makers Environmental Remediation Technology Assessment Matrix to site- specific advisory boards, restoration advisory boards, environmental justice organizations, Indian tribes, and federal facilities managers and regulators.
- ? Continued development of briefing materials about the matrix for presentation at national and regional conferences and symposia on public participation, waste management, environmental protection, and environmental justice among others.
- ? Writing of articles and papers about the matrix for publication in public participation, waste management, environmental protection, and environmental justice magazines and journals.

The second recommended activity is to field test the matrix at two or three different facilities. One of these facilities should be in Indian country and the other not. Testing the matrix should produce detailed and refined questions that in turn will yield more accurate and complete identification and description of a full range of tribal and community interests that may be affected by the installation, operation, and closure of environmental technologies.

## APPENDIX 1

### *Technology Summaries and Impacts on Tribal Interests*

#### **Technology:** Air Sparging

In situ – groundwater

**Summary:** The air sparging process injects air and/or other gases directly into the groundwater to remove contaminants. The air sparging system uses vertical wells and often a compressor to introduce pressurized air below the surface. The air increases the subsurface oxygen levels and helps remove the contaminants through volatilization. During the volatilization process, the contaminants dissolved in the groundwater are changed into a vaporized phase. The vaporized contaminants will move upward from the groundwater and toward the surface. The air sparging system uses vertical extraction wells to “capture” the volatilized contaminants. Often, an additional remediation technology, a soil vapor extraction system, is used in conjunction with the air sparging remediation technology to remove vaporized contaminants from the subsurface. The extracted vapors may require additional treatment to meet air emission standards.<sup>60</sup> The increased subsurface oxygen levels also dissolve in the groundwater enhancing bioremediation, a process that detoxifies, or breaks down, certain contaminants.<sup>61</sup> Biosparging is sometimes used interchangeably with air sparging to highlight the biodegradation process that occurs. Air sparging is also known as in situ aeration.<sup>62</sup>

**Ideal:** Air sparging is used ideally in coarse, permeable soils, such as sand or gravel. This allows the injected air to flow easily through the contaminated zone. The high air-flow rates deliver the air to the subsurface and extract contaminated vapors. This technology has been primarily used for the cleanup of fuel spills.<sup>63</sup> A mixture of contaminants may pose volatilization problems for the air sparging technology.

**Not ideal:** Air sparging is not used in soils that are impermeable or have low flow rates, including clay and silt soils. The low flow rate decreases the likelihood of air reaching the contaminated zone and volatilizing the contaminants. Heterogeneous soils, or a mixture of soil types, allow the air sparging system to reach some contaminated area, while not remediating others. This often produces “pockets” of contaminants within the target area. Because of the complexity of the soil types in the subsurface, achieving uniform air-flow rates to reach contaminants is difficult.

**Contaminants Treated:** Volatile and semi-volatile contaminants (VOCs and SVOCs), including gasoline (BTEX) components, chlorinated solvents (PCE, TCE, DCE, etc.), and NAPLs.

#### *Possible Tribal and/or Community Implications:*

- ? Compliance of air emission standards during treatment.
- ? Process involves drilling of injection wells (how land intensive/invasive to ecosystem?)

---

<sup>60</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

<sup>61</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to Soil Vapor Extraction and Air Sparging*. Washington: GPO, 1996. (EPA 542-F-96-008)

<sup>62</sup> Center for Public Environmental Oversight. “Air Sparging.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/airspa.htm>

<sup>63</sup> Marley, M.C., and C.J. Bruell. *In Situ Air Sparging: Evaluation of Petroleum Industry Sites and Considerations for Applicability, Design and Operation*. American Petroleum Industry Publication No. 4609. Washington, D.C. 1995.

- ? Air monitoring must be performed (by tribal members?)
  - ? Water and soil monitoring must be performed to document contaminant levels.
  - ? Some areas may have residual contamination because of low permeable soil makeup.
  - ? May be difficult to meet drinking water (or other water-based) standards.
  - ? How will residual contamination affect a tribe's cultural/natural resources?
  - ? Contaminated zones may experience a reduction of contaminants but are rarely completely cleaned up.
- 

### **Technology:** Bioremediation

#### In situ – soil and groundwater

*Summary:* In situ bioremediation use microorganisms, or microscopic bugs, to degrade, or breakdown, contaminants into less toxic or nontoxic substances. Microorganisms, such as bacteria, fungi, or yeast can be found naturally “living” at the site or imported, or brought to the site. Microorganisms “eat” and “digest” certain contaminants, such as fuels or solvents, for energy and transforms these chemicals into “harmless” byproducts – mainly carbon dioxide and water. Temperature, nutrients (fertilizer), and the amount of oxygen are subsurface factors that influence the rate bioremediation, or how quickly the microorganisms consume hazardous contaminants. To maximize subsurface conditions at a site, air, nutrients, and other substances (such as molasses and sucrose) may be introduced into the contaminated area through injection wells.<sup>64</sup> Oxygen may also be provided in a liquid phase as hydrogen peroxide through a system of pipes or sprinklers.<sup>65</sup> The microorganisms die once they have consumed the available “food,” or contaminants.<sup>66</sup> The length of time for a site to be remediated, or meet cleanup standards, will vary with each individual site. For example, the type and amount of contaminant(s) treated, size and depth of the contaminated area, the soil type, the weather, and other conditions influence cleanup times. In situ remediation often requires years to meet cleanup criteria.<sup>67</sup>

**Ideal:** The in situ bioremediation technology is most effective at contaminated sites with permeable, or sand and/or gravel soil types. This allows the injected microorganisms and nutrients to flow easily through the contaminated zone and interact with the contaminants. Because in situ bioremediation often takes years to meet cleanup goals, sites that do not require rapid remediation may be considered for this remediation technology.

**Not ideal:** Other remediation alternatives may be considered instead of in situ bioremediation in cold weather climates. The cold temperatures slow the bioremediation process. In situ bioremediation is not ideal for sites that require quick remediation. Additionally, low-permeability soils, or clay or silt soils, may add to difficulties in delivering nutrients to the contaminated zone. Heterogeneous zones, soils with multiple types of soil properties, may treat only the permeable soils and leave “pockets” of contamination within the impermeable soils. In situ bioremediation often requires years to meet cleanup criteria.<sup>68</sup>

*Contaminants Treated:* Organic contaminants, and fuels.

---

<sup>64</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to Bioremediation*. Washington, D.C.: GPO, 2001. (EPA 542-F-01-001)

<sup>65</sup> Center for Public Environmental Oversight. “Bioremediation-Perchlorate.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/bioperc.htm>

<sup>66</sup> U.S. Environmental Protection Agency, *A Citizen's Guide to Bioremediation*.

<sup>67</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to In Situ Soil Flushing*. Washington, D.C.: GPO, 1996. (EPA 542-F-96-006)

<sup>68</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to In Situ Soil Flushing*.



*Possible Tribal and/or Community Implications:*

- ? Soil and groundwater monitoring will need to be conducted on a long-term basis to ensure the remediation technology is working in lowering contaminant levels.
  - ? The introduction of additional nutrients may potentially degrade the groundwater quality at the contaminated site.
  - ? For sites that require long-term treatment, labor may be required to maintain the site.
  - ? The possible construction of injection and extraction wells may impact a tribe's cultural/natural resources.
  - ? Tribal members can perform long-term monitoring of the soil and groundwater.
- 

**Technology:** Bioremediation

Ex situ – soil and groundwater

*Summary:* The ex situ bioremediation process excavates, or removes, contaminated soil or pumps groundwater aboveground to treat contaminants. There are two types of ex situ bioremediation technologies for soil cleanup, the *slurry-phase* and *solid-phase* bioremediation. In the slurry-phase, the excavated soil is mixed with water and other additives, such as emulsion (detergent), in a large tank, called a “bioreactor” to create a slurry. A slurry has a mud-like consistency that keeps the contaminants in suspension, or located throughout the slurry mixture. Chemicals can be added to the slurry mix to keep microorganisms, or microscopic bugs, in contact with the contaminants. The microorganisms consume the contaminants for energy. Nutrients and oxygen may be added and pH, water content, and temperature can be controlled to maximize microbial activity within the bioreactor. Following treatment, excess water is removed from the soils and are disposed of at an approved site or treated further if contaminants persist.

The solid-phase bioremediation system mixes the contaminated soils with soil amendments, or additional “ingredients,” such as wood chips, plant waste, straw, hay, and manure. The additional ingredients are designed to increase the bioremediation process, or the rate at which microorganisms consume, digest, and detoxify, or break down, the contaminants. In an ex situ bioremediation process, called landfarming, the treated soil is mixed with clean soil, tilled into the earth, and periodically aerated, or agitated to expose the contaminated soil to the air (which can further detoxify, or break down, the contaminants). In others methods, such as bio-piles and composting, the soil and amendments are formed into piles and monitored to enhance bioremediation, or stimulate microorganism activity. For example, moisture, heat, nutrients, oxygen, and pH can be controlled and manipulated to provide optimal conditions for bioremediation, or microbial activity that breaks down the contaminants.<sup>69</sup> Systems are developed to capture the leachate, or contaminated liquids, emanating from the waste source. VOCs and SVOCs will volatilize, or transform into a vapor phase, and may need to be captured and treated before being released into the atmosphere.<sup>70</sup>

The ex situ system for groundwater cleanup uses an extraction well to remove contaminated groundwater and treats the contaminants in an aboveground water treatment system. Nutrients and oxygen are added to the captured water to increase and maximize conditions where microorganisms can consume contaminants. Injection wells return the “conditioned” water to the subsurface where the microorganisms continue to detoxify the contaminants

---

<sup>69</sup> Center for Public Environmental Oversight. “Bioremediation-Perchlorate.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/bioperc.htm>

<sup>70</sup> U.S. Environmental Protection Agency, *A Citizen's Guide to Bioremediation*.

**Ideal:** Ex situ bioremediation remediation can be useful when rapid remediation is a high priority. This process is also often used for fuel-contaminated soils. Ex situ bioremediation may be deployed at contaminated sites that do not contain sensitive or culturally significant species.

**Not ideal:** Ex situ bioremediation can be very land intensive. For example, when contaminated soil is mixed with clean soil, there is a net increase of the contamination. The excavation of soil may also cause destruction to the ecosystem.

*Contaminants Treated:* Organic wastes, SVOCs, VOCs, and explosives (UXO).

*Possible Tribal and/or Community Implications:*

- ? Excavation of soil may damage cultural/natural resources.
  - ? Ex situ bioremediation requires a large amount of space (much larger than the contaminated area), which may affect access to sacred sites.
  - ? Tribal members may be involved in maintenance and monitoring of the ex situ bioremediation equipment and systems.
  - ? Ex situ bioremediation may require the treatment of water, which may require the tribe to establish water quality standards.
  - ? Tribes may need a wastewater treatment facility to dispose of contaminated water.
  - ? Tribes may need to establish air emission standards for soil contaminated from VOCs and SVOCs.
  - ? The construction and/or process of excavating the soil and establishing the bioremediation systems may create excessive dust and noise.
  - ? Substantial labor is often needed to maintain the ex situ bioremediation system and may be performed by tribal members.
  - ? Tribes may have to further treat leachate emanating from the contaminated site or dispose of waste in an approved wastewater treatment plant.
  - ? Monitoring may be required to ensure that the areas surrounding the treatment site are not subjected to migrating contaminants.
- 

**Technology:** Chemical Extraction

Ex situ – soil

*Summary:* The chemical extraction process uses chemicals to separate contaminants from soils, thereby reducing the volume of the hazardous waste that must be further treated. Once the soil is excavated, it is physically separated into coarse (sand, gravel) and fine (clay, silt) soils. This is based on the assumption that smaller, fine soils contain higher concentrations of the contaminant. The contaminated soil is then placed into an “extractor,” or a large mixing tank where contaminants are separated from the soil. This is accomplished by mixing the contaminated soil with a chemical extractant, or a substance that is used to force and/or remove the dissolved contaminants from the soil. Generally, the chemicals used in this process are either hydrochloric acid (called “acid extraction”) or an organic solvent (called “solvent extraction”), a substance that contains mainly carbon, hydrogen, and oxygen and dissolves another substance or substances to form a solution. The acid extraction treats heavy metal contaminants, while organic solvents extract metals and mixtures of metal and organic contaminants. The soil-extractant mixture is pumped out of the extractor and into a “separator” to remove the contaminants, such as metals, from the chemical extractant. The recaptured metals and chemical extractant are potentially suitable for recovery and reuse. The soils are rinsed with water to remove acids and metals. Finally, excess water is removed from the soil, and lime and fertilizer may be added to neutralize

any remaining acid. Solvent extraction may also be used in conjunction with other remediation technologies, such as solidification/stabilization, incineration, or soil washing. The treated soil is often returned to the site after meeting established cleanup levels.

**Ideal:** Chemical extraction is suitable for contaminated sites where the excavation of soil would cause minimal damage to the ecosystem and/or natural/cultural resources. During the mixing with the chemical extractant, soils with minimal clay content will have a much higher success and efficiency rate versus soils with high clay content.

**Not ideal:** Higher clay content may reduce the efficiency of the chemical extraction process or require longer contact times.

*Contaminants Treated:* Heavy metals, mixtures of metal and organic compounds (such as PCBs, VOCs, halogenated solvents, and petroleum wastes).

*Possible Tribal and/or Community Implications:*

- ? The soil excavation process may damage cultural/natural resources.
  - ? The excavation and chemical extraction process may prevent access to sacred sites.
  - ? Recovered contaminants, such as metals, may need to be transported across Tribal lands.
  - ? Tribes may wish to expand or enhance its emergency response capability.
  - ? Cleanup standards are often difficult to achieve. For example, the ability to meet highly stringent heavy metal criteria.
  - ? Traces of solvent may remain in certain “pockets” of the treated soil, which may have adverse effects on the tribe’s cultural/natural resources.
  - ? Excessive noise and fugitive dust may occur during extraction.
- 

**Technology:** Cosolvent (or alcohol) Flushing

In situ – groundwater

*Summary:* The cosolvent flushing technology injects one or more solvents into the contaminated groundwater to dissolve and/or mobilize, or remove, the contaminants.<sup>71</sup> Alcohols, such as methanol, ethanol, propanol, are the most commonly used solvents. A common cosolvent flushing system consists of numerous injection and extraction wells arranged to sufficiently flood and flush the contaminated subsurface area. The alcohol/solvent-water mixture is usually injected up gradient, or upstream, from the contaminated area and extracted down gradient, or downstream. The mixture (with dissolved contaminants) usually requires additional treatment to meet appropriate discharge standards prior to releasing it into local wastewater treatment works or receiving streams. Recycling of the solvents has not yet been demonstrated. Volatile contaminants from recovered flushing fluids should be collected and treated (air emissions) to meet appropriate regulatory standards.<sup>72</sup>

**Ideal:** The cosolvent flushing system is generally used in permeable soils, including sand and gravel type soils. This allows the flushing solution to easily move through the subsurface and make contact with the groundwater to remove contaminants. Cosolvent flushing also has a relatively short application time when compared with other remediation technologies.

---

<sup>71</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

<sup>72</sup> Remediation Technologies Screening Matrix and Reference Guide, Version 4.0. “Soil Flushing.” *Federal Remediation Technologies Roundtable*. [http://www.frtr.gov/matrix2/section4/4\\_8.html](http://www.frtr.gov/matrix2/section4/4_8.html)

**Not ideal:** Cosolvent flushing is not used to treat contaminants in impermeable (clay) soils or heterogeneous, or mixed soils. Impermeable soils create poor contact between the flushing solution and the contaminants, which creates poor contaminant removal rates in the subsurface. While cosolvent flushing may remove contaminants from the groundwater, meeting stringent water quality standards, such as drinking water criteria, may be difficult.

*Contaminants Treated:* Chlorinated solvents, such as trichloroethene (TCE) and tetrachloroethene (PCE), BTEX (jet fuel), pesticides, VOCs, SVOCs, LNAPLs, and DNAPLs.

*Possible Tribal and/or Community Implications:*

- ? Some contaminants, such as VOCs and SVOCs may volatilize, which may need to be captured and treated to meet air emission standards.
  - ? Water quality standards may need to be established for the flushed groundwater.
  - ? Tribes may need to construct or establish a water disposal or wastewater treatment facility.
  - ? The cosolvent remediation process is not likely to achieve full recovery of contaminants from the contaminated groundwater.
  - ? The injection of the cosolvent solution may result in increasing the extent and furthering migration of NAPL contamination.
  - ? The initial injection of the cosolvent will result in increased concentrations of the contaminant, thereby increasing the short-term risk.
  - ? Tribes may be able to assist in the design of the cosolvent flush system, including injection and extraction wells.
  - ? Tribes may need to enhance their emergency response system because recovered solvents and fluids must be transported off-site for disposal.
- 

**Technology:** Dig and Haul

Ex situ – soil

*Summary:* Dig and haul excavates, or physically removes, the soil and contaminants using large “earth-moving” equipment and labors. The contaminated waste is then transported to an incinerator for further treatment or a landfill to stabilize the contamination.<sup>73</sup> Generally, dig and haul is a land disposal technology of hazardous wastes without any remediation treatment of the contaminants.<sup>74</sup> The contaminated material is often carried to a transferring station where the contaminants may be transferred from the current truck to a clean truck. Safety features to the equipment are provided and techniques are performed to meet the health and safety requirements and priorities of the workers and public. These modifications include providing transferring stations to remove the soil from the contaminated truck, providing clean breathing air to laborers working in a contaminated area, and preventing leaks of liquids and solids during transport. New topsoil is often imported to re-establish the ecosystem and native species.<sup>75</sup>

**Ideal:** The dig and haul process can be used to excavate and remove difficult to remediate soil contamination, such as a mixture of or persistent contaminants. This can also be used to remediate contaminated areas where remediation technologies have not proven to effectively

---

<sup>73</sup> Regens, James L., et al. *An Integrated Framework For Environmental Technology Evaluation*, n.p., The Medical University of South Carolina, 1999,

<sup>74</sup> U.S. Environmental Protection Agency. *Treatment Technologies for Site Cleanup, Annual Status Report (10<sup>th</sup> Edition)*. Washington: GPO, 2001. (EPA -542-R-01-004).

<sup>75</sup> Regens, et al. *An Integrated Framework for Environmental Technology Evaluation*.

cleanup the contaminants. Dig and haul can be used as a “quick” remediation process in addressing hazardous contaminants.

**Not Ideal:** The dig and haul process creates higher worker exposure to the contamination and increases the risks involved. The dig and haul process destroys the natural ecosystem, which may cause irreversible damage to the natural/cultural resources and possibly the landscape. The dig and haul remediation process should be reconsidered when the excavation may expose workers and nearby residents to excessive noise and/or fugitive dusts.

*Contaminants Treated:* A wide variety and mixture of contaminants.

*Possible Tribal and/or Community Implications:*

- ? Dig and haul causes a destruction of ecosystem/landscape – cultural/natural resources.
  - ? The excavation process may disturb access to sacred sites.
  - ? Tribal members may form the labor force needed during the dig and haul process.
  - ? An Indian-based environmental company may provide the necessary equipment.
  - ? Transportation of contaminated soil on Indian land may cause tribes to enhance their emergency response plan.
  - ? Tribes should consider how potentially excessive noise may impact tribal practices.
  - ? Fugitive dusts may be transported by the wind and cause an increase in exposure to workers, residents, and culturally significant species.
- 

**Technology:** Dehalogenation (Chemical)

Ex situ – soil

*Summary:* The chemical dehalogenation technology uses chemicals to remove the chlorine molecule from a contaminant in the soil. Some contaminants that contain a chlorine molecule include PCBs, dioxins, furans, and pesticides. The contaminated soil is excavated, screened to remove large debris, and then crushed. Next, the soil is mixed with chemicals, or reagents – a substance used to react (cause a chemical reaction) with another substance. This mixture is heated in a chemical reactor where the chemical reaction occurs. This reaction causes the chlorine molecule of the contaminant to either be replaced and/or partially decomposed or volatilized (vapor phase). Two common chemical dehalogenation processes include the *base-catalyzed decomposition (BCD)* and the *glycolate/alkaline polyethylene glycol (APEG)* process.

The BCD process is designed to cleanup liquids, sludge, soil, and sediment contaminated with chlorinated organic compounds, especially PCBs, dioxins, furans, pesticides, and some herbicides. Sodium bicarbonate, used as the primary reagent, is mixed and heated (from 600 to 800 F) with the contaminated soil. This causes the contaminated compounds to volatilize, or change into a vapor phase, and separate from the soil.<sup>76</sup> The volatilized contaminants are captured in a condensed liquid form. The liquid mixture can be incinerated or if possible recycled.<sup>77</sup> The soil is then removed from the reactor and, if it meets cleanup standards, may be returned to the site.<sup>78</sup>

---

<sup>76</sup> Center for Public Environmental Oversight. “Dehalogenation.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/dehalo.htm>

<sup>77</sup> U.S. Environmental Protection Agency, *A Citizen’s Guide to Chemical Dehalogenation*. Washington, D.C.: GPO, 1996. (EPA-542-F-96-004).

<sup>78</sup> Center for Public Environmental Oversight. “Dehalogenation.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/dehalo.htm>

During the APEG process, the excavated soil is mixed with the reagent and heated in a reactor tank. A chemical reaction occurs which breaks the carbon-chlorine bond. Vapors released during the heating process are collected and treated to meet air and disposal standards. The byproduct of the chemical reaction between the contaminated soil and reagent is a non-toxic salt (alkali metal salt) and a less toxic organic compound (glycol ether). The soil is then washed with water to rinse and recycle the remaining APEG reagent. The reagent is separated from the soil and recycled for future use. The water needs to be treated before discharge to a municipal water treatment system, a receiving stream, or other approved discharge areas. The soil is then tested and, if it still contains contaminants, re-enters the process or is transported to a landfill. If the soil meets cleanup standards, it may be returned to its original location at the site.<sup>79</sup>

Diesel fuel or natural gas is used to heat the reactor. The chemical dehalogenation process can be used to treat PCB-contaminated equipment as well.

**Ideal:** Chemical dehalogenation can be used to treat PCB-contaminated soil at almost any concentration. The equipment used during chemical dehalogenation is mobile and can be brought to the site.

**Not Ideal:** The presence of metals may affect performance of the chemical dehalogenation process. Soils with high clay and moisture content slow the remediation process. The APEG technique may have some performance concerns, such as the possible formation of dioxins and furans during the chemical reaction.

*Contaminants Treated:* PCBs, furans, chlorinated hydrocarbons, such as pesticides in the soil.

*Possible Tribal and/or Community Implications:*

- ? Tribes may have to address air emission issues (i.e., implementing tribal air emission standards).
  - ? Tribes may have to develop soil contaminant standards if the cannot be completely cleaned up to background levels.
  - ? The excavation of soil may damage natural/cultural resources.
  - ? The excavation process may inhibit the tribe to access sacred sites.
  - ? With the possibility of the transport of contaminated soil, tribes may have to develop an emergency response for the transport of contaminants across tribal land.
  - ? Tribes may have to construct a municipal water treatment system, locate a receiving stream, or other approved discharge areas for the disposal of treated water.
  - ? The operation and maintenance costs for the chemical dehalogenation process are relatively low and probably would not rely a great deal on tribal capacity.
- 

**Technology:** Electrokinetics

In situ – soil, sludges, and sediments

*Summary:* The electrokinetic process uses an electric current to separate, move, and extract contaminants from the contaminated soils. The electric current is applied by vertically inserting charged electrodes (a cathode and an anode) into the contaminated zone. The electrical current mobilizes, or moves, water and the contaminants within the target zone toward an electrode. The contaminants can then be stabilized in situ, or removed and treated ex situ by other remediation technologies. Surfactants or reagents, substances used to react with the contaminant, may be applied to the contaminated soil to increase contaminant removal rates at the electrodes. An

---

<sup>79</sup> U.S. Environmental Protection Agency, *A Citizen's Guide to Chemical Dehalogenation*.

acoustic field may also be applied (located between the cathode and anode), which enhances waste dewatering or leaching.

**Ideal:** Even though the electrokinetic technology process is in the early stages of development, it has been reported to treat organic contamination and metals in difficult-to-treat low-permeable soil (clay and silt type soils). The soil moisture content must be high enough to allow contaminants and water to migrate, or move. However, the soil should not be saturated.

**Not ideal:** The effectiveness of the electrokinetic process decreases in dry soils (with a soil moisture content less than 10 percent). If water is added to the contaminated area, the process may wash the contaminants from the target area. Preliminary tests have shown that the electrokinetic system may not be able to treat DNAPL contamination because it may clog the system.<sup>80</sup> The electrokinetic process is in its early stages of development and many of the limitations are not yet known.<sup>81</sup>

*Contaminants Treated:* Heavy metals, TCE, radionuclides, organics, inorganic contaminants (in low permeable soils). Removal of cadmium, cesium, chromium, copper, lead, mercury, nickel, strontium, uranium, and zinc have been demonstrated.

*Possible Tribal and/or Community Implications:*

- ? Tribes have to determine what remediation technology may be used for the “captured” contaminants and what implications additional technologies may have.
  - ? Some recovered contaminants may need to be transported across tribal land for further treatment and/or stabilization.
  - ? Since electrokinetic remediation technology is a relatively new technology, tribal colleges and researchers may be able to partake in the development and implementation of this technology.
  - ? If tribes cannot recover all of the contaminants from the subsurface, they may have to determine the consequences of the residual contamination on resources, access to sacred sites, and cultural practices.
- 

**Technology:** Impermeable Barriers

In situ – soil and groundwater

*Summary:* Impermeable, or physical, barriers are used for multiple reasons in managing and containing contaminated sites. Types of impermeable barriers include vertical engineered barriers (VEB), surface caps, and horizontal barriers. Although impermeable barriers are not a treatment technology, they are above and below surface barriers constructed to prevent uncontaminated water from flowing into a contaminated area; stop the migration of contaminated groundwater plume; completely encircle a contaminated site; and protect an environmentally sensitive feature (surface water or drinking water well) from a contaminated groundwater plume. In short, impermeable barriers can be used to isolate, or contain and/or divert both contaminated and uncontaminated groundwater.<sup>82</sup> For example, VEBs can be used for preventing the spread of

---

<sup>80</sup> Center for Public Environmental Oversight. “Electrokinetics.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/electro.htm>

<sup>81</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

<sup>82</sup> U.S. Environmental Protection Agency. *Treatment Technologies for Site Cleanup, Annual Status Report (10<sup>th</sup> Edition)*. Washington, D.C.: GPO, 2001. (EPA-542-R-01-004).

metal and radionuclide contaminants in groundwater. VEBs may also stabilize contamination over years to decades, which allow time for the chemicals to degrade and/or decay (radioactive). The development of improved remediation technologies may also occur during the containment period. A wide variety of materials are used in constructing vertical barriers. The construction materials depend on the soil type, contaminants being treated, and how the barrier is installed. The impermeable barrier technology can be used in conjunction with other technologies. For instance, VEB can be used with the pump-and-treat remediation technology to keep the contaminants within the confined area.

Surface caps commonly used at landfills, control water movement throughout the contaminated soils. The caps are specially layered and equipped with a water collection and sensor system.

Similar to surface caps, horizontal barriers (commonly called bottom barriers) are applied beneath hazardous waste, modern municipal, and DOE landfills. The subsurface horizontal barrier is placed beneath the existing contamination. For example, the horizontal barriers are able to stop the downward migration, or movement, of difficult contaminants, such as DNAPLs and metal contamination. The bottom barriers are installed through angle drilling. This involves drilling a set of angled holes down either side of the contaminated zone. A continuous hole encircling the entire contaminated zone may also be constructed.

For all barriers, determining the performance of the barrier is critical. In addition, all barriers have some level of permeability, which allows water to flow into and out of the contaminated area

**Ideal:** Impermeable barriers can be used to stop or divert the flow of contaminated water that poses imminent danger to a community resource, such as a drinking water source or surface water (i.e., lake or stream). Impermeable barriers can also isolate, or stabilize, the contaminants. This may allow time for chemical degradation, radioactive decay, or the development of environmental remediation technologies.

**Not ideal:** Impermeable barrier may have limited success in controlling and/or diverting contamination approximately 15 m (50 feet) or further. The trenching of the site to install the barrier may be land intensive and destroy the ecosystem. Impermeable barriers do not remediate or treat contaminants but instead contain them.

*Contaminants Treated:* Metals, radionuclides, DNAPL, and a wide variety of other contaminants.

*Possible Tribal and/or Community Implications:*

- ? The digging of trenches to construct and implement the impermeable barriers may damage ecosystem and cultural resources.
- ? Animals may burrow into the barriers (surface) and spread contamination in food chain/web.
- ? Tribes may need to determine potential impacts if/when contaminants leak through the impermeable barrier.
- ? The contaminants may cause the barrier to weather, crack, or shrink, which could cause the contaminants to migrate off-site.
- ? Tribes may assist in the maintenance of the barrier.
- ? Monitoring may need to be conducted to evaluate barrier effectiveness.
- ? The construction of the barrier and the operation of heavy machinery can be completed by an Indian owned business.
- ? Tribes must assess the effects of how the contained contamination will affect cultural resources, practices/traditions, and access to sacred sites.



---

**Technology:** Incineration (on- and off-site)

Ex situ – soil

**Summary:** Incineration uses high temperatures (1,400 to 2,200 F) in the presence of oxygen to destroy and/or volatilize (transform into a vapor phase) contaminants into their basic atomic elements. Excavation of the contaminated soil is required prior to incineration. Incineration usually destroys organic components in the soil with 99.99% efficiency. However, incineration also creates an off-gas emissions and ash (combustion residuals) by-products that may require additional treatment to meet tribal, state, and/or federal requirements. For example, the incinerator may be equipped with an air pollution-control system to remove particulates and noxious gases in meeting air emissions standards. When certain contaminants (including chlorinated hydrocarbons) are incinerated but not completely combusted or destroyed, carcinogenic and toxic chemicals, including dioxin, may be emitted from their stacks. Soils contaminated with heavy metals may also form a bottom ash by-product with high concentrations, which often require disposal. Other heavy metals, including lead, cadmium, mercury, and arsenic may vaporize and leave the incinerator through the stack and into the atmosphere.<sup>83</sup> If an off-site incinerator is used to treat the contaminated wastes, the potential risk of transporting the hazardous waste must be considered. Otherwise, incinerators may also be brought on-site to treat certain contaminants.

Public resistance to incineration, however, is high. According to a British study, there was an increase for all cancers combined among people living within 7.5 kilometers (4.65 miles) of an incinerator.<sup>84</sup> Incineration is also subject to a number of federal regulations and requirements, including air emissions (Clean Air Act), PCB treatment and disposal (TSCA), hazardous waste generation, treatment, storage, and disposal (Resource Conservation and Recovery Act), discharge to surface waters (NPDES), and noise (NCA).<sup>85</sup>

**Ideal:** Incineration may be used to destroy a wide variety of contamination, including mixed waste, which is difficult to remediate.

**Not ideal:** Because of the reported detrimental effects of incineration on the ecosystem surrounding the incinerator, communities may be concerned about dioxin contaminating their resources, including food and water.

**Contaminants Treated:** SVOCs, VOC, Explosives (UXO), dioxin, PCBs, PAHs, pesticides, and fuel.

**Possible Tribal and/or Community Implications:**

- ? Tribes may establish specific air emission standards for the incineration process.
- ? The disposal of the ash by-product may cause tribes to expand or enhance their emergency response capabilities for transporting wastes.

---

<sup>83</sup> Center for Public Environmental Oversight. "Incineration." *Technology Tree*.

<http://www.cpeo.org/techtree/ttdescript/incinr.htm>

<sup>84</sup> Rachel's Environment and Health News. "Incineration News." *Environmental Research Foundation*. #592 (April 2, 1998). <http://www.rachel.org/bulletin/index.cfm?St=4>

<sup>85</sup> Remediation Technologies Screening Matrix and Reference Guide, Version 4.0. "Incineration." *Federal Remediation Technologies Roundtable*. [http://www.frtr.gov/matrix2/section4/4\\_26.html](http://www.frtr.gov/matrix2/section4/4_26.html)

- ? Monitoring contaminants emitted from incinerator must be performed to ensure hazardous chemicals are not released into the atmosphere.
  - ? There is a possibility that the incinerator could contribute to the contamination of the surrounding environment.
- 

### **Technology:** Natural Attenuation

In situ – soil and groundwater

*Summary:* Although not generally regarded as a “technology,” natural attenuation involves the natural range of physical and biological processes that breakdown contaminants without deliberate human intervention. However, natural attenuation is not the same as “no action,” even though it may be perceived as such.<sup>86</sup> Natural attenuation relies on bioremediation (also known as biodegradation), which degrades, or breaks down, hazardous chemicals into less toxic or nontoxic substances.<sup>87</sup> Because of the uncertainty regarding the effectiveness of natural attenuation, long-term monitoring is conducted to continually determine and assess contaminant levels. For most sites, the rates of natural attenuation are slow and the need for long-term monitoring is crucial in determining if contaminant levels are decreasing at a significant rate. Techniques and technologies for predicting and monitoring natural attenuation, however, are still being developed and in their infancy.

Natural attenuation is becoming increasingly chosen as an environmental remediation option, especially for groundwater contaminated by leaking underground storage tanks containing petroleum products. However, for other chemicals, the natural attenuation may degrade contaminants into more harmful substances. For example, some chlorinated compounds may degrade into the more toxic and mobile vinyl chloride, a confirmed carcinogen, or cancer-causing substance. Natural attenuation must be proven effective for the original contaminant of concern, as well as other hazardous substances that are located with the principle contaminant. Natural attenuation may also be used in conjunction with other remediation technologies. For example, the outer portions of a contaminated plume with lower contaminant concentrations may be left for natural attenuation, while the rest of the plume may be subjected to other remediation treatments.

If natural attenuation is chosen for a site, a contingency remedy selection should be selected. A contingency, or an alternative, plan would be implemented if continual monitoring displayed that natural attenuation is failing in achieving cleanup objectives.<sup>88</sup> The success of natural attenuation depends on contaminant type and concentration, temperature, moisture, and the availability of nutrients and other compounds that influence bioremediation, or microbial activity in the subsurface.

**Ideal:** Natural attenuation can be used at sites where slow cleanup time is acceptable. This “technology” can also be used at sites with no evident exposure pathways, or paths for the contamination to reach human and environmental receptors. Natural attenuation can also be used at contaminated sites where in situ treatment is preferred because of the non-invasive nature of the technology.

---

<sup>86</sup> Center for Public Environmental Oversight. “Monitored Natural Attenuation.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/natatt.htm>

<sup>87</sup> U.S. Environmental Protection Agency. *A Citizen’s Guide to Natural Attenuation*. Washington, D.C.: GPO, 1996. (EPA-542-F-96-015).

<sup>88</sup> Center for Public Environmental Oversight. “Monitored Natural Attenuation.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/natatt.htm>

**Not ideal:** Natural attenuation is not recommended for sites where cleanup must be completed quickly. This includes areas where contamination poses an imminent risk to people and the environment. Additionally, natural attenuation should not be considered when a large contaminated plume is still migrating, or showing no signs of stabilizing.

*Contaminants Treated:* VOCs, SVOCs, PCBs, fuel hydrocarbons. Less effective: trichloroethylene (TCE).

*Possible Tribal and/or Community Implications:*

- ? Tribes may need to consider the possible bioaccumulation effect natural attenuation may have on natural/cultural resources.
  - ? Long-term monitoring may provide tribal training and/or employment opportunities.
  - ? Tribes may be involved in the educational and/or research of monitoring devices.
  - ? Tribes may need to develop contaminant standards in determining what levels are “safe” for tribal members and resources.
- 

**Technology:** Permeable Reactive Barriers (PRB)

In situ – groundwater

Summary: Permeable reactive barriers (PRB), also known as passive treatment walls, are installed down gradient, or down slope, and across the path of a contaminated groundwater plume. The PRB technology is passive, which means it depends on the natural flow of the contaminated plume to pass through the barrier. As the contaminated groundwater plumes passes through the barrier, the materials inside the barrier react with the contaminants in a variety of ways. First, the contaminants may be retained, or trapped, in a concentrated form within the PRB. This allows “clean” water to flow out the other side of the barrier. In other PRBs, a chemical reaction between the reactive material and contaminants may occur, which transforms the contaminants into less toxic, harmless byproducts that flow out of the PRB with the groundwater.

A PRB is constructed by digging a large trench to the appropriate width and depth. The trench is then backfilled with the selected reactive materials or by injecting the reactive material into the subsurface. The type of reactive filling will depend on the type of contaminants treated. PRBs are usually vertical walls, although horizontal configurations have been considered for addressing the downward migration, or movement, of contaminants.<sup>89</sup> These barriers may also use materials that increase the bioremediation process. The permeability of the barrier may decrease over time because of the accumulated concentration level of contaminants. PRB may also lose their effectiveness over time and be replaced. If the PRB is replaced, the reactive material may have to be disposed of as a hazardous waste. The reactive material, such as iron, may leach out, or wash away from the PRB and may become a contaminant if concentrations are high enough.

PRB may also be used with impermeable vertical barriers. For example, the impermeable barriers may redirect and guide the groundwater into the PRB (often called a funnel-and-gate system). In some instances, the PRB may also be used to increase the solubility and mobility of contaminants, which improves their removal by pump and treat remediation.<sup>90</sup>

---

<sup>89</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

<sup>90</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to Treatment Walls*. Washington, D.C.: GPO, 1996. (EPA-542-F-96-016)

**Ideal:** The PRB can be installed in areas that are down gradient, or down slope, from a migrating plume. The construction of the PRB can occur in areas where trenching will not pose a great deal of damage to the environment. After the PRB is constructed, it requires very limited maintenance.

**Not ideal:** Because the capture of the entire plume may not be achieved, the PRB technology should not be used in areas where complete contaminant capture is required. The migrating contaminated plume may also bypass and miss the PRB. This may cause the contaminants to migrate, or travel, to places where exposure to human and environmental receptors may be hazardous. The PRB process may require many years for the entire contaminated plume to pass through the reactive materials and treat the contaminants.

*Contaminants Treated:* Metal, radionuclides, VOCs, SVOCs, and organic contaminants.

*Possible Tribal and/or Community Implications:*

- ? Tribes will have to evaluate how the excavation process to install the PRB will affect their cultural resources and access to sacred sites.
- ? The removal of contaminants captured in the PRB may cause the tribe to enhance their emergency response capabilities, especially if hazardous materials and/or replaced PRB will be transported over tribal land.
- ? If complete capture and remediation of the contaminated plume cannot be accomplished, will the residual contamination create problems for tribal practices or resources?
- ? Long-term monitoring must be conducted (possibly by tribal members) to determine if technology is working and there is a decrease in contaminant levels.
- ? An Indian owned company can perform the construction of the barrier.

---

### **Technology:** Phytoremediation

In situ – soil and groundwater

*Summary:* Phytoremediation uses living green plants to “remove, transfer, stabilize or destroy” contaminants in the soil and/or groundwater.<sup>91</sup> Different plants are used to treat different types of contaminants. For example, for metal contamination, various plants are used to stabilize or remove metals (through processes called *phytoextraction*, *rhizofiltration*, and *phytostabilization*). Plants uptake and transport metal contaminants from the soil into the aboveground portions of the plant (called “phytoextraction”). “Hyperaccumulators,” plants that absorb unusually large amounts of metals, are often used at these sites. Once these plants reach a specified height, they are harvested and incinerated. The incinerated ash, a by-product of the incineration process, must be disposed of in a hazardous waste landfill. In a process called rhizofiltration, plants are raised in greenhouses with their roots immersed in water (and eventually contaminated water) instead of soil. These plants are then planted in the contaminated area where the roots uptake the water and contaminants. These plants are also harvested and incinerated once the roots become saturated with the contaminants. Certain types of plants also immobilize contaminants in the groundwater and soil by reducing the migration, or mobility, of the contaminants (called “phytostabilization”). This process prevents the contaminants from moving from the soil into the groundwater or into the food chain.<sup>92</sup>

---

<sup>91</sup> U.S. Environmental Protection Agency. *A Citizen’s Guide to Bioremediation*. Washington, D.C.: GPO, 2001. (EPA-542-F-01-001)

<sup>92</sup> U.S. Environmental Protection Agency. *A Citizen’s Guide to Phytoremediation*. Washington, D.C.: GPO, 1998. (EPA-542-F-98-011)

To remediate organic contaminants, different plants and phytoremediation processes are used (*phytodegradation*, *rhizodegradation*, and *phytovolatilization*). Certain species of plants can use their metabolic process, or digestive process in converting energy, to destroy contaminants in their plant tissue (called “phytodegradation”). Other plants release natural substances through its roots, which supply nutrients, or food, to the microorganisms and increase bioremediation (called “rhizodegradation”). Finally, plants may also uptake water and dissolved contaminants and then releases the contaminants into the air through their leaves in a process called Phytovolatilization.<sup>93</sup>

Phytoremediation can also be used in other remediation practices to control and/or divert contamination. For example, through a process called hydraulic control, plants can influence groundwater movement. Trees act as natural pumps when their roots located above the water table rapidly uptake large quantities of water. Hydraulic controls are used in riparian (on the bank of a river) corridors and around the perimeter of landfills to control, intercept, or remediate migrating contamination.<sup>94</sup>

Plants used and studied most often in the phytoremediation process are poplar trees. Other plants include: Uncertain whether plant droppings can lead to bioaccumulation effects in animals.

**Ideal:** Phytoremediation is used to treat contaminants with low depth rates. This enables the tree roots to reach and remediate contaminants. The phytoremediation technology is easily implemented and is inexpensive compared to other remediation alternatives. The plants are also used to treat areas with low contamination levels. Phytoremediation requires a large amount of surface area for remediation.

**Not ideal:** Phytoremediation is not used to treat contaminants found at deep depths because the roots are unable to reach and remediate the contaminants. Plants used to remediate sites with high levels of remediation may die.

*Contaminants Treated:* Metals, radionuclides, organic compounds, PCE, TCE, TNT, lead, uranium, selenium, pesticides, solvents, explosives, polyaromatic hydrocarbons, landfill leachate, SVOCs and VOCs.

*Possible Tribal and/or Community Implications:*

- ? Tribes may have to decide how the introduction of a non-native species may affect their resources and landscape.
- ? The harvesting of plants with hazardous contaminants and/or the transport of incinerator ash across tribal land may require tribes to establish or expand their emergency control capabilities.
- ? When the harvested, contaminated plants are incinerated, the tribe may have to develop tribal specific air emission standards.
- ? Tribe may have to evaluate how the transfer of contaminants across media (i.e., from the soil to the air) may increase risks to their community.
- ? Tribes may have difficulty disposing high-level contamination off-site.

---

**Technology:** Pump and Treat/Pump to Contain

<sup>93</sup> Center for Public Environmental Oversight. “Phytoremediation.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/phytrem.htm>

<sup>94</sup> Center for Public Environmental Oversight. “Phytoremediation.”

## Ex situ – groundwater

*Summary:* The pump and treat technology extracts contaminated groundwater by using pump wells strategically placed about the contaminated plume. The extracted contaminated water is then treated with aboveground technologies (such as air stripping) until it meets established water standards (usually drinking water standards). The treated water is usually returned to its original location.

Although currently the most commonly deployed remediation technology to treat groundwater contamination, there are concerns regarding the effectiveness of the pump and treat technology. For example, the pumping action depresses, or lowers, the groundwater level and leaves the contaminants suspended, or attached, to the soil. When the treated water is returned to the original site, the contaminants become re-dissolved in the “clean” water, thereby re-contaminating the water. This process is known as “rebound.” The pump and treat technology can be used as a hydraulic control to contain and limit the migration of contaminated plumes.<sup>95</sup>

**Ideal:** Pump and treat technology is a well-established technology that is being used extensively to treat contaminated groundwater. Pump and treat can be used to successfully remediate contaminated sites with “simple” contamination and favorable geologic settings. This technology can also be used to contain, or control the migration, of a contaminated plume.

**Not ideal:** The pump and treat technology is usually not efficient in achieving groundwater cleanup standards (usually drinking water standards). Complex wastes, such as DNAPL, tend to bind to the soil when the contaminated water is removed and become re-dissolved in the “conditioned” water when it is returned. The pump and treat technology may require a long time (50-100 years) to achieve remediation goals.

*Contaminants Treated:* VOCs, SVOCs, fuels, UXO, and dissolved metals.

### *Possible Tribal and/or Community Implications:*

- ? Tribe may want to assess how potentially long cleanup up times, especially for complex wastes, will affect the Tribes ability to access sacred sites.
  - ? Long-term water sampling and monitoring may create training and employment opportunities for Tribes.
  - ? Since contaminants may be suspended in the soil and make it difficult to achieve clean water standards, Tribes may want to establish or enhance regulatory standards.
  - ? Because of the potential transport of hazardous waste, Tribes may want to assess their emergency response capabilities, including the costs involved.
- 

## **Technology:** Soil Flushing

### In situ – soil and groundwater

*Summary:* The soil flushing technology uses large volumes of water and often additives, such as surfactants (detergents), cosolvents, and other treatment chemicals, to flood and remove contaminants from the soil. The additives are used to increase the contaminants ability to be removed from the soil and be dissolved in the solution. The type of additive will vary depending on the contaminant treated. For example, surfactants remove oily contaminants by helping mix

---

<sup>95</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

substances such as oil and water that normally do not mix.<sup>96</sup> The soil flushing process involves the drilling of injection and extraction wells at the site. The solution is then applied to the soil or injected into the groundwater through injection wells, surface flooding, sprinklers, leach fields, and/or horizontal injection wells. The subsurface flooding raises the water table into the capillary fringe, or the area directly above the water table where the rocks and soils are saturated and high concentrations of contamination is often located.<sup>97</sup> The solution passes through the soil and “picks up” contaminants along its way as it flows toward the extraction wells. The extraction wells collect and pump out the elutriate, or the flushing solution mixed with the contaminants. The elutriate is treated by a wastewater treatment system to remove and treat the contaminants. The treated water can be recycled or transported for off-site disposal. In situ soil flushing systems that recycle the flushing solution are often referred to as injection/recirculation system.<sup>98</sup>

**Ideal:** Soil Flushing is usually deployed in contaminated areas with permeable soils (gravel, sand). These soils allow the water and additives to flow through the soil medium to reach and remove the contaminants that adhere, or are bind, to the soil.

**Not ideal:** The soil flushing technology has limited success in low permeable soils (clay or silt soils). These impermeable soils may block the water and additives flow rate and ability to reach and treat the contaminants. Thus, some contaminated areas are treated while others are not. This often leaves “pockets” of contamination in areas in proximity to low permeable soils.

*Contaminants Treated:* Metals, including radioactive contaminants, organic contaminants, VOCs, SVOCs, fuels, and pesticides.

*Possible Tribal and/or Community Implications:*

- ? After the treatment, residual amounts of the flushing additive may be located in the soil or groundwater; Tribes may need to assess how these additives may potentially affect cultural/natural resources.
  - ? Tribes may want to assess their water standards for recovered contaminated groundwater that may require further treatment to meet discharge standards.
  - ? Tribes may want to assess their emergency response capabilities because recovered contaminants may need to be transported across Tribal lands to an off-site disposal area.
  - ? The treatment of VOCs will result in air emissions; Tribes may want to assess or establish their own air emission standards.
- 

### **Technology:** Soil Washing

Ex situ – soil

*Summary:* The soil washing technology uses water, often with chemical additives, such as surfactants (detergents), to mix, wash, and rinse excavated soils to remove contaminants. The contaminated soil is first excavated and moved to an area where the soil washing technology is located. Since the soil washing equipment is transportable, this may be done on site. The excavated soil enters a soil scrubbing unit, where the soil is mixed vigorously with a washing solution (water with chemical additives). The wash water with the contaminants is drained from the soil. The contaminants are removed from the wash water before can be used again. The soil

---

<sup>96</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to In Situ Soil Flushing*. Washington: GPO, 1996. (EPA-542-F-96-006)

<sup>97</sup> Center for Public Environmental Oversight. “Soil Flushing.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/soilflus.htm>

<sup>98</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to In Situ Soil Flushing*.

is then rinsed with clean water and tested for contaminants. The “clean” soil can be used either at the site or transported elsewhere as backfill. If the soil still contains contaminants, it may be run through the soil washer again, collected for an alternative remediation technology, or disposed off-site.<sup>99</sup>

During the soil washing process, the contaminants are removed from the soil in one of two methods. First, the contaminants may be dissolved within the wash solution and then removed. The wash solution containing the contaminants is treated by wastewater treatment processes and may be recycled for further use. Second, the total volume of contaminated soils may be reduced (volume reduction). During this process, the contaminated soil is separated according to soil size. The concept of soil separation is based on the notion that fine-grained particles, such as silt and clay, contain more hazardous contaminants than coarse-grained particles, such as sand and gravel. Hazardous contaminants tend to bind, either chemically or physically, to the fine-grained soil particles. This reduced volume of soil can be treated with other remediation processes, such as incineration or bioremediation, or disposed of according to federal, state, or tribal regulations.<sup>100</sup> The “clean” soil (gravel, sand) must be tested for residual contamination.

**Ideal:** Soil washing may be used at sites to decrease the original amount of contamination. In most cases where contaminants have been reduced, a 90% reduction (10% of original volume) has been achieved. The technology works best on coarse soils (sand or gravel). These soils allow the water and additives to mix well with the contaminants. Soil washing has been reported to treat a wide variety of contaminated wastes (but not a mixture of contaminated waste). This technology can be used at sites where excavation of the contaminated site is an option. Soil washing may be used in combination of other remediation technologies, such as bioremediation and incineration.

**Not ideal:** Soil washing may have decreased effectiveness in treating a mixture of contamination. The additives, or washing solutions, may be difficult to find in treating a mixture of contamination. The technology works best on soils that do not contain a large amount of silt or clay. These soils do not allow the water and additives to mix well with the contaminants. Soil washing often does not achieve a 100% removal rate.

*Contaminants Treated:* Metals (cadmium, chromium, copper, mercury, and lead), organic contaminants, petroleum hydrocarbons, and polynuclear aromatic hydrocarbons (from the soil), and pesticides.

*Possible Tribal and/or Community Implications:*

- ? Tribes may need to establish, expand, or enhance their emergency response capability because contaminated soil may be transported across Tribal lands for disposal.
- ? Tribes may want to assess their wastewater treatment capabilities for the contaminated wastewater.
- ? Since soil washing is an ex situ process, Tribes may want to assess damage to the ecosystem and cultural resources and how this will affect access to sacred sites.
- ? Because the residual contamination may remain in the soil after the treatment, Tribes may want to develop its own regulatory levels or determine the consequences of relying on federal and/or state cleanup levels in returning the “clean” soil to its original site.

---

<sup>99</sup> U.S. Environmental Protection Agency. *A Citizen's Guide to Soil Washing*. Washington: GPO, 1996. (EPA-542-F-96-002)

<sup>100</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.



- ? Since the soil washing technology may be brought on-site, Tribes may want to assess how land and resource intensive the process will be.
  - ? Tribal member may want to be involved in the long-term monitoring of soil contamination at the site.
  - ? Tribal colleges may be able to participate in the implementation of the soil washing technology (since it can be transported on-site).
- 

**Technology:** Soil Vapor Extraction (SVE)

In situ (most common) and ex situ – soil

*Summary:* SVE separates contaminants from the soil by introducing an air flow through the unsaturated (vadose) zone, which is located above the water table.<sup>101</sup> The air flow is introduced into the subsurface through an air vent, vacuum, or injection well (often with an air compressor to aid in the process). The air flow increases the air and oxygen levels in the subsurface and causes the contaminants to vaporize, or transform into a vapor phase, and become mobile.<sup>102</sup> The volatilized contaminants are then captured and removed from the soil by a vacuum source (i.e., a vacuum pump), which is connected to an extraction well. The recovered air and the vaporized contaminants are discharged directly into the atmosphere, destroyed, or treated according to established standards and regulations.<sup>103</sup> Most SVE systems use vertical wells although horizontal wells can be constructed.

Groundwater pumps can also be used in conjunction with SVE systems to keep the groundwater from rising into the unsaturated zone. The pumps may be used to lower the water table and increase the depth of the unsaturated zone. SVE can also be used in conjunction with other remediation technologies, such as pump-and-treat, bioremediation, and natural attenuation. SVE can also be applied on excavated soils, although a large amount of space is required.<sup>104</sup>

**Ideal:** SVE is used in contaminated zones with moderately to highly permeable soils (coarser-grained soils, such as sand and/or gravel). This allows the air flow to uniformly travel throughout the soil to vaporize, mobilize, and remove the contaminants.

**Not ideal:** SVE cannot be used to treat contaminants in wet, clayey soils (low permeable soils). Overly saturated soils decrease the air flow and contaminant removal rate. These soils may also leave “pockets” of contamination in the subsurface. The SVE system cannot remove many persistent and/or hazardous materials, such as heavy oils, metals, PCBs, and dioxin. SVE cannot be used to treat contaminated soils covered by an impervious surface, such as concrete or asphalt.

*Contaminants Treated:* VOCs, some SVOCs, NAPL, and chlorinated solvents.

*Possible Tribal and/or Community Implications:*

- ? Tribes may want to establish their own air emission standards for the treated volatilized contaminants.

---

<sup>101</sup> U.S. Environmental Protection Agency. *Analysis of Selected Enhancements for Soil Vapor Extraction*. Washington: Office of Solid Waste and Emergency Response, 1997. (EPA-542-R-97-007)

<sup>102</sup> U.S. Environmental Protection Agency. *A Citizen’s Guide to Soil Vapor Extraction and Air Sparging*. Washington: GPO, 1996. (EPA-542-F-96-008)

<sup>103</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999

<sup>104</sup> Center for Public Environmental Oversight. “Soil Vapor Extraction (SVE).” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/soilve.htm>.

- ? Tribal businesses may be involved in the operation of the SVE system.
  - ? Tribal members may want to be involved in the maintenance of the SVE operating equipment.
  - ? Tribal member may want to be involved in the long-term sampling of the off-gas treatment system and conduct soil sampling.
  - ? Tribes may want to be involved in determining SVE goals, such as desired extraction flow rates, VOC concentrations, oxygen and carbon dioxide concentrations, temperature, etc.
  - ? Tribes may want to establish, expand, or enhance their emergency response capabilities if hazardous waste is transported over tribal lands for disposal.
- 

**Technology:** Solvent Extraction (passive/permeable)

Ex situ – sediments, sludges, and soil

*Summary:* The solvent extraction process uses a solvent, a fluid that can dissolve another substance, to separate or remove contaminants from sediments, sludges, and soil. Solvent extraction concentrates contaminants in the excavated soil. The solvent is thoroughly mixed with the contaminated soil in an extraction unit, or a large tank that may vary in size. Within the extraction unit, the contaminants transfer from the soil to the solvent. The solvent with the dissolved contaminants then enters into a separator. Within the separator, the soil and contaminants are separated into different components. For example, the solvents and dissolved contaminants, the soil (or “solids”), and water are separated into different components. Contaminants in each fraction will receive further treatment, be recycled, or disposed.

Sometimes the contaminant may be treated and destroyed by another remediation technology, such as incineration. Solvents used in the solvent extraction process include liquid carbon dioxide, propane, butane, triethylamine, acetone, methanol, hexane, and dimethyl ether. Solvent extraction system reduces the volume of contaminated material and is designed to operate without air emissions.<sup>105</sup>

**Ideal:** Solvent extraction should not be used at contaminated sites with sensitive ecosystems and/or culturally significant resources.

**Not ideal:** Solvent extraction is not used to remove heavy metal contamination. It has also demonstrated limited success with high moisture content soils.

*Contaminants Treated:* VOC, SVOCs, pesticides, ordnance, organic contaminants (PCBs), petroleum wastes, halogenated solvents (bromine, chlorine, iodine), and metals.

*Possible Tribal and/or Community Implications:*

- ? Tribes may want to establish, expand, or enhance their emergency response capability if the contaminants are transported across tribal land for disposal.
  - ? Tribes may want to assess the damage to the ecosystem during the excavation of soil.
  - ? Tribes may want to determine how traces of the solvent that may remain after the treatment might affect cultural/natural resource.
  - ? Tribes may want to assess how the excavation process may affect the Tribe’s ability to access sacred sites.
- 

<sup>105</sup> U.S. Environmental Protection Agency. *A Citizen’s Guide to Solvent Extraction*. Washington, D.C.: GPO, 1996. (EPA-542-F-96-003)

## **Technology:** Steam Injection

In situ – groundwater

**Summary:** The steam injection technology injects steam (at the boiling point of water) into the contaminated zone to remove and capture the contaminants. The steam is introduced into the subsurface through a system of injection wells that surround a pool of volatile contaminants in the subsurface.<sup>106</sup> Steam causes contaminants with boiling points lower than water to volatilize and mobilize, or become dislodged and move away from their original placement in the soil. During the volatilization process, contaminants transform into a vapor phase. In a vapor phase, the contaminants are much easier removed from the soil and captured at the surface. An extraction well is installed in the center of the contaminated zone to capture contaminated water and vapor and mobilized contaminants. The recovered fluids (hot water and the contaminants) must be treated at the surface. Steam generators and steam handling equipment are available and can be transported to the site.<sup>107</sup> Steam injection can be used to treat contaminants found above or below the water table.<sup>108</sup>

After the steam injection process, residual contamination may remain within the contaminated zone. Natural attenuation and/or bioremediation may be considered because microbial populations have been demonstrated to survive the steam injection process.

**Ideal:** The steam injection technology is used in permeable, coarse soils, such as gravelly and sandy types. This causes the steam to be uniformly distributed throughout the soil. This allows the steam to react and dislodge the contaminants. This technology can also be transported on-site.

**Not ideal:** Steam injection has limited success in low permeability soils, such as silt and clay, and heterogeneity soils, or a mixture of different types of soils. Heterogeneous soils may leave “pockets” of contaminated soil. The initial startup costs to deploy the steam injection technology may be high. After the steam injection technology is completed, total contaminant recovery is unlikely and residual contamination often exists.

*Contaminants Treated:* NAPL, DNAPL, and petroleum hydrocarbons.

*Possible Tribal and/or Community Implications:*

- ? Tribes may want to assess the potential effects on natural/cultural resources if residual contamination is left in the subsurface.
- ? Tribal member may be responsible for the monitoring of contaminant levels in the soil and groundwater, especially when bioremediation and natural attenuation are remediation choices after the steam injection process is completed.
- ? Tribes may want to assess additional remediation technologies that must be deployed aboveground to treat captured contaminants.
- ? Tribes may want to assess how land intensive and disruptive the construction and operation of the steam injection technology.

---

<sup>106</sup> Davis, Eva L. *Ground Water Issue – Steam Injection for Soil and Aquifer Remediation*. U.S. Environmental Protection Agency. 1998. (EPA-540-S-97-505)

<sup>107</sup> U.S. Environmental Protection Agency. *A Citizen’s Guide to Phytoremediation*. Washington, D.C.: GPO, 1998. (EPA-542-F-98-011)

<sup>108</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

- ? Because some contaminants may volatilize, Tribes may want to establish, expand, or enhance their air emissions standards.
- 

**Technology:** Surfactant-enhanced Flush

In situ – groundwater and soil (saturated)

*Summary:* The surfactant-enhanced flushing technology uses the injection surfactants into the contaminated zone to displace and remove contaminants.<sup>109</sup> Surfactants, the primary ingredient of many soaps and detergents, enhance the effectiveness of dislodging contaminants from the saturated soil.<sup>110</sup> Most surfactants are non-toxic, food-grade, and biodegradable. Surfactants are introduced into the subsurface through injection wells and flood and “sweep” the contaminated zone. The surfactants and dislodged contaminants are removed downgradient by an extraction well. Air emissions should be monitored and controlled at the aboveground treatment site. The extracted fluids are treated aboveground to separate the injected surfactants from the contaminants and groundwater. The surfactants are re-used and re-injected into the subsurface or dispose into a surface body of water or sewer. The contaminants may also be recovered and reused.

Surfactant-enhanced flush has been reported to achieve a 99% removal rate of NAPL contamination and be accomplished in weeks or months. Hydraulic controls (such as pump and treat) or subsurface containment walls may be used to contain the surfactant solution and prevent the spread of the contaminated plume. Surfactant-enhanced flush is often used in conjunction with the pump-and-treat remediation technology for removing DNAPL contamination.

**Ideal:** The surfactant-enhanced flush technology is used in soils with moderate to high permeability (sandy/gravelly). These soil types allow the surfactants to flow through the soil to flood and remove the contaminants.

**Not ideal:** The surfactant-enhanced flush is less efficient in low permeable soils (clay/silt) and heterogeneous soils, or mixed soil types often with clayey components. Heterogeneous soils may leave “pockets” of contaminated soil because the surfactants are unable to reach and react with the contaminants.

*Contaminants Treated:* Primarily for NAPL DNAPL; chlorinated solvents (most often TCE, PCE), LNAPL, and carbon tetrachloride, and VOCs.

*Possible Tribal and/or Community Implications:*

- ? Tribes may want to establish, expand, or enhance, their air emission standards.
- ? The capture of contaminants above surface may require transport for disposal across Tribal lands.
- ? Tribes may want to assess how complimentary remediation technologies, such as pump and treat and subsurface containment barriers, may affect their cultural/natural resources, access to sacred sites, and/or regulatory authority.

---

<sup>109</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

<sup>110</sup> Center for Public Environmental Oversight. “Surfactant Enhanced Recovery.” *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/surfenh.htm>

- ? After treatment, residual surfactants may be left in the groundwater or saturated soil. Tribes may want to assess if these surfactants will cause any damage to their cultural/natural resources.
- 

**Technology:** Thermal Desorption

Ex situ – soil

*Summary:* The thermal desorption technology process heats the contaminated wastes (from 200 to 1,000 F) to separate the contaminants from the soil. First, the soil is excavated and may require dewatering to achieve the appropriate soil moisture content. The excavated soil is then heated in a chamber where organic contaminants and select metals are vaporized, or transform into a gas phase. The volatilization process separates contaminants with low boiling points from the soil. The thermal desorption unit is equipped with an off-gas treatment system to capture and treat vaporized contaminants and particulates.<sup>111</sup> Residual contamination can be treated by other remediation technologies.

Depending on the operating temperatures, the thermal desorption technology can be classified into two categories: low-temperature thermal desorption (LTTD) and high-temperature thermal desorption (HTTD). LTTD operates between temperatures of 200 to 600 F and is generally used to treat soils contaminated with petroleum products in all soil types. HTTD heats wastes from 600 to 1,000 F. Because of the high temperatures, the treated soils may not be able to support microbial activity that may be important to the overall health of the ecosystem.

Unlike incineration, the thermal desorption process does not destroy contaminants. Instead, the thermal desorption technology physically separates the contaminants from the soil. The thermal desorption unit is also transportable and can often be brought to the site.<sup>112</sup>

**Ideal:** Thermal desorption has historically been used for soils contaminated with petroleum products. This technology may be employed in areas where excavation would do minimal damage to landscape and cultural resources. Thermal desorption is a transportable technology and can be brought on-site.

**Not ideal:** Thermal desorption is not used to treat mercury. This contaminant may leach during the excavation process or mobilize, or move, from the stockpiled soil. This is a particular concern around sites close to water (fish contamination). Low permeable (clay soils) will need longer reaction times to remove the contaminants.

*Contaminants Treated:* VOCs, SVOCs, polychlorinated biphenyl (PCBs), and polyaromatic hydrocarbons (PAHs), pesticides, and solvents.

*Possible Tribal and/or Community Implications:*

- ? Tribes may want to establish, expand, or enhance their air emissions standards (because of volatized contaminants).
- ? Tribes may want to assess their emergency response capability because of the potential transport of contaminants across Tribal lands.
- ? If the treated soil does not meet regulatory standards, Tribe may want to assess options they have in disposing of or furthering treating the contaminated soil.

---

<sup>111</sup> Center for Public Environmental Oversight. "Thermal Desorption." *Technology Tree*. <http://www.cpeo.org/techtree/ttdescript/thedesop.htm>

<sup>112</sup> Center for Public Environmental Oversight. "Thermal Desorption."

- ? Tribes may want to assess how the excavation and stockpiling of contaminated soil may potentially migrate (from wind and rain) and create further contamination.
  - ? The use HTTD may cease microbial activity in the returned, treated soil, which may impact and affect the health of the surrounding ecosystem.
  - ? Tribes may want to assess how the excavation of soil may impact the landscape, their cultural/natural resources, and access to sacred sites.
- 

**Technology:** Vitrification

In situ and ex situ – soil

**Summary:** The vitrification remediation technology applies an electrical current in the contaminated soil to produce extreme heat (2900 to 3650 F) and melt and immobilize the contaminants.<sup>113</sup> The molten contaminated soil is then allowed to cool. This contaminated soil then forms a hard, stable glass-like substance that encapsulates, or traps, the contaminants within the solidified soil. This reduces the ability of contaminants to mobilize, or move and spread throughout the immediate environment. The large glass-like solid cannot be penetrated by water. According to preliminary reports, the melt may require about one year to cool before subsurface sample may be collected.

The soils are heated by inserting several electrodes in the ground. As the electrical current is applied through the electrodes, the temperature may exceed 1700 Centigrade. Pieces of graphite and glass may be used to start the melting process. At this extreme temperature moves through the contaminated area, the contaminants may be destroyed or volatilize, or transform into vapor phase. Once volatilized, the contaminants move upward in the soil and to the surface. A metal hood or dome is placed over the melt to collect and treat gases, vapors, and particulates released from the melt. Because the contaminants within the soil are volatilized during this process, the vitrified, or glass-like, material has 20-50% less volume than original material. Backfill may be used to account for the loss of volume.<sup>114</sup>

The vitrification process may also be accomplished ex situ. Ex situ vitrification uses a plasma torch, an electric current, or another heat source at high temperatures (1,600 to 2,000 C) to melt and convert contaminated soil, sediments, and sludges into a glass-like substance. Similar to the in situ method, this process also immobilizes and destroys contaminants. The contaminants are encapsulated in an impermeable mass of glass, or glass “logs.” These logs are suitable for disposal in a landfill or an appropriate location for long-term storage.<sup>115</sup>

**Ideal:** Vitrification is capable of treating a variety of soil types and multiple contaminants at once. The in situ process decreases the exposure of worker and the community to contaminants. The cooled vitrified contaminants forms into a hard substance and can serve as a foundation for different types of construction.

**Not Ideal:** The vitrification process is irreversible. This means that once the glass-like contaminants are formed, it cannot be reversed into its original state. The in situ process often is

---

<sup>113</sup> U.S. Environmental Protection Agency. *A Citizen’s Guide to Bioremediation*. Washington: GPO, 2001. (EPA-542-F-01-001)

<sup>114</sup> National Research Council. *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants*. Washington, D.C.: National Academy Press, 1999.

<sup>115</sup> Torvik, Solveig. “Vitrification: How nuclear waste is turned into glass.” *Seattle Post Intelligencer*. April 19, 1998. <http://seattlepi.nwsource.com/specials/eternity/vitri1.html>.

not able to support living species, including microbial populations. There must be an appropriate and safe storage area for the “glass logs.”

*Contaminants Treated:* Organic compounds (including DNAPLs, heavy metals, radioactive compounds), hazardous and mixed waste, metals, mercury, dioxins, pesticides, herbicides, and PCBs.

*Possible Tribal and/or Community Implications:*

- ? Tribes may want to assess how the irreversible destruction of contaminated area (into impermeable glass) will affect the species that rely on the ecosystem.
  - ? Since many contaminants will volatilize during the vitrification process, Tribes may want to establish, expand, or enhance their air emission standards.
  - ? Tribes may want to establish, expand, or enhance their emergency response capabilities if the transport of vitrified materials will occur on Tribal lands.
  - ? Tribes may want to assess their ability and/or interest in storing the vitrified hazardous waste on Tribal lands.
  - ? Tribes may want to assess how the excavation of soil will impact the ecosystem and their cultural/natural resources.
  - ? Tribes may conduct long-term monitoring of soil and groundwater to ensure the entire contaminated zone is treated, and the migration of contaminants is prevented.
-

## APPENDIX 2

### GLOSSARY:

**Aeration:** to expose or supply with air; to treat or remediate a contaminated area with air.

**BTEX:** benzene, toluene, ethylbenzene, and xylene: chemical makeup of gasoline; BTEX may contaminate soil and groundwater through leaky underground storage tanks (LUST).

**Biodegradation:** the breakdown of a substance and/or contaminants by living things (such as microorganisms) into harmless products.

**Byproduct:** a secondary product that originates from the chemical reaction between the target contaminant and the substances/chemicals used during the remediation process; can either be more or less hazardous than the original contamination.

**Capillary fringe:** the zone immediately above the water table, where rocks and soil are saturated,<sup>116</sup> high concentrations of contaminants are often found in this zone.

**Carcinogen:** cancer-forming substance.

**Catalyst:** a substance that causes or accelerates a chemical reaction, or change to occur.

**Chlorinated solvents:** used widely for degreasing aircraft engines, automobile parts, and electric components; a type of contaminant found in groundwater and/or soil.

**Cleanup:** the process of addressing contaminated land, facilities, and materials according to regulatory requirements; does not imply that all hazardous contamination will be removed from the site; “remediation” is also used synonymously with cleanup.

**Corrosives:** a substance that has the ability to corrode and/or consume (i.e. an acid).

**Department of Energy (DOE):** The cabinet-level U.S. Government agency responsible for nuclear weapons production, energy research, and the cleanup of hazardous and radioactive wastes at those sites.

**Dioxin:** a hazardous substance suspected to cause cancer in humans.

**DNAPLs:** an acronym for “dense, non-aqueous phase liquids” which are oily liquids denser than water. Most DNAPLs do not degrade in the subsurface and tend to persist for long periods of time (hundreds of years) in the soil. DNAPLs are chlorinated solvents, such as wood preservative wastes, coal tar wastes, and pesticides; the most common DNAPL components are TCE and PCE.

**Elutriate:** mixture of water, a flushing solution, and dissolved contaminants; often a product of soil flushing.

**Environmental Protection Agency (EPA):** A Federal agency established in 1970 to enforce environmental laws.

---

<sup>116</sup> Center for Public Environmental Oversight. “Glossary.” *Technology Tree*. October 26, 1998.  
<http://www.cpeo.org/techtree/glossary/A.htm>



**Ex situ:** requires excavation, dredging, or other processes to remove the contaminated medium before treatment either on site or off site.

**Exposure pathways:** the course a chemical travels from the original source to an exposed organism (either human or ecological).

**Extraction wells:** a human-constructed well designed to capture and remove contaminants, water, and treated chemicals and substances from the subsurface.

**Furans:** suspected carcinogen; often a byproduct during incineration.

**Halogen:** any of the non-metallic elements fluorine, chlorine, iodine, bromine, and astatine.

**Hazards:** materials or conditions that have the potential to cause harmful effects to health, safety, and/or the environment.

**Heterogeneous soils:** a mixture or numerous soil types within a specified area or contaminated zone.

**Hydraulic control:** process where plants can control the groundwater flow through the uptake of large quantities of water during the phytoremediation process; pump and treat remediation technology can also be used for hydraulic control.

**Hyperaccumulators:** plants that absorb unusually large amounts of metals; often used in phytoremediation.

**Impermeable:** a substance that does not allow water or other liquids to penetrate.

**Injection wells:** a human-constructed well designed to introduce or insert air and/or reactive chemicals into the subsurface.

**In situ:** remediation technologies in which the contaminants are treated or removed from the contaminated zone without excavating, pumping, or otherwise moving the contaminated soil and/or groundwater to the surface.

**Innovative technology:** are newly invented processes that have been tested and used as treatments for hazardous waste and other contaminated materials; however, they still lack enough information about their cost and how well they work to predict their performance under a variety of operating conditions.

**Inorganic contaminants:** includes metals and radionuclides that are often extremely difficult to capture from the subsurface with existing remediation technologies.

**Leachate:** A solution containing dissolved or suspended materials in water that has percolated, or filtered, through solids (i.e., soils, solid wastes and rock layers); can contain hazardous contaminants.

**Microorganisms:** a microscopic plant or animal; used in bioremediation to consume and digest contaminants.

**Mixed waste:** contains both hazardous and radioactive wastes.

**Media:** specific environmental components (e.g., air, water, and soil) that are subject of regulatory concern and activities.

**Metals:** can be a dangerous contaminant in large quantities within groundwater and soil; includes mercury, lead, copper, etc.

**Organic compounds:** each molecule contains one or more carbon atom (i.e., petroleum-based fuels).

**Oxidant:** a chemical agent that oxidizes, or uses oxygen to assist in the breakdown of a contaminant.

**Oxygen:** used by microbes (during bioremediation) to detoxify, or break down, contaminants.

**Particulates (or particulate matter):** includes dust, soot and other tiny bits of solid materials that are released into and move around in the air. Particulates are produced by many sources, including burning of diesel fuels by trucks and buses, incineration of garbage, mixing and application of fertilizers and pesticides, road construction, industrial processes such as steel making, mining operations, agricultural burning (field and slash burning), and operation of fireplaces and woodstoves. Particulate pollution can cause eye, nose and throat irritation and other health problems.<sup>117</sup>

**Permeable:** a substance that allows water and other liquids to penetrate and flow through its surface.

**Permeable soils:** soils such as sand and gravel that allow air and fluids to easily pass through.

**Pesticides:** chemicals applied to plants and used to prevent pests, such as flies or mosquitoes.

**pH:** "Potential of hydrogen." This is a measure of the acidity or alkalinity of a solution. The pH scale ranges from 0 (extremely acidic) to 14 (extremely alkaline). Distilled water and neutral solutions have a pH equal to 7.<sup>118</sup>

**Phytoremediation:** A remediation technology that uses plants and trees for contaminated soil and groundwater.

**Plume:** contaminated groundwater that contains dissolved organics; usually begins from the contaminated zone and flows down gradient for some distance depending on soil and chemical conditions.

**Polychlorinated biphenyls (PCBs):** PCBs are non-flammable and chemically stable with electrical insulating properties; were used as dielectric fluid in various types of electrical equipment including heat transfer systems, fluorescent lamp ballasts, television sets, and numerous other kinds of electrical appliances. In addition, PCBs were used as plasticizers in paints, plastics and rubber products, in pigments, dyes, carbonless copy paper and many other applications. It has been discovered that PCBs are also toxic substances that are a hazard to human health and the environment; suspected carcinogen.

---

<sup>117</sup> U.S. Environmental Protection Agency. "Definition of Selected Permitting Terms." *U.S. EPA Region 9*. October 29, 1998. [http://www.epa.gov/region09/air/permit/defn.htm#Particulate%20Matter\(PM-10\)](http://www.epa.gov/region09/air/permit/defn.htm#Particulate%20Matter(PM-10)).

<sup>118</sup> Center for Public Environmental Oversight. "Glossary." *Technology Tree*. October 26, 1998. <http://www.cpeo.org/techtree/glossary/A.htm>

**Radionuclides:** substances that emit radiation because their atoms are unstable. They decay, or break down, as they release energy. The decay is a natural process.

**Reagent:** A substance used to react with another substance.<sup>119</sup>

**Rebound:** a process where contaminants become re-dissolved in “clean” water when it is returned back to the contaminated site; associated with pump and treat technology in treating contaminated groundwater.

**Remediation:** see *cleanup*.

**Riparian:** an ecological area or zone located on the banks of a river or stream.

**Saturated Zone :** an area that is soaked thoroughly with a liquid (i.e., water).

**Sediments:** fine-grained rock and mineral fragments which have settled to the bottom of a water body, such as a river or lake.

**Semi-Volatile Organic Compounds (SVOCs):** Substances composed primarily of carbon and hydrogen atoms that have boiling points greater than 200 (i.e. PCBs and PAHs).<sup>120</sup>

**Sludge:** mud-like material produced from industrial or sewage waste.

**Solvents:** a substance used to dissolve another substance or substances to form a solution.

**Subsurface:** area located beneath the surface; may include soils and groundwater.

**Surfactant:** Short for 'SURFace ACTive AgeNT' - a molecule that lowers surface tension; the active ingredients in soap, as one chemical component sticks to grease and dirt while another component sticks to the water.

**Vadose Zone :** the unsaturated zone of soil.

**Vaporize :** to transform from a visible matter to one suspended in air.

**Vitrification:** A process by which waste is transformed from a liquid or sludge into a glass-like solid. Although vitrification does not reduce radioactivity, the radioactive and hazardous wastes are stabilized in glass-like compound to prevent the contaminants from leaching or migrating.

**Volatile Organic Compounds (VOCs):** One of a group of carbon-containing compounds that evaporate readily at room temperature. Examples of VOCs include trichloroethane, trichloroethylene, benzene, toluene, ethylbenzene, and xylene (BTEX).<sup>121</sup>

**Volatilization:** chemicals change from a liquid phase to the gaseous phase. For example, during evaporation, water changes from a liquid to a vapor.

**Water Table :** depth below where the ground is saturated with water.

---

<sup>119</sup> Center for Public Environmental Oversight. “Glossary.” *Technology Tree*. October 26, 1998.  
<http://www.cpeo.org/techtree/glossary/A.htm>

<sup>120</sup> Center for Public Environmental Oversight. “Glossary.”

<sup>121</sup> Center for Public Environmental Oversight. “Glossary.”

## APPENDIX 3

### AN APPROACH FOR IDENTIFYING TRIBAL INTERESTS AND THE AFFECTS THEREON

#### Introduction

The Tribal and Community Decision-Makers Environmental Remediation Technology Matrix is an excellent tool for comparing the risks, costs, and opportunities of different environmental technologies, but the matrix can provide only as much information, insight and analysis as the interviewer obtains. The interviewer bears the burden of customizing interview questions for specific tribal audiences and for ensuring that a broad range of tribal audiences are queried. What follows is not intended to be an all-purpose questionnaire. Rather our intention is that these questions provide a starting point from which the interviewer can design tribal- and audience-specific questionnaires to elicit responses that accurately characterize the wide range of tribal and community interests and concerns that may be affected by the installation, operation, monitoring, and closure of environmental remediation technologies.

#### Potential Impacts on Tribal Regulatory Capability

These questions should be directed to the tribal legal office, environmental protection regulatory agency, tribal court, and tribal council. Before interviewing staff from these agencies the interviewer should know what, if any, process residuals, emissions, by-products, and nuisances such as noise, noxious odors, or increased traffic may result from the installation, operation, monitoring, and closure of the proposed technology. The interviewer should also know through what media such process residuals, emissions, or by-products will travel.

1. What tribal statutes, codes, ordinances, regulations, policies, and guidance are currently in place?
2. Are such statutes, codes, ordinances, regulations, policies, and guidance adequate to address any activities and impacts that may result from the installation, operation, monitoring, and closure of the proposed technology?
3. What, if any, tribal statutes, codes, ordinances, regulations, policies, or guidance will have to be enacted to address activities and impacts that may result from the installation, operation, monitoring, and closure of the proposed technology?
4. What regulatory-related cooperative agreements, memoranda of understanding, or memoranda of agreement between and among the tribe, the state, local governments, or federal agencies are currently in place?
5. To what extent, if any, will such cooperative agreements, memoranda of understanding, or memoranda of agreement have to be renegotiated?
6. What, if any, legal, technical, management, or administrative systems or institutions will have to be put in place or enhanced to address activities and impacts that may result from the installation, monitoring, and closure of the proposed technology?
7. What, if any, personnel or consultants will have to be hired?
8. What, if any, monitoring or other equipment will have to be purchased or leased?
9. What, if any, additional training will current legal, technical, management, or administrative staff require?
10. Are there legal challenges to the tribe's regulatory authority? Will tribal regulation of the installation, operation, monitoring, and closure of the proposed technology help or hinder the tribe's case?
11. How much will it cost to establish, or improve tribal regulatory capacity?

## Health and Safety

The assessment of health and safety issues is usually done via risk assessments. Health and safety risks of environmental cleanups can be thought of as a stack of coin. Generally, “risk” is a descriptor related to hazards and the probability of those hazards actually causing harm. Where hazards exist and there is no exposure to those hazards, they pose no risk of harm. In practice, the computation of worker, public health, and environmental risk is complex and accompanied by great uncertainty. For example, while the consequences of human exposure to high doses of radiation are well known (i.e., the risk of high level radiation to human health as measured in real illness or death), the consequences of human exposure to low levels of radiation are still largely unknown.

Risk has a temporal component—hazards can pose immediate or acute risks (e.g., the risk of breaking a limb as a result of slipping on an icy street) and long-range risks (e.g., the risk of dying from cancer in 2000 induced by exposure to a carcinogen in 1975) — as well as a spatial dimension (i.e., site hazards can pose risks to on-site workers, the public living near the site, and to people living far from the site (e. g., by contaminating regional water supplies)). The interviewer should craft questions that address short- and long-term issues and that address the uncertainty of long-term exposure to contaminants.

1. What tribal police, fire protection, medical, and emergency response capabilities are currently in place?
2. What public health and safety-related cooperative agreements, memoranda of understanding, or memoranda of agreement between and among the tribe, the state, local governments, or federal agencies are currently in place?
3. How will the technology address site contamination?
4. What, if any, is the possibility of an accidental release?
5. What, if any, tribal emergency procedures are needed in order to prevent, alert and address a harmful accidental release?
6. What is the cost of developing and implementing the needed emergency response procedures?
7. Will the technology require the transportation of wastes?
8. If so, how will the waste be transported?
9. What is the proposed transportation route?
10. Is it through populated areas and well traveled roadways/rail lines?
11. What is the total distance of the transportation route?
12. Are current tribal emergency response procedures capable of addressing accidents along the transportation route?
13. If not, what needs to be established or improved?
14. What, if any, site safety concerns and hazards are associated with the technology?
15. What, if any, site safety standards and procedures need to be implemented (fencing, sign postings, security measures, containment structures, etc.)?
16. What considerations need to be made in order to ensure the life-long process of health screening and monitoring of workers and of local residents?
17. Will the technology transfer dangers to human health and safety to other populations outside the surrounding area?
18. Will the technology affect local food resources? In the short term? In the long term?
19. If so, how will it affect the nutritional balance and health of the Tribe, or community?

## **Environment**

Here, too, the interviewer should know what, if any, process residuals, emissions, by-products, and nuisances such as noise, noxious odors, or increased traffic may result from the installation, operation, monitoring, and closure of the proposed technology. The interviewer should also know through what media such process residuals, emissions, or by-products will travel. Additionally, the interviewer should know how different environmental resources are used by different tribal or community audiences and should have some sense of how those resources could be affected.

1. What, if any, affects will the technology have on natural resources including:
  - a. Air
  - b. Soil
  - c. Surface water
  - d. Groundwater
  - e. Plants
  - f. Animals
  - g. Fish?
2. What affects, if any, will the technology have on the sensory attributes of surrounding areas such as sound, smell and visual aesthetics?
3. To what extent can the technology restore current environmental damages?
4. To what extent can the technology create additional environmental damages?
5. Does the technology provide some degree of reversibility in the event that geological and climatic changes and human disruption require the relocation of the waste or new technologies are developed that increase the levels of human health and safety and environmental protection?
6. How much total land will be used by the implementation of the technology?

## **Future Land-Use**

The cleanup of contaminated sites can be a long-term effort, the duration of which can be directly affected by the choice of environmental remediation technologies. The choice of technologies will also have a direct bearing on the possible uses of the contaminated site for the present and for the future. For example, natural attenuation and enhanced bioremediation technologies generally require more time to clean up contaminants to safe levels; however, these technologies do not produce process waste that require regulation, management, storage, transportation, and disposal.

Short of removing all contaminated soil, at present there are no technologies that can rid a contaminated site of the last molecule of contamination. Here too, the interviewer should craft questions that ask tribal and community members how they would like the tribe and federal agencies to deal with this uncertainty.

1. Considering contamination levels, what, if any, future land-use options are available after the implementation of the technology:
  - a. Residential
  - b. Business District
  - c. Agriculture
  - d. Industrial
  - e. Open space
  - f. Manicured parks?
2. What, if any, land use restrictions and prohibitions are associated with the technology?

3. If there are land use restrictions and prohibitions, how long will they be in place and what areas are affected?
4. Are the future land-use option(s) associated with the technology acceptable to the tribe, or community?
5. If applicable, what opportunities, if any, will the technology have to restore on-site facilities?

### **Economic Issues**

The interviewer should have an understanding of the life cycle of the proposed environmental remediation technology from basic research to closure and should consult with a wide range of tribal audiences. The interviewer should also know what supplies, equipment, and services the proposed technology requires. These may include, but are not limited to filters, shipping and storage containers, transport, protective clothing, site security, construction, and long-term monitoring.

1. What job opportunities, if any, will the technology provide to tribal and local community members?
2. How many tribal and local community members can expect employment at any given time?
3. What is the expected duration of employment?
4. What, if any, profitable opportunities are available to the tribe and community through technology implementation?
5. What is the possibility of manufacturing the technology, or components of the technology, in Indian country?
6. Can the technology be installed and/or operated by Indian/community owned businesses?
7. What external costs, if any, are imposed on the tribe or community due to technology implementation (noxious smoke, polluted water, decreased tourism and property values)?
8. Will the technology require long-term monitoring which might provide future economic opportunities that tribe/community can perform?
9. How can the tribe/community participate in the transfer of the technology within the U.S. and internationally?
10. Can tribal expenditures for regulation of the technology and associated process residuals be recovered?
11. Does the technology have the potential to be applied toward the restoration of other contamination problems affecting the tribe or community?

### **Education and Research**

The installation, operation, monitoring, and closure of environmental remediation technologies may present opportunities for tribal members, the tribe or tribal institutions and organizations to participate in, develop, or enhance education and research programs. The players involved in federal facility cleanup include the cognizant federal agency (generally the Department of Defense or Department of Energy, but also the Department of the Interior and Department of Agriculture); the federal regulator (generally the U.S. Environmental Protection Agency, but may also include the U.S. Nuclear Regulatory Commission); the technology developers (private, university, and federal including National Laboratories); and technology vendors.

Some educational opportunities are well publicized. For example, the Department of Energy operates an internship program that places college students in DOE headquarters, field offices, and National Laboratories for the summer. Other educational and research opportunities are not as obvious. For example, some environmental technologies are of recent vintage and in most

instances have not been installed in Indian country. The responsible federal agency and technology developer may have a strong interest, or could be convinced to have a strong interest, in learning how the particular technology affects different tribal interests. The tribe could expand and refine this matrix to carry out that research. And once the research is conducted, the tribe can work with the agency to present research results at industry conferences such as Waste Management and the National Defense Industrial Association environmental symposia, or at Indian and environmental justice meetings. Research results can also be written up as journal articles.

1. What opportunities, if any, are available to collaborate with the federal agency and contractor associated with the technology to provide for, or assist in developing, training and technical assistance programs to establish or improve the capability of environmental justice organizations, Historically Black Colleges and Universities and tribal colleges to conduct health, scientific, technical, policy and regulatory analyses and studies?
2. What opportunities, if any, are available for tribal/community participation in the actual research, development and/or demonstration of the technology?
3. What opportunities, if any, are available to establish education programs including internships, fellowships and scholarships for tribal and community students in mathematics, engineering and science at environmental justice organizations, federal research institutes and laboratories?
4. What educational opportunities, if any, are available for tribal and community students ages K-12 (field trips, demonstration of technology implementation)?

### **Environmental Justice**

Many of the tribe's or community's environmental justice interests and concerns, in the main, will be addressed by questions under the Religion and Culture, Tribal Sovereignty and Treaty Rights, and other topics. This point was underscored at the American Indian and Alaskan Native Environmental Justice Roundtable in Albuquerque in August 2000. The issues and recommendations produced by a diverse group of Indians and Alaskan Natives were grouped in four categories: Implementing Existing Environmental Policies; Consultation, Capacity Building; and Trust Responsibility. Rather than deal with substantive environmental justice issues here, we recommend the interviewer concentrate instead on procedural justice issues such as fairness and transparency.

1. Will the federal agency consult with the tribe or community prior to any decision on design, engineering, installation, operation, monitoring, and closure of the environmental remediation technology?
2. Will the federal agency bring off-site waste to be treated at the proposed environmental remediation facility?
3. What opportunities, if any, are available to collaborate with the federal agency and contractor associated with the technology to provide funds for retaining independent technical consultants to advise on the design, engineering and operations of the technology?
4. What opportunities, if any, will be provided to tribes and communities to independently monitor all technology operations?
5. What opportunities, if any, will be available for tribes and communities to monitor air, surface water and ground water?
6. Will the tribe be able to order operations to cease when emissions exceed standards?



## **Religion and Culture**

Many non-Indians misapprehend the pervasiveness of tribal religious beliefs and spirituality and equate protection of specific sacred sites with the protection of Indian religious and cultural interests. It is important to understand and describe, to the greatest degree practicable, the interplay between tribal religious and spiritual interests on one hand, and cultural interests on the other. Take pottery, for example. The potter may prepare herself by cleansing herself at a certain place. She may seek inspiration at another place. She may obtain her clay at another place and the raw material for dyes, glazes, and paints at still other places. Tribal weavers, basket makers, carvers, healers, storytellers, and others may carry out similar activities in similarly wide-ranging places. The interviewer should also understand that the sound of the wind blowing through a grove of trees, of water rushing over a rocky stream bed; the sight of an eagle circling overhead; and the earthy smell of the clay deposit may also be integral to the sacredness of a place and should craft questions that elicit comprehensive responses.

1. Will the installation, operation, monitoring, and closure of the proposed technology prevent or limit access to religious and cultural places?
2. Will the installation, operation, monitoring, and closure of the proposed technology produce noise, vibrations, or other results that diminish the religious or cultural value of such places?
3. Will the installation, operation, monitoring, and closure of the proposed technology produce vibrations sufficient to endanger sacred, culturally, or historically significant buildings and structures?
4. Will the installation, operation, monitoring, and closure of the proposed technology construction and operation of the technology prevent, or limit tribal access to religious sites and adversely affect the right of Indian people to practice their religion?
5. Will process residuals, emissions, or by-products from the installation, operation, monitoring, and closure of the proposed technology contaminate religious and culturally significant places or resources?
6. Will the installation of the proposed technology disturb religious, culturally, or historically significant places?

## **Tribal Sovereignty and Treaty Rights**

Generally, federal agencies and their contractors will not purposely violate the tribe's sovereignty. However, if not forewarned, agency personnel may inadvertently violate tribal sovereignty by, for example, seeking state well construction and NPDES permits instead of tribal ones. These questions, in the main, should be directed to the tribe's legal, fisheries, and timber agencies.

1. What treaties, if any, were negotiated between the United States and the tribe?
2. What rights, powers, authorities, and resources did the tribe reserve in such treaties?
3. Are there state, local government, or private challenges to tribal jurisdiction or to the tribe's exercise of its sovereign powers?
4. Are there state, local government, or private challenges to the tribe's and tribal members' exercise of treaty rights?
5. What effects, if any, will the installation, operation, monitoring, and closure of the proposed technology have on any legal challenges to tribal sovereignty?
6. Will the installation, operation, monitoring, and closure of the proposed technology enhance or hinder tribal efforts to exercise its governmental powers and authorities?
7. What effects, if any, will the installation, operation, monitoring, and closure of the proposed technology have on treaty resources such as fish or game?

8. Will the technology prevent access to tribal hunting, gathering, fishing and other sites where traditional activities occur?
9. Will the technology impair habitat of treaty-protected resources?

### **Federal/Tribal Trust Relationship and Federal Indian Policies**

The impacts of the installation, operation, monitoring, and closure of environmental technologies on the federal/tribal trust relationship are subtle since the operation of the trust obligation will often be a qualitative difference in the way certain procedures or activities are implemented and not whether such procedures or activities are implemented in the first instance. What constitutes an appropriate level of consultation or level of protection of a particular resource for a non-tribal stakeholder may be entirely inappropriate for a tribal one. To understand the impact of the installation, operation, monitoring, and closure of environmental technologies on the federal trust relationship the interviewer should have an awareness of the tribe's trust assets. More importantly the interviewer should understand and make federal agency personnel aware that the trust obligation both underlies and elevates the tribe's right to participate in the educational, economic, and other aspects of the installation, operation, monitoring, and closure of the proposed environmental technology.

1. What trust lands and trust assets such as timber, water, etc, may be adversely affected by the installation, operation, and closure of the proposed technology?
2. If process residuals and by-products must be transported, what trust lands and trust assets such as timber, water, etc, are located along planned transportation corridors?
3. Have federal agency personnel been made aware of their trust obligations regarding consultation, education, economic development, and promoting tribal governance?
4. Have federal agency personnel indicated how the federal trust obligations will be honored as part of the installation, operation, monitoring, and closure of the proposed environmental remediation technology?