Chapter 4
Green Building Technologies, Opportunities, and Issues at HTRW Sites

4-1. Contractual Issues

Possibly the most effective Green Building Technology Opportunity for HTRW sites is to incorporate Green Building considerations into the contracts for work at the site. Contracts should state that Green Building technologies are to be used where practicable and cost-effective. The USACE PARC Instruction Letter 99-2 (Appendix F) provides guidance for meeting Federal Acquisition Requirements for Recovered Material Certification (FAR 52.223-4) and Certification and Estimate of Percentage of Recovered Material Content for EPA-Designated Items (FAR 52.223-9). Following are some examples where Green Building technologies can be stipulated in contracts:

a. Stipulate that selection of high-efficiency electrical equipment (e.g., pump and blower motors) should be considered; the Energy Star Program and Federal Energy Management Program (FEMP) should be consulted.

b. Stipulate that materials used at the site (e.g., plastic liners and covers, building materials such as siding and roofing, and process tanks) should contain recycled material to the extent practicable.

c. Stipulate that materials used at the site should be selected with future recycling potential in mind and that materials taken from the site (e.g., construction debris, packaging) should be recycled to the extent practicable.

d. Stipulate that procedures and a coordinator responsible for implementing Green Building technologies be identified as part of the site work.

4-2. Paper Reduction

HTRW activities, due to the nature of mandatory reporting, have potential to require large volumes of paper. Much of this paper is used in reports (e.g., Preliminary Assessment, Site Inspection, Remedial Investigation) detailing conditions at the site. It is common to require contractors to supply numerous copies of these reports to the site managers and regulators. Considerable paper (and consequently forest resources) could be conserved by coordinating with managers and regulators to determine what portions of the reports are needed in hard copy format and what portions could be supplied in electronic format only. The use of CD-ROMs should be considered as an electronic format because of their large storage capacity. Care should be taken in the use of various electronic formats to avoid compromise of privileged information. When hard copies are needed, double-sided duplication should be used. The PARC Instruction letter

(Appendix F) provides guidance on the use of recycled content in paper and double-sided copying.

4-3. Partnering

Management of HTRW sites can be a complex process, requiring interaction among owners, managers, contractors, and regulators. Recently, the benefits of up-front cooperative decision-making (i.e., partnering) for Green Building applications at HTRW sites has been demonstrated in the areas of solid waste diversion, energy recovery and waste minimization. Since much of the decision-making at HTRW sites is regulation-driven, major benefits from the Green Building perspective can be achieved through partnering. That is, by cooperating with regulators from the start, agreements can be negotiated for compliance with regulations in a manner that provides the greatest Green Building benefits.

4-4. Waste Segregation

a. HTRW sites often consist of several sub-sites that have a variety of contaminants and varying degrees of contamination. Considerable cost and waste handling and treatment can often be avoided if wastes are segregated. Waste segregation often allows materials with low levels of contamination or with non-listed contaminants to be handled and treated differently (and often at much less cost) than those materials with high levels of contamination.

b. It should be noted that in some instances waste segregation may not be appropriate. For example, where waste volumes are very small, or where contamination is minimal, or where treatment processes dictate blending, it may not be cost-effective or environmentally beneficial to segregate wastes.

4-5. Mobilization

Energy and money can be saved if the activities (e.g., investigation activities) are planned in a way that minimizes the requirements for personnel to be on-site and that avoids repeated mobilizations to the site. The use of qualified local drilling contractors can provide a substantial energy savings compared to mobilization from great distances. Appropriate use of the USACE Engineer Manual 200-1-2, Technical Project Planning, guidance can be useful in this regard.

4-6. Management of Investigation-Derived Waste (IDW)

a. *Solid IDW (Soil, Sludge).* Considerable waste can be eliminated by managing investigation-derived waste (IDW) onsite. This can represent a significant cost savings depending on the volumes involved.

(1) Sometimes soil cuttings can be returned to the site of origin from the on-site staging area after they have been tested and shown to be "uncontaminated," shown to contain chemicals in concentrations below regulatory concern (i.e., by evaluating analytical data of samples from a boring), or by ensuring contaminants will be adequately addressed by the final remedial action. In this case, it is important to not mix cuttings from outside the area of contamination (AOC). In general, it is important to segregate waste streams from each other, and wastes from non-waste materials, so that in the event treatment is required, the amount of material to be managed can be minimized.

(2) Steel drums used to temporarily contain wastes such as soil cuttings and decontamination water can be cleaned and reused (minimizing the need for new drums) or sold for salvage. The state may also regulate waste metals, electrical equipment, and construction materials if they came into contact with hazardous site constituents, but may allow for reuse or recycling of the materials. In some cases, decontamination may be necessary.

b. Aqueous IDW. Sometimes regulatory agencies will allow decontamination and purge water to be discharged at a sampling site after the water has been sampled, tested, and shown to be "uncontaminated" or to contain chemicals in concentrations below regulatory concern. If the regulatory program and agencies will allow placing decontamination or purge water back onto the site, considerable waste can be eliminated.

(1) Alternatively, if waste water meets pretreatment requirements, it may be possible to discharge it to the local sanitary sewer. If these discharge options are not available, it may be possible to treat the water in the treatment process selected for remedial activities at the site.

(2) Otherwise this waste needs to be containerized, tested for hazardous characteristics, and disposed of (possibly in a hazardous waste facility). This can be very expensive, depending on the volumes involved. If multiple sites are sampled during a field investigation, consideration should be given to segregating wastes. If wastes from different sites are segregated, it may be possible to minimize the amount of decontamination waste that ultimately needs to be sent to a hazardous waste facility (i.e., wastes with low levels of contamination may be able to be disposed of in a municipal waste facility, such as a publicly owned treatment works).

(3) Other methods of minimizing wastes include reuse of drums and utilization of low-flow sampling methods. In particular, use of low flow (minimum draw-down) groundwater sampling methods (USEPA, 1995) results in smaller purge volumes and decreases waste disposal costs. However, it is important to remember that the sampling technique must provide representative samples and follow procedures that are acceptable to the regulators and the designer.

c. IDW Guidance. Two USEPA publications that describe management of investigation-

derived waste are: OSWER Publication 9345.3-03FS April 1992, "Guide to Management of Investigative-Derived Waste" (USEPA, 1992) and EPA/540/G-91-009, May 1991 "Management of Investigative-Derived Wastes During Site Inspections" (USEPA, 1991a). In addition, the USACE HTRW CX has a fact sheet on IDW management that can be found at the following web site: http://www.environmental.usace.army.mil/environmental/COMPLYfs.html.

4-7. Direct Push Soil Sampling

a. Where sampling with direct push equipment is both feasible and cost effective, using this technology can significantly reduce or eliminate soil cuttings and wastes. Direct push techniques can be used to characterize site media to confirm treatment processes. In addition, any in-situ technology that requires extraction or monitoring points be installed, such as soil vapor extraction, air sparging, or bioslurping, would be a candidate for direct push technologies, for installing extraction/injection wells or monitoring points.

b. An example of direct push soil sampling is the Site Characterization and Analysis Penetrometer System (SCAPS). It was developed by the U.S. Army Engineer (USAE) Waterways Experiment Station (WES) under the sponsorship of the U.S. Army Environmental Center to provide DOD with a rapid and cost-effective way to characterize soil conditions at DOD sites that are being cleaned up. The SCAPS platform is an 18,000 kg (20-ton) truck equipped with vertical hydraulic rams that force a cone penetrometer into the ground at a speed of 2 cm/s to depths of approximately 50 m in nominally consolidated fine-grained soils. The SCAPS multisensor penetrometer probes are equipped to simultaneously measure tip and sleeve resistance to determine soil stratigraphy, layer boundaries, and soil type, as well as contaminant-specific data to determine the presence of pollutants in each soil stratum. The soil and contaminant data are collected and processed in real time, which allows investigations to visualize site conditions in three dimensions.

c. The SCAPS sensors and samplers include a Laser Induced Fluorescence (LIF) Petroleum, Oil and Lubricant (POL) Sensor, an Explosives Sensor, a Thermal Desorption VOC Sampler, a Hydrosparge VOC Sensing System, and a Multiport Sampler. Few or no soil cuttings are generated by this direct-push technology. Use of SCAPS provides other advantages. The unit can decontaminate the push rods as they are withdrawn and containerize the decontamination fluids that are generated. This eliminates the need to build a separate decontamination station for drilling equipment. A trailer-mounted grout pumping system accompanies the SCAPS truck, and test holes are backfilled with pressurized grout as the push rods and probe are withdrawn.

d. For more information about SCAPS, contact: USAE Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, Phone (601) 634-2446. The web site is: http://www.wes.army.mil/el/scaps.html.

4-8. Sampling Equipment Management

a. As much as possible, sampling equipment (e.g., stainless steel scoops and bowls) should be reused after decontamination. Recycled and cleaned drums should be considered for storing IDW. Many of the "disposable" items that are routinely discarded at HTRW investigation sites can be recycled. This is true of most plastic items such as:

- Decontamination buckets and brushes.
- Tygon tubing.
- Teflon bailers and tubing.
- Tyvek clothing.
- Inner and outer gloves.
- Respirator cartridges.

b. Many DOD facilities at which USACE HTRW activities take place have active Pollution Prevention (P2) programs. Coordinating the recycling, reuse, or disposal of such items as bailers, tubing, plastic sheeting, gloves, and Tyvek protective clothing with the facility P2 Manager can minimize waste disposal and encourage recycling.

4-9. Wastewater Management

a. Sometimes, local publicly owned treatment works (POTWs) will accept aqueous wastes if they meet pretreatment requirements. Disposal of wastewater with a local POTW should be arranged in advance of the site investigation work, and it should be discussed with the regulatory agencies who will review project reports. All appropriate documentation of waste characteristics and volumes should be provided to the POTW prior to disposal.

b. Beneficial uses of the treated water (e.g., lawn and crop irrigation, constructed wetlands) should be investigated. Sprinkling water contaminated with low levels of VOCs in sprinkler irrigation systems can be used as a "disposal" method, and it can be used to air-strip the VOCs at the same time. The use of constructed wetlands for treatment is an immediate beneficial use of the water, providing green space and ecological habitat. However, providing ecological habitat may have negative effects if bioaccumulating contaminants are present. If beneficial uses of treated water cannot be found, discharging the water to a local sanitary sewer should be considered.

c. State or local authorities may allow discharge of treated water to the ground surface. An NPDES permit may be required if the water is to be discharged to a river, stream, waterway, or other location that can be defined as a "water of the state" or "water of the United States."

Some states define road ditches, or other normally dry drainage ways, as waters of the state if

discharge to the drainage way could potentially reach surface water or groundwater.

4-10. Plastics Management

a. Most plastic items used for decontamination and sampling activities (e.g., plastic sheeting, tubs, buckets, brushes, and scrapers) are recyclable thermoplastics. These waste streams will be low volume, and bulk sale of these items is unlikely. Most items will probably have to be shipped directly to a recycler or handled through the facility P2 program. Used liners and covers should be recycled. Liners and covers should be made of recycled material where feasible. Air stripper packing should be made of recycled material. Packing material should be reused for subsequent operations if possible.

b. Generally, recyclable plastic products are made of high density polyethylene (HDPE), which includes items such as milk jugs; low density polyethylene (LDPE), including items such as polyethylene film and plastic bags; or polyethylene terephthalate (PET), including items such as soft drink bottles and clam-shell packaging.

c. The American Plastics Council maintains a nationwide list of plastics recyclers. They can be reached at (202) 974-5400 (Toll Free, 800-243-5790). In addition, planners should check with state recycling programs for information regarding recycling opportunities. Any recycling service shall be procured in accordance with Federal Acquisition Regulations.

d. Note that geomembranes and geonets used in landfills should typically not be made from recycled materials owing to the long life required by the geosynthetics. It is acceptable, however, to use regrind material in the manufacture of geomembranes and geonets. Regrind material is composed of the material created while trimming geomembranes during the manufacturing process. Some geotextiles are manufactured using recycled material. This material may be used in some non-critical applications (such as erosion control) for construction.

4-11. Occupational Health and Safety Program: Personal Protective Equipment Management

a. Recycling and reuse of materials are the primary viable Green Building opportunities for management of Personal Protective Equipment (PPE). To ensure use of Green Building technology opportunities, Green Building management practices should be specified in the Site Safety and Health Plan that is required in USACE ER 385-1-92 for all HTRW site investigation and remediation work.

b. Items such as hardhats and boots are routinely reused. Other items of PPE, such as Tyvek coveralls, gloves, and respirator cartridges, are routinely discarded. PPE waste streams are usually of low volume at HTRW sites, so sales of bulk quantities of materials to recyclers are

unlikely. Recycling may still be possible by sending materials directly to a nearby recycler. DuPont has established a network of 80 recyclers across the U.S. who currently accept uncoated Tyvek and a network of 28 recyclers who accept coated Tyvek. A listing can be obtained by calling 1-800-44-TYVEK. Recycled Tyvek is suitable for applications such as plastic lumber, toys, construction fencing, park benches, and mud flaps. A barrier to recycling PPE is contamination, which may necessitate decontamination prior to recycling.

c. In addition to recycling and reuse, waste can be saved by not using more PPE than is required. For example, where site conditions permit, washable cotton and cotton/polyester blend coveralls may be used instead of disposable Tyvek coveralls. Launderable coveralls in many cases provide adequate protection in addition to reducing the PPE waste stream and associated costs. An added occupational health benefit of using launderable coveralls is the reduced heat load and heat stress for the worker because of the inherent moisture permeability of the cotton coveralls (see Chapter 5, Success Stories, Paragraph 5-4, Use of Cotton Coveralls Instead of Tyvek).

4-12. Efficient and Properly Sized Electrical Motors and Blowers

a. The selection and use of electrical equipment, including motors and blowers for USACE applications, is governed by CEGS Section 16415, Electrical Work Interior. Some rationale for using efficient electrical systems include the following.

b. Use of efficient and properly sized electric motors for blowers, pumps, and mixers can reduce energy requirements for remediation systems and building systems such as heating and air conditioning. For example, oversized blowers have to be throttled or have dilution air added. Throttling results in direct energy consumption. Dilution reduces the efficiency of subsequent off-gas treatment processes, such as activated carbon adsorption, thereby requiring more carbon to be used, or if off-gas is burned, more fuel is required to bring the dilution air to the combustion temperature, and the inherent fuel value of the off-gas is reduced.

c. Efficient electrical equipment may require a higher capital cost than standard motors. However, energy-efficient equipment saves money through using less energy, and it benefits the environment by using less electricity and consequently causing less air pollution from electrical generation.

4-13. Activated Carbon Management

a. Spent activated carbon can be disposed of in an appropriate waste facility, regenerated on-site, or returned to the supplier for regeneration. The choice between disposal and regeneration will depend primarily on the volumes involved and on the waste treated. Disposal results in a loss of activated carbon and no destruction of contaminants. Thermal regeneration

saves activated carbon and destroys organic contaminants but requires energy. Steam regeneration allows reuse of the activated carbon, but it does not destroy contaminants. Activated carbon is more likely to be regenerated if a specialty contractor is used to bring it on-site and to pick up the expended carbon when it needs to be replaced. Note that the cost of regeneration may be lower than the cost of disposal if the regeneration facility is close enough to keep transportation costs low.

b. The need for exhaust air treatment depends on factors such as the type of contaminants present, concentrations, and local air regulations. Up-front discussions with regulatory agencies, and perhaps air pathway modeling, should be conducted to weigh the environmental impacts associated with treating the exhaust air compared to discharging it to the atmosphere.

c. Rather than using activated carbon to adsorb contaminants in exhaust gas, resulting in carbon waste which needs disposal or regeneration, the exhaust gas could be thermally or chemically oxidized to destroy organic contaminants. This alternative will likely require higher capital costs and use more energy than activated carbon with disposal. However, energy use may be comparable to that necessary to regenerate activated carbon.

4-14. Process Optimization

a. It may be possible to save energy by optimizing the way remediation systems operate based on factors such as spacing and orientation of injection and pumping wells and injection and pumping rates for groundwater remediation. Locating treatment units (e.g., incinerators) near the waste sources can minimize fuel use for transporting contaminated media to the treatment unit and treated media to disposal sites.

b. Energy can be conserved by staging operations to minimize handling and transporting contaminated media.

c. Wastes, such as plastic sheeting, can be saved by optimizing the size of treatment units, such as decontamination pads. The components used to construct a decontamination pad should also be reviewed to ensure that the pad is not more complicated than necessary.

d. Oxygen monitoring can be used to optimize air flow rates at bioventing, biopile, and composting operations, and it can be used to ensure that adequate oxygen is present for biological activity. Oxygen concentrations beyond these levels do not significantly enhance the biological activity. The efficiency of technologies such as bioventing can often be improved if the process is designed to treat contaminants in-situ, thus avoiding the need for ex-situ treatment.

e. Energy can be saved at soil vapor extraction sites by minimizing flow rates or by cycling pumps after the removal of contaminants has become diffusion-limited. Using air

injection methods rather than extraction/injection methods where possible can save energy and resources. In addition, the use of dilution air to control vacuum should be avoided.

f. Matching the requirements of solidified waste with the use of solidification amendments could save resources such as cement or could encourage use of waste materials such as fly ash. For example, arbitrarily high unconfined compressive strength requirements should be avoided in non-critical applications. Also, using specialized solidification reagents such as phosphates or silicates may reduce the amount of cement needed to solidify contaminated soils.

g. Investigation costs and wastes can be minimized by optimizing analytical needs. Only chemical testing that is required to meet the needs of the project should be done. For example, if it is known that petroleum hydrocarbons are the chemicals of concern at a site, it may not be necessary to test for unrelated chemicals, such as pesticides. In addition, it generally is not necessary to specify detection limits that are more stringent than those required to make site remediation decisions (e.g., risk-based levels).

h. Remediation system efficiency should be periodically evaluated in accordance with the Remediation System Evaluation (RSE) Instruction Guide available to USACE personnel at http://w3.environmental.usace.army.mil/library/guidance/remcheck/remcheck.html. Use of the USACE EM 200-1-2 Technical Project Planning guidance can be helpful to ensure that site activities are efficiently planned and carried out.

4-15. Piping/Process Equipment Recycling/Reuse

a. Piping and electrical wiring from process equipment may be recyclable. Process tanks and other equipment may also be able to be recycled or reused. Electrical and control equipment can often be salvaged and reused. When designing remediation process equipment, consideration should be given to using materials with recycled content and to using materials that can be reused or recycled. This could include piping, tanks, and plastic liners. Materials and equipment that have come into contact with contamination may need to be decontaminated before recycling or reuse.

b. There is a fact sheet at the HTRW CX homepage on how to manage scrap metal that may be sent for recycling. The fact sheet can be accessed at: http://www.environmental.usace.army.mil/info/technical/comply/complys/complys.html#guidance.

4-16. Use of Packaged or Skid-Mounted Treatment Vessels

a. Where possible, packaged treatment vessels or remediation equipment should be used so that they can be reused after treatment is finished. This will eliminate the need for trying to recycle parts of the reactors and disposing of parts that can't be recycled.

b. As an example, Corps of Engineers Guide Specification CEGS 11225 discusses the requirements for the use of modular (packaged) treatment vessels for treatment with activated carbon. The CEGS states that, "Transportable units should be considered for units containing less that 900 kg (2,000 pounds) of activated carbon...," and that, "Modular units need not be new if pressure rating and all other requirements of this section are met."

4-17. Plant Tissue Residue Management

a. It may be possible to find beneficial uses for plant tissue derived from processes such as phytoremediation or from brush clearing rather than disposing of them in a hazardous waste facility. For example, it may be possible to burn these materials for energy (e.g., as firewood, in cement kilns, or in incinerators). The materials may be shredded and used for mulch or soil amendments (e.g., for composting operations or pretreatment materials for soils requiring incineration). Woody vegetation may be used for paper pulp, firewood, or construction material, rather than being disposed of in a hazardous waste facility. The use of these materials likely depends on the level and types of contaminants present.

b. State or local requirements may require management of the plant tissue as hazardous waste, if regulatory threshold concentrations are exceeded. Even if the wastes are not defined as hazardous, they may be defined as "special" or industrial solid wastes, with more restrictive management and disposal requirements than municipal solid waste. Therefore, up-front discussions with regulatory agencies are needed in the project planning.

4-18. Resource Recovery From Treatment Sludges

Depending on the contaminants that are present (e.g., precious metals) and on the volumes of waste generated, it may be feasible to further concentrate the contaminants and to use another technology (e.g., mining technologies) to recover them for recycling. This is likely to be practical only where one principal contaminant is recovered and where that contaminant has a relatively high resale value (see Chapter 5, Success Stories, Paragraph 5-3, Ashland 2 FUSRAP Site: Recycling Uranium Tailings).

4-19. Reuse of Treated Soils and Soil Residues

a. Where treated soil cannot be replaced in the original excavations, consideration should be given to using the treated soil for beneficial purposes, such as construction fill, landfill cover material, or asphalt additive.

b. Stabilizing reagents from local waste streams, such as fly ash, should be considered for soil stabilization. If treated soil can be used for beneficial purposes, it may be possible to leave the excavation unfilled and use it for aquatic or wetland habitat (see Chapter 5, Success

Stories, Paragraph 5-6, IAAP: Innovative Use of excavations and Dredged Material). If the stabilized soil can be used for beneficial purposes, it may be possible to recover some of the cost of the stabilization process.

c. Up-front partnering with regulatory agencies may be useful in obtaining permission for final disposal solutions (e.g., using stabilized soil for construction fill and using the unfilled excavation for aquatic habitat). In addition, up-front discussions about the engineering properties (e.g., compressive strength) of the treated soils may result in more optimum use of resources and waste materials.

4-20. Stormwater Management

Limiting the quantity of precipitation and resulting stormwater that contact contaminated media (e.g., excavations with residual contamination, soil stockpiles, bioremediation piles) will conserve energy and treatment resources, such as activated carbon, by limiting the amount of water that needs to be treated. Stormwater can be managed by use of covers, liners, and flow diversion ditches and berms.

4-21. Use of Waste Organic Materials and Agricultural Wastes

Local waste material (e.g., agricultural waste such as corn cobs, feedlot bedding) should be considered as soil amendments for composting or pretreatment before incineration.

4-22. Use of Excavations For Aquatic Habitat

If treated soil can be used for beneficial purposes such as construction fill or landfill cover, it may be possible to leave excavations unfilled and use them for aquatic or wetland habitat (see Chapter 5, Success Stories, Paragraph 5-6, IAAP: Innovative Use of excavations and Dredged Material). Care must be taken, however, when residual contamination (especially bioaccumulating contamination) remains in the excavations. In addition, it may be necessary to obtain a CWA 404 Dredge and Fill Permit from the USACE when creating or altering a wetland.

4-23. Use of Incinerators For Waste to Energy Processors

Depending on the planned operation schedule, the location of the treatment facility, and on the media and contamination to be incinerated, it may be possible to use incinerators or other thermal processors in a waste-to-energy operation. Wastes that could be used for energy might include used tires, wood, recovered fuels, or recovered solvents (see Chapter 5, Success Stories, Paragraph 5-2, Holloman Air Force Base: Waste to Fuel). In addition, the fuel value of extracted gasses (e.g., from landfills) should be considered.

4-24. Use of Dredged Material/Lake Rehabilitation

When topsoil is needed for a site, it may be possible to get it by dredging a local water body. This can provide excellent topsoil, while removing unwanted sediment from the water body (see Chapter 5, Success Stories, Paragraph 5-6: IAAP: Innovative Use of Excavations and Dredged Material). The dredging should be done with the oversight of local wildlife agencies so that it improves aquatic habitat in the water body. Note that it is necessary to obtain a 404 Permit from the USACE when dredging from a water body identified as "waters of the United States."

4-25. Building and Building Material Management

a. Where possible, use of existing buildings at or near the HTRW site should be considered. This will eliminate significant amounts of building materials and wastes if buildings need to be dismantled. If existing buildings cannot be used, it may be possible to construct a building that will have a use after HTRW activities are finished. The buildings could be sold or transferred as appropriate. This will reduce waste because demolition will not be necessary.

b. When planning building construction, prefabricated buildings should be considered because they typically create less waste than buildings constructed on-site. When planning and constructing buildings that will be dismantled after HTRW activities are finished, the potential recycling and reuse of building components should be considered. For example, concrete rubble may be used as fill, or crushed and used in new concrete, or used directly as road cover. Electrical equipment, heating equipment, plumbing and fixtures, and ventilation blowers can be salvaged and reused. Sheet metal can be recycled. Wood sheeting and dimensional lumber can be salvaged and reused, or used as fuel. Windows and doors can be salvaged and reused (see Chapter 5, Success Stories, Paragraph 5-1, Mead Army Ammunition Plant: Use of Concrete Rubble for Construction).

c. Insulation should be made of recycled materials. For example, cellulose insulation is made from recycled paper or cotton waste. Managers should stipulate that no CFCs be used as the propellant when blowing insulation into building spaces.

d. Consideration should be given to the "embodied energy" of materials selected for construction of HTRW buildings. Embodied energy is the energy required to extract, transport, process, install, and dispose of or recycle the materials. As examples, the embodied energy ratings of several materials are as follows: concrete is 1.2 – 2, lumber is 4 – 7, particle board is 14 – 20, and steel is 25 – 39 (Cole and Rousseau, 1992). More information can be found on the Federal Energy Management Program's (FEMP) web site (http://www.eren.doe.gov/femp/greenfed/).

e. USACE criteria for Sustainable Design for Military Facilities provides guidance to

designers of new Army facilities, as well as the rehabilitation/renovation of existing facilities (see Paragraph 3-1 for more details). In addition, the NIST computer program, BEES (Building for Environmental and Economic Sustainability), provides planners a PC-based life-cycle assessment tool to help them select building materials that are both environmentally friendly and cost effective.

f. Economic analysis (and decision analysis) tools for energy-saving Green Building technologies can be found in the FEMP web page. The FEMP web page provides access to the National Institute of Standards and Technology's "Building Life-Cycle Cost" computer program, which helps evaluate costs and benefits of energy conservation projects in facilities. The program can calculate annual and life cycle CO_2, SO_x, and NO_x emissions for building energy systems. While this program is intended for permanent facilities, the information could be useful for selecting equipment for HTRW facilities as well. The site also provides access to the NIST life cycle analysis program (BEES). Another web page that provides useful information regarding energy-efficient motors can be found at: http://energy.copper.org/motorad.html.