Pollution Prevention Assessment for the Brookhaven National Laboratory Graphite Research Reactor (BGRR)

July 2000

Executive Summary

The U.S. Department of Energy (DOE) Office of Technical Program Integration, Pollution Prevention Team (EM-22), with the Office of Site Closure (EM-34) and the Office of Project Completion (EM-40), have recognized the importance of integrating pollution prevention and waste minimization (P2/WMin) into the remediation and decommissioning activities taking place across the DOE complex. Using P2/WMin techniques can reduce the risks associated with waste management and can reduce waste volumes and waste management costs. Reducing waste volumes directly affects project baseline costs and assists the project manager in achieving efficiency goals and cost savings.

The Pollution Prevention Team developed a P2 assessment methodology to assist sites in identifying cost-saving and waste volume reduction opportunities during environmental cleanup. Two pilot assessments were performed to test the methodology during FY-1999: one at the Laboratory for Energy-related Health Research (LEHR) in Davis, CA, and one at the Rocky Flats Environmental Technology Site (RFETS). Both pilot assessments were successful in identifying P2 opportunities which would reduce project baseline costs and reduce forecasted project wastes. In FY-2000, the P2 assessment methodology was formalized and Brookhaven's Graphite Research Reactor Decommissioning Project (BGRR) was chosen for the third P2 assessment. The P2 assessment took place on February 23 and 24, 2000.

The LEHR and RFETS sites were chosen for P2 assessments because they fit the criteria defined in the methodology: 1) accurate and documented baseline waste forecasts and budget information, 2) project personnel available to assist in the assessment, 3) no adverse affects on the project schedule, and 4) completion and documentation within a short time period. The BGRR project was chosen for a P2 assessment because of the initiative of the BGRR project team and the DOE BGRR Project Manager. The project team was proactive in searching for the best, most cost-effective methods to decommission the BGRR. They requested several studies and assessments, including this P2 assessment, to be performed independently of their planning efforts, to target appropriate opportunities and process improvements they may have overlooked.

The P2 assessment methodology includes the use of a team of experts, with varying areas of expertise, drawn from across the DOE complex. These experts apply lessons learned from around the complex and from their particular site or program to target their knowledge and identify innovative ideas and approaches to specific site concerns. The experts for the BGRR P2 assessment were identified and selected based upon the types of contaminants, waste forms, and issues associated with the BGRR cleanup project and based on their personal application of techniques and technologies for resolving these issues. The BGRR P2 expert team included members with expertise in the areas of waste management, material recycle/reuse, asset sales, residual radiological release standards, innovative treatment technologies, systems engineering, life-cycle assessment, and pollution prevention/waste minimization. The BGRR assessment team also included a Project Manager from the DOE Office of Science and Technology (EM-50), Large Scale Demonstration and Deployment Project Program, in Morgantown, WV. Several P2 opportunities using EM-50 technologies were identified during the P2 assessment.

The P2 assessment focused on BGRR activities where problems or concerns existed concerning proposed waste disposition options and/or costs for waste disposal. The DOE Project Manager was interested in reducing the baseline cost of the decommissioning project and requested assistance in finding methods to reduce waste volumes and overall project costs.

The BGRR project team, under the leadership of DOE and Bechtel National, Incorporated, has integrated value engineering principles and best practices into the project planning phases of the BGRR project since its inception. During the P2 assessment, the P2 assessment team noted numerous practices and techniques being deployed by the BGRR project team that have reduced waste and/or reduced project costs. These practices, reviewed by the P2 assessment team and validated as best practices, are discussed in Subsection 4.2 of the report. These successes should be shared with other sites to encourage the integration of good ideas into all DOE projects.

The project activities chosen for the BGRR P2 assessment consisted of the BGRR Removal Action Alternative 4 work scope areas, including the common elements.   These activities included removal of the fans and decontamination of the Fan House; removal of the pile fan sump; isolation of Building 703 from Building 701; removal of the remaining soils found to be contaminated above the Derived Concentration Guideline Levels (DCGLs); and removal of the below ground ducts, filters, coolers, Instrument House, Canal House, Water Treatment House, and the Above Ground Ducts. The dispositioning of Building 701 and the removal of Building 701 experimental equipment were also included in the P2 assessment.

In addition to the above-mentioned activities, the BGRR project team also requested that the P2 assessment team review the alternative of removing the graphite pile (Building 702).

The waste volume estimates for soil and debris (approximately 187,000 cubic feet of radiologically contaminated and 23,000 cubic feet of clean soil and debris) are by far the largest waste types by volume expected to be generated during decommissioning activities. The contaminated metal waste estimate of approximately 2 million pounds also provided the P2 assessment team with an additional focus area for an assessment during the site visit. The soil, debris, and contaminated metal waste streams account for over 85 percent of the forecasted waste volumes from the BGRR decommissioning project. The P2 assessment team targeted these particular waste streams and concentrated their expertise on identifying methods and techniques to reduce the amount of these wastes being shipped offsite as low-level waste.

A summary of the P2 opportunities identified by the P2 expert team in conjunction with the BGRR project team are discussed below. Details of the opportunities are presented in Section 6 of this report. Three broad categories of P2 opportunities are discussed: General P2 Opportunities, Above Ground Duct Removal Action P2 Opportunities, and Metal and Materials P2 Opportunities.

General P2 Opportunities

These opportunities are not task-specific and pertain to the general type of activities taking place at the BGRR. These opportunities can provide even greater savings (return-on-investment) in costs, efficiencies, and waste volumes if they are deployed on every cleanup action taken at BNL, and if contractually required of subcontractors during cleanup tasks. Direct cost savings to the BGRR project are not identified because the applications and cost savings vary depending on the activity, waste type, work plan, and waste volume. The P2 assessment team recommends that the BGRR project team more fully evaluate use of the following techniques/technologies during the BGRR project.

- *Personalized Ice Cooling System (PICS*) - Use PICS to reduce worker heat stress and increase worker efficiency by increasing worker stay times in controlled areas. Cost savings are accrued based upon more efficient labor and reduced equipment and disposable personal protective equipment (PPE) costs.

- *Heat Stress Monitoring System* - Eliminate heat-stress situations through real-time monitoring of workers' vital signs. The MiniMitter VitalSense Telemetry System was demonstrated at DOE Hanford by Bechtel Hanford and EM-50 and provided improved worker efficiency (increased stay times) and improved worker safety.

- *Launderable Personal Protective Equipment* - Use launderable (reusable) PPE rather than disposable PPE. This can reduce project costs for PPE by 60 percent.

- *Define Soil/Debris Segregation Limits* - Segregate soil and debris into lots based upon approved site cleanup levels. Soil/debris above 23 pCi/g Cs-137 could be shipped offsite as low-level waste. Soil/debris between background and 23 pCi/g Cs-137 could be used as onsite fill. Soils/debris not above background levels could be released and used as offsite fill. The BGRR has approximately 157,00 cubic feet of soil to be remediated in accordance with the baseline. If 80 percent of the soil could be segregated and used on site as fill rather than disposed of off site, the BGRR could save approximately $1.7 million in disposal costs alone.

- *Sequence Offsite Waste Disposal Transportation with Princeton Plasma Physics Laboratory (PPPL)* - Investigate potential teaming arrangements with PPPL and the Tokamak Fusion Test Reactor (TFTR) decommissioning project when shipping low-level waste to a commercial disposal facility. Sharing rail or other transportation costs between the two DOE sites could offer greater cost efficiencies.

Above Ground Ducts Removal Action

The Above Ground Ducts Removal Action is estimated to generate approximately 9,200 cubic feet of radioactive concrete. Even though the BGRR project team has recently awarded the removal action work scope to a subcontractor, the P2 assessment team felt that the P2 opportunities identified were still viable and should be considered:

- *Recycle/Reuse Crushed Concrete Ducts Onsite as Fill* - Reduce the concrete ductwork to rubble onsite using a concrete crusher transferred/borrowed from the DOE Ohio Field Office. Crushed concrete meeting the approved release limits could be segregated and used as fill onsite, possibly for the Below Ground Ducts Removal Action. The savings to the BGRR project could be accrued from reduced waste transportation, processing, and disposal costs.

- *Spectro Xepos X-ray Fluorescence (XRF) Analyzer* - Use of the XRF Analyzer for PCB and heavy metals sample collection, preparation, and analysis is six percent of the cost of traditional laboratory analysis and provides results in minutes, rather than in the 90 days typically needed for laboratory analysis results. The BGRR project should examine the benefits of using this technology for detecting PCB content in the painted surfaces of Above Ground Ducts.

- *Diamond-Wire Cutting with Liquid Nitrogen Cooling* - Evaluate the use of liquid nitrogen for cooling during potential diamond-wire cutting operations. Diamond-wire cutting for reinforced concrete is the typical technology utilized by demolition companies. Use of liquid nitrogen could eliminate the generation of any secondary wastes from using water as the cooling agent.

- *Diamond Concrete Shaver* - Evaluate the use of the diamond concrete shaver for the inside and outside surfaces of the Above Ground Ducts. The diamond concrete shaver reduces worker fatigue, is five times faster than traditional scabbling tools, and leaves a smoother surface for more reliable radiological release surveys. The diamond concrete shaver is also 50 percent less costly to operate due to increased productivity.

BGRR Metals and Materials

During the original development and drafting of this section of the report, the July 13, 2000 Secretary's Office Announcement regarding the release of scrap metal from radiologically controlled areas had not been issued. While this Secretarial Announcement effects the release of scrap metal to general commerce, it is unclear at this juncture what degree it will effect the BGRR P2 metal recycle recommendations. Consideration will need to be given to several factors including: the DOE Headquarters requirements for the release of clean scrap metal from radiological areas, the BNL schedule for implementing those DOE requirements, and the BGRR project teams schedule for the release of scrap metal. However, based on current guidance at this time, the restricted internal shield block reuse option detailed in this section is not only viable but now endorsed through the Secretary's direction as outlined in the July 13 memo.

The P2 assessment team assumed the BGRR project would have only two dispositions available for metals and materials (equipment). Metals that are known to have or are suspected to have radiological contamination, because of the nature of the contamination and the challenges of off-site release, are treated as scrap metal. Metal not suspected to be radiologically contaminated are segregated onsite by physical and administrative controls and verified as clean by process data, historical knowledge, and verification surveys. The metals are then sent to an offsite recycling facility.

The current BGRR estimate for excess metals and equipment consists of approximately 500 tons of potentially radiologically contaminated material and 27 tons of clean material. Some of this metal and equipment is coated with a paint formulated with PCBs. The P2 assessment team has provided the BGRR project team with an overview of the new TSCA Megarule (Appendix B), which allows these coated metals and equipment to be treated as PCB Bulk Product Waste, with allowances that will save the BGRR project time and waste management costs. The TSCA Megarule amendments provide the BGRR with several disposition alternatives for this PCB-painted material rather than full characterization, laboratory analysis, thermal or chemical processing, and disposal of the residuals as TSCA waste. If notifications are made to the state regulatory agency, the BGRR project team can send the paint-coated PCB material to a state-permitted municipal or non-municipal, nonhazardous waste landfill. If the paint is scraped off the metal surface, which can be done without TSCA approval, the two waste streams can be dispositioned separately. The metal can be reused, based upon a visual inspection of the surface verifying it is clean of paint, and the removed paint can be sent to a nonhazardous municipal landfill. Smelters can now take metals and equipment with PCB-formulated paint on the surface and, with the facility's assertion that the operation meets the Megarule requirements, simply notify the EPA of their intent to dispose of PCBs.

Using the Megarule provisions, the BGRR metals and equipment can be dispositioned as either clean or as radiologically contaminated, eliminating the need to manage the metals or equipment as TSCA waste. The four disposition alternatives identified by the P2 assessment team for BGRR metals and materials (equipment) are:

1) Send clean metal/material to an industrial landfill;
2) Send clean metal/material to an existing BNL scrap metal contractor for recycle;
3) Send radiologically contaminated metal/material to a low-level waste disposal facility; and
4) Send radiologically contaminated metal/material to a smelter for beneficial reuse as shield block.

The P2 recommendations for clean and radiologically contaminated BGRR metals and materials are outlined below.

<u>Clean Metal</u>: *Disposal as Industrial Waste versus Utilizing Existing Clean Metal Scrap Contract* - In the P2 assessment team's cost analysis, it was assumed that the BGRR project could use local transportation and pay regional landfill fees for disposal with no additional sizing requirements beyond the initial removal. The total cost for industrial landfill disposal is estimated at $20 K.

Under the scrap metal recycle alternative, the BGRR project could utilize existing recycle contracts at BNL and would incur no additional cost for ultimate disposition of the material, beyond the initial staging costs. The recycle option for the clean metal allows the BGRR project to utilize the potential asset value of the material to achieve disposition of the metal in an environmentally sound manner while achieving a project cost reduction.

<u>Radiologically Contaminated Metal</u>: *Disposal as Low-Level Radioactive Waste Versus Recycle/ Reuse as Shield Block* - When considering the two disposition alternatives for the contaminated metal, the results are so close they can be considered equal to the BGRR project baseline of $3M for disposal (when considering a number of assumptions in the analysis). However, the net benefit to the DOE Office of Science for the acquisition of the shield block (a credit of approximately $1 M at $.50/lb) pushes the decision in favor of the recycle option, both in terms of cost and in net environmental benefit. The P2 assessment team recommends that this net benefit to DOE be considered when the BGRR project team makes its final determination on which contaminated metal disposition alternative to pursue.

The P2 assessment has provided the BGRR project team with the initial information necessary to perform a quantitative analysis of the identified P2 opportunities in order to determine the true life-cycle cost of the alternatives. It is recommended that the project team conduct a thorough evaluation of the P2 alternatives and involve the stakeholders and regulators in the decision process.

The results of any pilots, demonstrations, or implementation successes resulting from the P2 opportunities identified during this assessment should be published on the DOE's Lessons Learned website **(http://www.em.doe.gov/lessons)**, as well as on EM-50's technology websites. This will ensure that other DOE sites are made aware of successful applications of P2/WMin techniques and technologies.

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1.0 Pollution Prevention Assessment Background

The U.S. Department of Energy (DOE) Office of Technical Program Integration, Pollution Prevention Team (EM-22), with the Office of Site Closure (EM-30) and the Office of Project Completion (EM-40), have recognized the importance of integrating pollution prevention and waste minimization (P2/WMin) into the remediation and decommissioning activities taking place across the DOE complex. Using P2/WMin techniques can reduce the risks associated with waste management and can reduce waste volumes and waste management costs. Reducing waste volumes directly affects project baseline costs and assists the project manager in achieving efficiency goals and cost savings.

Over the last several years, the Pollution Prevent Program together with the Office of Environmental Restoration have developed numerous tools and resources to assist environmental restoration (ER) project managers and project teams in the effective integration of P2/WMin techniques into ER projects. The existing pollution prevention tools and resources have been geared toward administrative (guidance and training) and planning (case studies, guides, tracking, and technique listing) activities, but have not been directed at actual opportunity identification and implementation assistance. To move toward implementation, a pilot P2 assessment methodology was developed and funded by EM-22 in FY 1999. The location for the initial P2 assessment pilots was chosen based upon several criteria, including: 1) the site or project would have accurate and documented baseline waste forecast and budget information, 2) site project personnel were available to assist in the assessment, 3) the assessment would not adversely affect the project schedule, and 4) the assessment could be completed and documented within a 4 month period.

The P2 assessment methodology included the use of a team of experts with varying areas of expertise, drawn from across the DOE complex. These experts applied lessons learned from their sites and targeted their knowledge and identified innovative ideas and approaches on a site or project which had the potential for waste reduction. These experts were identified and selected based upon the site specific concerns, contaminants, and issues being addressed in the P2 assessment and based on their personal application of techniques and technologies for resolving these issues.

The initial P2 assessment pilot was conducted at the Oakland Operations Office's Laboratory for Energy-related Health Research (LEHR) in Davis, CA. The LEHR P2 assessment was conducted in March 1999 and identified four project-specific P2 opportunities. These opportunities, if successfully implemented, could save the site approximately $1.1M over the remaining cleanup baseline for the site of $25M. The low level waste volumes could be reduced by an estimated 2,900 cubic yards, or a reduction of 51 percent in site-wide estimated low level waste volumes. Currently, the site is finishing a proof-of-concept study, funded by EM-22, to test one P2 opportunity for successful implementation.

The Rocky Flats Environmental Technology Site (RFETS) was chosen for the second pilot of the P2 assessment methodology because the projects chosen fit a majority of the criteria mentioned above. The P2 assessment would not adversely effect the project schedule, site personnel requested the assessment and were willing to assist before and during the assessment process, and approximate project baseline costs and waste forecasts were documented.

Personnel at the DOE's Rocky Flats Field Office (RFFO) chose three particular projects or areas of concern at the site which required either new approaches in order to reduce project wastes and disposal costs or projects which needed innovative technologies in order to reduce schedules and meet regulatory concerns. The three projects chosen for the P2 assessment were as follows:

- Building 444 Hazard Removal Project
- TRU-contaminated waste oil treatment technologies to meet the Waste Isolation Pilot Project (WIPP) Waste Acceptance Criteria (WAC)
- Disposition of Depleted Uranium

Opportunities were identified in all three project areas and offered considerable savings over the project baseline approach. A proof-of-concept study funded by EM-22 is also being performed at Rocky Flats on an innovative treatment technology for TRU oils. If successful, the treatment technology will be shared with other sites with similar issues.

The P2 assessments performed at LEHR and Rocky Flats offered a chance to test the P2 assessment methodology on two very different sites. The LEHR P2 assessment focused on a very small site with a finite project, schedule and detailed planning in place. Rocky Flats was a very large, complex site and the three projects chosen for the assessment were in varying degrees of planning without a finite schedule or budget. Both sites provided excellent opportunities to pilot test the P2 assessment methodology and both assessments offered the site project personnel P2 alternatives which would help reduce waste volumes and project costs.

It is important to note that the pilot P2 assessments at LEHR and Rocky Flats were being used to test the methodology and ascertain whether it could be a valuable tool for use at other sites across the complex. The intent was to perform the assessment at both sites and evaluate the concept and approach of the P2 assessment methodology and revise the methodology (as necessary) to create a useful tool for identifying pollution prevention techniques and practices for use at other environmental restoration projects. While the focus of the pilot P2 assessments was toward piloting the P2 methodology *process,* it was anticipated that the team would identify cost-effective P2 opportunities at the sites and provide alternatives to the existing baseline. The P2 assessment team also validated current P2 practices being deployed at the site.

The current P2 assessment conducted at Brookhaven's Graphite Research Reactor (BGRR) was no longer considered a pilot test of the P2 assessment methodology, but a finalized working model. The same approach was used for the BGRR P2 assessment as in the first two pilot assessments. Significant cost savings and waste reducing opportunities were identified and will be discussed in the remainder of this report. The BGRR project was chosen for the P2 assessment because of the initiative of the BGRR project team and the DOE Project Manager. The project team was proactive in searching for the best, most cost-effective methods to decommission the BGRR. In doing so, they requested several studies/assessments, including this P2 assessment, to be performed independently of their planning efforts to target appropriate opportunities they may have overlooked. The P2 assessment team has documented the P2 opportunities in this report. The P2 assessment team also wishes to thank the BGRR staff for their support during the assessment and for providing the detail needed to perform the cost analysis.

2.0 Key Pollution Prevention Regulatory Drivers

Figure 2-1 graphically depicts various drivers for practicing pollution prevention and waste minimization in routine, recurring operations. These regulatory drivers, to a large degree, can also be applicable to cleanup activities. Although there are no specific regulations that drive the inclusion of P2/WMin principles in cleanup and stabilization activities, DOE has chosen to create internal drivers for encouraging and rewarding the evaluation and implementation of waste reduction practices.

2.1 DOE's Strategic Plan

The highest level DOE document that discusses incorporating P2/WMin in cleanup activities is *DOE's Strategic Plan*. This Plan sets the goals, objectives, and strategies that will be implemented within DOE through the Annual Performance Plan, the budget, and the Performance Agreement with the President. Two objectives in the Strategic Plan deal with the application of P2/WMin to meet DOE goals.

The first P2 objective in the Plan states that DOE must "prevent future pollution." To accomplish this objective, the illustrative measure to "reduce waste generation from cleanup and stabilization activities by ten percent annually, beginning in Fiscal Year 1999" was established.

The second P2 objective in the Plan states that the DOE must "reduce life-cycle costs of cleanup." To accomplish this objective, the illustrative measure to "enhance performance, increase efficiency, and reduce costs by recycling and other waste minimization techniques" was established.

These measures provide the incentive for ER project managers to evaluate and deploy technologies and techniques that will improve productivity and reduce the life-cycle costs of cleanup projects.

2.2 Accelerating Cleanup: Paths to Closure

DOE's *Accelerating Cleanup: Paths to Closure* is a management tool that forecasts, on a project-by-project level, the technical scope, cost, and schedule required to complete cleanup at DOE sites across the complex. In a *Status Report on Paths to Closure* issued in March 2000, the life-cycle cost estimate to complete cleanup at the remaining sites will likely require $168 to $212 billion (1997-2070).

Federal Drivers	Pollution Prevention Act of 1990 Resource Conservation & Recovery Act (RCRA) Comprehensive Environmental Response, Compensation, Liability Act (CERCLA) 1980 Clean Air Act/Clean Water Act Emergency Planning and Community Right-to-Know Act Energy Policy Act of 1992
Executive Orders	E.O. 12856 - Federal Compliance with Right-to-Know Laws and Pollution Prevention Compliance E.O. 13101 - Greening the Government Through Waste Prevention, Recycling and Federal Acquisition E.O. 13148 - Greening the Government Through Leadership in Environmental Management
DOE Orders	DOE Order 5400.1 - General Environmental Protection Program DOE Order 435.1 - Radioactive Waste Management

Figure 2-1. P2/WMin Regulatory Matrix

Paths to Closure provides critical information on technical activities, budgets, risks, and worker safety and health in order to inform the public about these issues and to provide them with the depth of understanding required to make cost-effective and sound decisions.

Paths to Closure provides a closure plan for each site that identifies the key technical and programmatic activities that must occur and the decisions that must be made before a site can be closed. Additionally, a Waste and Materials Disposition Map (flow chart) that describes each projected waste stream, the steps for processing and managing that waste, and where the waste is intended to be permanently disposed (if known) has been produced for each site. Although many of these projections will change due to the development of new technologies, more economical cleanup approaches, and changes in the interests of stakeholders and regulators associated with each site, the Waste Material and Disposition Maps can be utilized as pollution prevention tools. ER project managers and project teams can utilize the site specific Waste and Materials Disposition Maps in identifying high priority projects that can be expected to generate large quantities of regulated wastes.

Paths to Closure also discusses the use of "Performance Enhancement Mechanisms" that will help DOE meet the programmatic challenges of accelerating cleanup while reducing costs. Pollution prevention has been identified as one of the mechanisms that will improve efficiencies by reducing waste volumes and associated disposal costs. Other mechanisms that improve efficiencies include technology deployment, integration, project sequencing, contract reform, and lessons learned. The aggressive application of pollution prevention techniques for cleanup projects is expected to provide streamlined approaches for managing wastes.

2.3 Environmental and Energy Leadership Goals

The Department of Energy P2 and Energy Efficiency (E2) Goals were announced by the Secretary in November 1999. There are 15 new P2/E2 goals; five in the area of waste reduction, one in affirmative procurement, and nine in the areas of energy usage, ozone depleting substances, greenhouse gases, vehicle emissions, and energy efficient fuels. The P2 Goal established for sanitary wastes states that for waste generation from all operations, including cleanup and stabilization, 33 percent of the sanitary waste must be recycled. Progress toward this goal must be reported annually. Another P2 goal for cleanup and stabilization includes a 10 percent annual reduction in waste (primary and secondary wastes) from cleanup, stabilization, and decommissioning activities.

2.4 CERCLA and RCRA Drivers for P2/WMin in Cleanup Activities

It is important to note that pollution prevention and waste minimization should be a part of cleanup activities regulated under both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and under the Resource Conservation and Recovery Act (RCRA). CERCLA includes "reduction in the toxicity, mobility, or volume of a waste through treatment" as one of the nine criteria used to evaluate the acceptability of a response action. RCRA requires that hazardous waste generators have a program in place to reduce both the volume and the toxicity of hazardous wastes. These statutes provide drivers for sites regulated under CERCLA or under RCRA to employ P2/WMin during cleanup actions.

3.0 BGRR Pollution Prevention Expert Team Members

Based upon the types of activities being assessed at the BGRR and the contaminants and issues examined, a team of experts was assembled which provided expertise in these areas. Each team member provided unique and qualified knowledge in particular areas and created a dynamic mix of DOE complex experience.

The P2 Expert Team Members for the BGRR P2 assessment included:

- *Mr. Greg McBrien* - DOE EM-22, DOE P2 Program, P2 Assessment Director. Expertise in pollution prevention and waste minimization program management and project deployment. DOE HQ's P2 Return-on-Investment project manager.
- *Mr. Lee Bishop* - DOE Oak Ridge, Program Manager for DOE's Center of Excellence for Metals Recycle. Expertise includes material release criteria, applied health physics, analytical management, recycle/reuse, and waste management operations.
- *Mr. Steve Bossart* - DOE National Energy Technology Laboratory, Morgantown. Project Manager for DOE's Office of Science and Technology's Large Scale Demonstration and Deployment Projects (LSDDPs). Expertise in innovative technology development and integration.
- *Mr. Don MacKenzie* - DOE HQ, EM-33, Rocky Flats Office. Expertise in applied health physics and management of nuclear materials.
- *Dr. Kathy Yuracko* - Director of ORNL's Center for Life Cycle Analysis. Expertise in life cycle analysis and cost flow.
- *Mr. Conrad Cooke* - Project Manager for MOTA Corporation. Expertise includes commercial and government nuclear facilities D&D and waste management.
- *Ms. Lisa Burns* - P2 Project Manager for IT Corporation, Contractor for EM-22 and an expert in the area of P2 in environmental restoration and waste minimization deployment. Acted as Team Lead and Assessment Coordinator.

Site personnel involved in the P2 assessment offered invaluable expertise. These individuals are listed below.

- *Mr. Jim Goodenough* - DOE BNL BGRR Project Manager, currently at DOE-RL
- *Mr. Steve Pulsford* - Bechtel BGRR Project Manager
- *Mr. Clyde Newson* - BGRR Project Engineer
- *Mr. George Goode* - BNL Site P2 Coordinator
- *Mr. Matt LaBarge* - BGRR Project Team Member
- *Mr. Glen Todzia* - BNL P2 Group Member

Others offering expertise in compiling this report include:

- *Mr. Mike Morris* - ORNL Life Cycle Analysis Expert. Developed flow diagrams and researched cost estimates.
- *Ms. Christine Goddard* - IT Corporation. Developed cost estimates and cost spreadsheets.
- *Ms. Dee Markelonis* - DPRA, Inc. PCB Megarule expert.

4.0 Brookhaven Graphite Research Reactor Background

4.1 Project Description

In August 1950, construction of the Brookhaven Graphite Research Reactor (BGRR) was completed and operations commenced. The BGRR was the first peacetime reactor constructed in the United States to provide neutrons exclusively for research. The reactor was in operation from 1950 - 1969, when it was deactivated. The BGRR was used as a science museum from 1977 - 1997. The decommissioning plan was begun in 1997. Refer to the BGRR project map, Figure 4-1.

The BGRR was designed as a graphite moderated, thermal-neutron, air-cooled research reactor. The original fuel was aluminum-clad natural uranium elements. The original fuel elements were subject to stress-related failures and as a result, 28 fuel element failures occurred. This resulted in the dispersion of the uranium/fission product/plutonium oxide particles throughout the affected graphite channels, air ducts, and air filters.

In 1958, the natural uranium fuel elements were replaced with iron-clad, enriched uranium-aluminum alloy plate fuel elements. The power level of the reactor during the enriched fuel-loading was 20 megawatts thermal (MWt). This particular reactor is a scale-up of the Oak Ridge X-10 reactor.

The primary contamination within the BGRR area is a result of the spread of oxidized uranium particles containing fission products, such as cesium-137, strontium-90, and activation products such as cobalt-60.

The reactor is close to 50 years old and some degradation has been found in the past. The canal facilities (where fuel-elements were shielded, stored, and prepared for shipment) had all of the radioactive equipment and piping removed and the contaminated water was pumped out, treated, and disposed. Loose contamination was also removed from accessible areas. Geo-membranes, soil grading, and paving of areas has been done in order to alleviate the spread of contamination and prevent water intrusion. Following permanent shutdown, the control rods were disconnected from the drives and inserted into the graphite reactor pile. The biological shield penetrations for the control rods were covered with metal plates which were tack-welded into place. The experimental openings were closed or plugged.

The characterization information for the BGRR is limited, but ongoing. The BGRR decommissioning project team has decided on an approach of limited characterization up-front in the project and more detailed characterization as the project commences in order to speed up the work activities and not spend so much time doing sampling and analysis early in the project. Waste estimates and waste types have been based upon limited characterization data. The estimates were calculated utilizing extensive historical information and documents to create assumptions for waste planning purposes.

Fission products have been found in association with the BGRR. Sampling has indicated gross alpha/beta contamination as well as gamma emitters such as Cs-137 in the soils and in some of the facilities systems. An underground Sr-90 groundwater plume has also been found and associated with the BGRR. Little radiological information is available for the air-cooling exhaust plenum, exhaust filters, or the reactor pile. The TRU contaminants were associated with fuel handling operations and failures. Hazardous materials which exist in the BGRR include lead, mercury, asbestos, oil, and paint contaminated with PCBs, and possibly some heavy metals.

The key areas to characterize in FY-2000 include the reactor pile (fission products from fuel failures), below ground air ducts, filters, instrument house, and the spent fuel canal (fuel storage area and soils). Characterization of the pile fan sump (soil contamination) has been completed.

The BGRR will follow an accelerated decommissioning strategy. The BGRR will be decommissioned in compliance with the Brookhaven Interagency Agreement (IAG), between DOE, EPA and the of New York State Department of Environmental Conservation (NYSDEC), and the EPA/DOE Joint Policy on Decommissioning DOE facilities. This joint agreement specifies that DOE facilities should be decommissioned as removal actions under CERCLA. BNL was placed on the CERCLA National Priority List (NPL) on December 21, 1989.

The BGRR removal action objectives include achieving the Record Of Decision (ROD) in a manner which protects human health and the environment, achieves future land-use objectives (yet to be determined), removes or permanently isolates contaminants of concern, minimizes impacts of waste management, transportation and disposal, and meets all Applicable or Relevant and Appropriate Requirements (ARARs).

There are seven work activities associated with the BGRR (identified as AOC 9 in the IAG):

1) Equipment removal and maintenance
2) Pile fan sump (AOC 9D)
3) Above ground ducts
4) Canal house (AOC 9A)
5) Below-grade ducts (AOC 9B)
6) Reactor pile
7) Remaining soils (AOC 9C)

The IAG allows areas of concern (AOCs) to be addressed as removal actions. Four sub-AOCs have been identified as AOC 9A thru AOC 9D. Sub-AOCs will be remediated and documented in a ROD.

The draft Removal Action Alternatives Study (RAAS) was completed in January 2000, and the final RAAS was completed in April 2000. Seven decommissioning alternatives were identified based upon input from the public, BNL, US EPA, and DOE. The alternatives span from "No Action" to "Total Removal" of all affected areas including the pile, the reactor building, and all associated fans, ductwork, piping, and soils. The "No Action" alternative was used as the baseline against which all other alternatives were evaluated. All of the alternatives were evaluated with respect to CERCLA, NEPA, and community values.

For planning purposes, the scope, schedule and cost of the BGRR decommissioning project has been developed using Alternative 4. This will be considered the "baseline alternative" for the purpose of the P2 assessment as well. The scope, schedule, and cost will most likely change as the project progresses, further regulatory and stakeholder input is provided, and better characterization is accomplished.

Alternative 4 includes the "common elements" of the decommissioning activity which include: disposal of water collected from the underground cooling ducts (completed); removal of the fans and decontamination of the Fan House; removal of the pile fan sump; removal of the former museum walls and displays (completed); isolation of Building 703 from Building 701; and removal of remaining soils found to be contaminated above the Derived Concentration Guideline Levels (DCGLs).

Alternative 4 also includes the following; removal of the Below Ground Ducts, filters, coolers, Instrument House, Canal House, Water Treatment House, and the Above Ground Ducts. The dispositioning of Building 701 and the removal of Building 701 experimental equipment are also included.

The BGRR decommissioning project assumptions include:

- Building 702 (graphite pile, control rods, biological shield) and the underground plenum surrounding the building will remain in place
- Building 701 (concrete, steel and brick building which houses the reactor pile) will remain in place
- Contaminated soils will be removed as needed to meet the cleanup criteria
- BGRR structures will be removed or decontaminated and soils removed to meet 15 mR/yr dose from all radionuclides measured above background at post decommissioning.

The Engineering Evaluation/Cost Analysis (EE/CA) for each removal activity will be evaluated for each of the four alternatives identified in the RAAS.

It is anticipated that the final no-action-required ROD, with the exception of remaining soils, should be approved in early FY-2005 with project completion later in FY-2005. Work will continue to be done as a series of removal actions. When an activity is completed, a closure report is prepared for approval by the DOE and regulators. These documents become part of the administrative record. The ROD will be prepared and will reference the approved action memos, EE/CA, and activity closure report.

4.2 Project P2 Activities and Validated Best Practices

The current BGRR project team, under the leadership of DOE BNL and Bechtel National Incorporated has integrated value engineering principles and best practices into the project planning phases of the BGRR project since its inception. During the P2 assessment, the P2 assessment team noted numerous practices and techniques being deployed by the BGRR project team which reduced waste and/or reduced project costs. These practices were reviewed by the P2 assessment team and validated as best practices. These successes should be shared with other sites to encourage the integration of good ideas into all DOE projects.

The following is a listing of the noted best practices found during the P2 assessment of the BGRR:

1. The current BNL request-for-proposal (RFP) process includes incentives for the subcontractor to reduce wastes and costs. RFPs are written in a non-prescriptive fashion which allows the subcontractor to utilize best practices during planning and implementation of the project.

2. The BGRR project team has incorporated the Standards-Based Management System (SBMS), including Integrated Safety Management (ISM) and Environmental Management Systems (EMS), into their subcontract specifications, ensuring consistent and common goals and objectives.

3. The BGRR project team has been responsive and sensitive to community issues and concerns and have involved them in each step of the decommissioning process. This approach has provided a good working relationship between the project and community and has helped in establishing trust between the two groups.

4. The BGRR project team has been sensitive to other BNL site missions, particularly the Office of Science. The BGRR is part of DOE's EM program, but ownership and operations will return to the Office of Science (OS) following final decommissioning. The BGRR project team has reviewed and discussed with OS potential end uses which would favor the OS mission as well as other BNL activities.

5. The BGRR project team has developed a soil management strategy that minimizes the amount of soil removed for offsite disposal. The project team has developed a soil screening approach using the In Situ Object Counting System (ISOCS) which provides immediate, accurate nuclide-specific results for field measurements of any object. This ensures that only contaminated soil (at the cleanup levels specified) is being removed and managed as radioactive waste. This process has saved the project waste management dollars and provided additional funds for other activities.

6. The BGRR project team is open to new ideas and new methods for performing the decommissioning work. The project team has continued to investigate process improvements and approaches which would reduce the project costs, including the P2 assessment and value engineering studies.

7. The BGRR project staff includes subject matter experts which understand the BGRR and BNL and have been involved with the BGRR and the BNL site for many years. Rather then utilizing only specified contractor staff to plan the project, the contractor enlisted the support of the real experts who were involved with the project/reactor over the past 10-15 years. This knowledge is evident in the detailed planning and understanding of the BGRR decommissioning scope and the resulting forecasted waste streams and cost detail.

8. The Project Work Plans are not rigid and prescriptive, allowing flexibility in the manner and method of implementation, although the Work Plans are based on funding availability. Improvements can be made without major schedule and planning modifications.

5.0 BGRR Pollution Prevention Assessment Focus Areas

The activities chosen for this P2 assessment were based upon the BGRR and DOE project personnel's recommendations. A preliminary visit was made to the site on September 14, 1999, by Greg McBrien (DOE EM-22), Bob Fleming (DOE EM-34), Karin King (DOE Oakland Operations Office), Mark Bollinger (DOE Chicago Operations Office), S.Y. Chen (Argonne National Laboratory) and Lisa Burns (P2 Assessment Coordinator). The BGRR project team met with the preliminary P2 assessment team to discuss the pilot P2 assessment concept and to discuss the BGRR project and focal areas.

The P2 assessment was focused on BGRR activities where problems or concerns existed with proposed waste disposition options and or costs for waste disposal. The DOE Project Manager was interested in reducing the baseline cost of the decommissioning project and requested assistance in finding methods to reduce waste volumes and overall project costs.

The activities chosen for the BGRR P2 assessment consisted of the BGRR Removal Action Alternative 4 work scope areas, including the common elements. As discussed previously in Section 4, these activities are; removal of the fans and decontamination of the Fan House; removal of the pile fan sump; isolation of Building 703 from Building 701; removal of remaining soils found to be contaminated above the Derived Concentration Guideline Levels (DCGLs), removal of the Below Ground Ducts, filters, coolers, Instrument House, Canal House, Water Treatment House, and the Above Ground Ducts. The dispositioning of Building 701 and the removal of Building 701 experimental equipment were also included in the assessment.

The BGRR project team also requested that the P2 assessment team review the alternative of removing the graphite pile (Building 702).

6.0 Results/Opportunities

The BGRR P2 assessment took place on February 23 and 24, 2000.

The site P2 assessment took place in the offices of the BGRR project team in Building 701. A tour was conducted by Mr. Clyde Newson, the BGRR project engineer. Each of the P2 focus activities discussed in Section 5 were reviewed, as were the waste forecasts, and assessed for P2/WMin opportunities. The opportunities were then recommended for more detailed evaluations after an initial screening by the assessment team and site personnel. The following sections discuss these opportunities. Some opportunities were dismissed after further evaluation (these are identified in the text) and several were determined to have cost-saving potential for the BGRR project and should be evaluated further by the BGRR project team.

See Table 6.1 for the Removal Action Waste Stream Estimates.

The opportunities for metals and materials (Subsection 6.3) was evaluated against the BGRR baseline activity using a qualified-approach to the life cycle analysis methodology developed by Oak Ridge National Laboratory (ORNL). It is important to remember that life cycle analysis is a decision making tool and is meant to assist project managers in making reasonable and defensible decisions. While an attempt was made to include all potential costs and other criteria such as health and safety, environmental impacts, schedule impacts, regulatory requirements, pollution prevention, and local economic impacts, the site staff will need to perform a more quantified analysis and explore these opportunities thoroughly before making a final decision to implement the P2/WMin alternative. Consultation with local stakeholders may also be needed.

6.1 General P2 Opportunities for the BGRR

The P2 assessment team identified several P2/WMin opportunities which were not task-specific and pertained to the general type of activities taking place during BGRR decommissioning. These P2/WMin opportunities can provide even greater savings (return-on-investment) in costs, operating efficiencies, and waste volumes if they are deployed on every cleanup action taken at BNL and if contractually required of subcontractors during cleanup tasks. Direct cost savings to the BGRR are not identified because the applications vary depending on the activity, waste type, work plan, and waste volume, but a direct correlation can be made between the use of these techniques and a reduced cost to the project, as well as increased worker productivity. The P2 assessment team recommends that the BGRR project team evaluate the use of the following techniques/technologies during the BGRR project.

Table 6-1
Removal Action Waste Stream Estimates

Description	Waste Type	Waste Quantity	Units
Water Disposal	Rad Water	57,000	gals.
Fan Removal	Rad Metal Rad Debris	200,000 700	lbs. cu. ft.
Pile Fan Sump	Rad Soils Rad PPE Rad Debris	1,600 25 150	cu. ft. cu. ft. cu. ft.
Above Ground Ducts Removal	Rad Concrete Slabs	9,200	cu. ft.
Museum	Rad Debris	100	cu. ft.
Seal Pile Openings at Bio-Wall	Rad PPE	100	cu. ft.
Isolate Building 701 from 703	Rad PPE	100	cu. ft.
Experimental Equip. Removal	Rad Debris/PPE	600	cu. ft.
Equip. & Systems Removal	Rad Metal Rad Lead	521,000 164,000	lbs. lbs.
Underground Air Plenum to Building 701			
Filters	Rad Debris Rad Concrete Plugs	853 2,850	cu. ft. cu. ft.
Cooling Coils	Rad Debris/Metals	700	cu. ft.
Below Ground Ducts	Rad Metal Rad Soils/Debris Clean Debris	1,100,000 14,000 20,200	lbs. cu. ft. cu. ft.
Above- & Below Ground Canal Houses & Soils	Rad Asbestos Rad Soils/Debris	82 27,000	cu. ft. cu. ft.
Below-Grade Piping Sys. & Soils Removal	Rad Soils/Debris	8,760	cu. ft.
Remaining Soils	Rad Soils	120,000	cu. ft.
Building 701 Stays, Equip. Removed, 702 Stays	Asbestos Rad Debris Clean Debris Clean Metal	8,800 12,000 2,6466 56,000	cu. ft. cu. ft. cu. ft. lbs.
Totals	Hazardous	8,882	cu. ft.
Soils/Debris/PPE 125-150 lbs. Per cu. ft.	Rad Soils/Debris/PPE	186,688	cu. ft.
Concrete Slabs/Plugs 150 lbs. Per cu. ft.	Rad Concrete Slabs/Plugs	12,050	cu. ft.
Steel 450 lbs. Per Cu. ft.	Rad Metal Rad Water Clean Debris Clean metal	1,985,000 57,000 22,846 55,000	lbs. gals. cu. ft. lbs.

6.1.1 Personalized Ice Cooling System (PICS)

PICS is a self-contained core body temperature control system that uses ice (made with tap water) as a coolant and circulates cool water through tubing that is incorporated into a durable and comfortable, full-body garment suit. PICS can be used when the weather is hot and work activities require the use of various types and layers of personal protective equipment (PPE). The typical baseline technology is limiting worker stay times in controlled areas and the use of cool-down rooms. Using regular PPE compromises the body's ability to cool itself and can result in heat stress and longer down-times for the workers, which then reduces productivity.

The PICS technology was demonstrated at the Fernald Environmental Management Project as part of DOE's Office of Science and Technology's Large-scale Demonstration and Deployment Project. Key results of the technology demonstration were:

- Worker stay times were increased by more than four hours when temperatures were 100 degrees F or above.
- The higher the temperature in the work area, the greater the increase in stay times and the greater the productivity increase.
- The use of PICS decreases the use of disposable PPE (and low-level waste generation) because workers don and doff PPE fewer times since they stay in work areas longer.
- Based on stay times observed during the demonstration, the cost savings resulting from the use of PICS are $47/hour per two-person crew (a 39% savings) for work temperatures between 70 - 85 degrees F and $159/crew-hour (66% savings) for temperatures greater than 85 degrees F. Cost savings are based upon labor, equipment, and disposable PPE. The pay-back period for the PICS is 30 crew-hours of work at temperatures between 70-85 degrees F and only 9 crew-hours at temperatures above 85 degrees F.

The BGRR project team will be performing numerous tasks during the summer months and the PICS may be a method to reduce heat stress and increase each workers efficiency.

See References (Section 8) for more detailed information.

6.1.2 Heat Stress Monitoring System

The MiniMitter VitalSense Telemetry System provides real-time monitoring of vital signs of up to ten workers per station. The system consists of a series of probes worn by the worker, a portable monitor, a monitoring system that utilizes wireless signal transmissions, and a personal computer. The signals from a worker are transmitted in three seconds; if you have ten workers on the system, their vital signs are scanned every thirty seconds. This system is used to monitor workers health status during decommissioning activities in hot weather while they are wearing

PPE and/ or respirators and visual observation is compromised. The system helps to prevent heat stress.
The database of information established by the telemetry system can be used to adjust individual worker stay times in controlled areas and increase a workers productivity. Use of this technology may be justified purely on the basis of improved safety, but it *has* the potential to pay for itself by reducing worker time lost caused by heat-stress incidents.

Like the PICS system in 6.1.1, the BGRR project may be able to utilize this technology during summer decommissioning activities in order to improve worker efficiency and safety.

See References (Section 8) for more detailed information.

6.1.3 Utilize Launderable (Reusable) Personal Protective Equipment (PPE)

The use of launderable PPE at other DOE sites across the complex has been increasing in the past five years. With the advent and use of launderable protective apparel, numerous offsite laundering facilities have emerged and have improved their monitoring capabilities to ensure clean clothing is returned to the site. Using launderable PPE has typically reduced the overall project cost of PPE usage/disposal during cleanup projects. Laundering and reusing PPE can save up to 60 percent over disposable PPE usage and disposal. BNL has recently convened a PPE Committee to set a site standard for the use of launderable or reusable PPE. This committee was set up as a result of a Radiological Awareness Report which recommended the use of launderable PPE at the BNL site.

BNL currently has a contract with an offsite laundering facility. Problems have been encountered in the past with PPE being returned with higher levels of contamination than originally sent. The contract is being rebid. The new contract will specify that PPE be laundered in batches (from similar facilities and activities at BNL) to eliminate commingling. The new contract will also specify the survey requirements.

The BGRR project team should supply the BNL PPE Committee (Mr. Bill Pemberton, Chairman) with BGRR-specific requirements and survey specifications in order to be included in the new contract for laundering PPE.

6.1.4 Define Soil/Debris Segregation Limits

The Record of Decision (ROD) for BNLs Operable Unit 1 and Radiologically Contaminated Soils (BNL, 1999), states that the cleanup goal for radionuclides is based on a total dose limit of 15 mrem/yr above background. Soil preliminary remediation goals (PRGs) are calculated using the DOE Residual Radioactive Material Guidelines (RESRAD) computer code or are based upon regulatory documents. The BGRR has developed radionuclide PRGs for the project. These values have not yet been approved for the BGRR but are used for planning purposes.

The cleanup goal for Cs-137 is 23 pCi/g and for Sr-90 is 15 pCi/g, both for residential land use. Depending upon the volume of contaminated soil found, arguments could be made to use the industrial cleanup level of 67 pCi/g Cs-137. This would dramatically reduce soil remediation costs. These remediation goals can be used to project the amount of soil/debris which could be used as offsite fill, onsite fill, or sent offsite for disposal, if properly segregated.

The BGRR project team has already developed a soil/debris management strategy that minimizes the amount of soil/debris removed for offsite disposal (above 23 pCi/g Cs-137 and 15 pCi/g Sr-90). The project team has also developed a screening approach using the In Situ Object Counting System (ISOCS) which provides immediate, accurate nuclide-specific results for field measurements of any object. This ensures that only contaminated soil and debris (at the cleanup levels specified) are removed.

The P2 assessment team recommends that the BGRR project team go one step further and segregate soils and debris which could either be used offsite as fill (soils/debris not above background) and soils which could be used as onsite fill (soils between background and 23 pCi/g Cs-137 and 15 pCi/g Sr-90). See Subsection 6.2.1 for more details on the reuse of materials (soil and concrete) onsite as fill and the development of volumetric acceptance criteria. For the BGRR only, estimates of contaminated soil and debris are approximately 157,000 cubic feet. If all of this soil/debris is shipped to a commercial disposal facility (at $14 per cubic foot) the costs could accrue in the $2.2 M range for offsite disposal. An 80 percent segregation of soils for onsite reuse could save approximately $1.7 million in disposal costs alone. This cost does not include onsite costs to characterize, package and ship to the disposal facility. Segregation of soils between background\and 23 pCi/g Cs-137 and 15 pCi/g Sr-90 could benefit the project in terms of reduced waste management and disposal costs. Discussions with the BGRR project team indicated that a majority of the soil may meet this criterion. The BGRR project team has segregated soil and debris less than 23 pCi/g Cs and used it as onsite fill during the Pile Fan Sump remediation activity. This practice should be continued and expanded on future soil remediation projects.

6.1.5 Sequence Offsite Waste Disposal Transportation with Princeton Plasma Physics Laboratory (PPPL) and the Tokamak Fusion Test Reactor (TFTR) Decommissioning Project

The TFTR Decommissioning Project has recently completed a cost analysis for waste disposal alternatives for low-level wastes from PPPL decommissioning activities. Commercial, offsite disposal was found to be the cheapest alternative for bulk, low-level wastes from PPPL. Waste profiles have been completed for the various low-level waste streams. PPPL is currently submitting a formal request to DOE HQ to allow shipments of low-level wastes to a commercial disposal facility. Shipments would probably utilize intermodel containers which would leave the site by truck and be loaded onto railcars for shipment to the disposal facility. PPPL is attempting to have two DOE-approved choices for offsite disposal of decommissioning wastes.

The P2 assessment team encourages the BGRR project team to investigate potential teaming arrangements with PPPL when shipping low-level waste to the commercial disposal facility by railcar. Although PPPL does not currently have approval from DOE for shipping by rail (or truck) to the commercial disposal facility, they hope to have final approval in FY 2001. Sequencing waste disposal shipments by rail from the two DOE sites could provide a savings to DOE in transportation and disposal costs by utilizing an economies-of-scale approach. This approach allowed the DOE's Ohio Field Office to negotiate reduced rates to a commercial facility for bulk low-level waste. BNL currently uses the Ohio contract to obtain the $14/cubic-foot rate for bulk LLW. Sharing rail or other transportation costs between the two DOE sites could offer greater cost efficiencies.

6.2 P2 Opportunities for the Above Ground Ducts Removal Action

The Above Ground Ducts are part of the Removal Action Alternative Work Scope. The ducts will be removed by a subcontractor starting in the summer of 2000.

The above ground ducting is constructed of reinforced concrete. The wall thickness is approximately nine inches. The exterior of the duct is coated with paint containing hazardous materials such as PCBs, lead, and asbestos. The interior of the duct is concrete and has been contaminated with radioactivity. The extent of contamination is unknown, but the fans located downstream of the duct became contaminated due to fuel ruptures. An analysis of a side wall of the duct in 1999 showed Cesium-137 and Americium-241. A survey in 1991 also showed Cobalt-60.

The waste stream estimate for the Above Ground Duct Removal Action is 9,200 cubic feet of radioactive concrete. See Figure 6-1 for a diagram of the Above Ground Ducts.

Figure 6-1

The BGRR project team has accepted a bid from a contractor to remove the Above Ground Ducts, segment/cut the duct work for transportation to an offsite processing facility, process (remove the radioactive and hazardous constituents), and dispose of the clean material at an industrial landfill, dispose of the hazardous and TSCA waste at an approved disposal facility, and transport the radioactive waste to a designated commercial disposal facility. This will be considered the baseline. See Figure 6-2, Flow Diagram for BGRR Above Ground Ducts Disposition Disposal Alternative.

The P2 assessment team evaluated the original removal action baseline, which was basically the same as above; removing the Above Ground Ducts, segmenting the ducts for transport, and then transporting the segments to a vendor for processing and disposal. The baseline cost estimate was between $800 K and $1.2 M.

The P2 assessment team evaluated this baseline approach for P2/WMin and cost savings opportunities. The following opportunities were identified as possible alternatives to the Above Ground Duct Removal Action disposition disposal baseline approach.

6.2.1 Recycle/Reuse of Crushed Concrete Onsite

The P2 assessment team discussed a possible recycle/reuse alternative for the concrete from the ducts onsite rather than disposal offsite. See Figure 6-3, Flow Diagram for the BGRR Above Ground Ducts Disposition Recycle Alternative. The concrete ducts could be cut into manageable sections using the diamond-wire cutting method with liquid nitrogen cooling (discussed in 6.2.3) for handling purposes. The ducts could then be processed at the BGRR project site rather than shipped to an offsite waste processor. The outside surface of the ducts could be scabbled, using a diamond concrete shaver (discussed in 6.2.4) to remove the PCB paints and hazardous materials adhering to and embedded in the painted surface. The scabbled residuals would then be characterized, treated (if required), and shipped offsite for disposal as hazardous/TSCA waste.

The concrete ductwork could then be reduced to rubble onsite using a concrete crusher transferred/borrowed from the Ohio Field Office. The concrete crusher is currently at the Mound Environmental Management Project. The concrete crusher was originally utilized at Hanford and was listed as excess equipment. The property transfer was completed between Hanford and Mound and the equipment arrived at the Mound site in October of 1999.

The crusher was originally purchased in 1993. The throughput capacity is about 200 tons per hour. It weighs about 130,000 pounds, is 71 feet long, 10 feet wide, and 14 feet tall. It is portable by truck, depending on the highway weight limitations.

Mound performed a cost/benefit analysis in May 1999 which concluded that there was a large potential cost savings related to crushing radioactively contaminated concrete. The cost savings estimate ranged from approximately $4 M to over $12.5 M, depending on what fraction could be reused on the Mound site versus sent to Envirocare for disposal at the reduced soil (rather than debris) rate, which Envirocare has informally agreed to. Mound has asked for DOE approval of supplemental release limits for onsite reuse of crushed concrete. Evaluations of residual radioactivity levels in demolition debris against the supplemental release criteria will allow the proper disposition of the materials as either radioactive waste or as materials containing safe levels of radioactive material that could remain uncontrolled in an industrial setting. Without the approval, Mound will be required to containerize, store, and manage the concrete as radioactive waste.

Requirements for establishing supplemental limits for release of materials is presented in DOE Order 5400.5, "Radiation Protection of the Public and the Environment". A memorandum from R.F. Pelletier dated November 17, 1995, "Application of DOE 5400.5, Requirements for Release and Control of Property Containing Residual Radioactive Material", states that DOE Field Office Managers can approve such supplemental limits without EH-1 written approval, if the applicable criteria of DOE Order 5400.5 are met and an assessment of potential dose demonstrates that the subject material will not cause a maximum individual dose to a member of the public in excess of 1 mrem/yr or a collective dose of more than 10 person-rem in a year.

If the BGRR crushes the concrete ducts, which contain radioactive constituents, the crushed material would need to meet established risk-based cleanup levels established for the BGRR of 15 pCi/g Sr-90 and 23 pCi/g Cs-137. BNL is currently pursuing an authorized release approval as part of the sampling and analysis plan for several upcoming projects. Off-site analysis would be required in order to verify cleanup levels before the material is returned to the excavation site. If DOE approvals are obtained and the regulators and stakeholders give approval, the crushed concrete could be used as backfill on site. One such area where backfill may be needed is the Underground Ducts Removal Action, where a large area of void space will need to be filled. If the crushed concrete is above the cleanup level of 23 pCi/g Cs-137, the material will need to be disposed at an approved low-level waste disposal facility.

6.2.2 Use of Spectro Xepos X-ray Fluorescence (XRF) Analyzer to Measure Polychlorinated Biphenyls (PCBs) and RCRA Heavy Metals in Paint and Soil

The Above Ground Duct Removal Action will require the characterization of the interior and exterior or the concrete ductwork, as well as sampling of any scabbled material/paint from the surfaces. This will be done either by the BGRR project team or the chosen contractor. The exterior of the ducts contain hazardous materials such as PCBs, lead and asbestos. The interior has been contaminated with radioactivity.

The typical technology for characterizing samples with PCBs and RCRA heavy metals is the use of contract laboratories which can take up to 90 days to receive results and cost up to $1,000 per sample. The use of an innovative technology, such as the Spectro Xepos XRF Analyzer, can decrease the cost of sample collection, preparation and analysis and increase the speed of obtaining the results. The XRF Analyzer also reduces worker exposure due to less sample media required and provides equivalent data to traditional laboratory analysis.

The XRF Analyzer uses polarized radiation to detect elements such as uranium and sodium after the sample material is ground up and uniformly mixed. Chlorine is used as an indicator for the detection of PCBs. The XRF Analyzer provides simultaneous determination of the elements present in a single measurement within 100 - 500 seconds.

The XRF Analyzer was demonstrated at INEEL by EM-50 and was six percent of the cost of the baseline technology. The most significant difference in the demonstration test was the laboratory analysis cost. The XRF Analyzer eliminates the need for laboratory analysis.

The BGRR team should examine the benefits of using this technology for PCB detection in the painted surfaces of the Above Ground Ducts and other tasks at the BGRR which require analysis for PCBs and RCRA heavy metals. The contractor(s) chosen to perform work at the BGRR should evaluate the cost-effectiveness of this technology for the analysis of the paint and/or scabbled material from the Above Ground Ducts or other activities. BNL has used PCB Field Test Kits for PCB detection in soil, water, and oil. For soil samples, the test kits are more cost effective. The test kits add some acids, which can produce a mixed waste. The XRF analyzer does not produce a mixed waste. Thus, the XRF analyzer is more effective for PCB detection on painted surfaces. Subsection 6.3 will detail the use of the new TSCA Amendments or "Megarule" to non-porous (metal) surfaces painted with paint containing PCBs. The TSCA Megarule would not apply to concrete surfaces, as it is considered a porous surface.

6.2.3 *Use of Diamond-Wire Cutting with Liquid Nitrogen Cooling on the Concrete Ducts*

The Above Ground Ducts Removal Action will require the removal of the concrete ducts from the first expansion joint above the ground to the end of the ductwork over the Fan House roof. The ductwork must be segmented for transport to an offsite processing facility. The ducting is constructed of reinforced concrete with a wall thickness of nine inches. The size of the ducting (cross section) varies from 12-foot by 12-foot to 8-foot by 6-foot over the 130-foot length.

The baseline technology for cutting reinforced concrete is typically diamond-wire using water as a coolant for the diamond wire rope. Use of water as a coolant requires good engineering controls. The collection and recirculation of the water is critical to minimizing waste and controlling radioactive liquid hazards. The water and slurry collected must be solidified for disposal, if contaminated.

The use of liquid nitrogen for cooling purposes was demonstrated at PPPL by EM-50 and eliminated any secondary, liquid waste. The liquid nitrogen can potentially produce greater particulate emissions during cutting and may require some respiratory protection. Using liquid nitrogen does cost a bit more in up-front costs (to purchase the liquid nitrogen and equipment) but is cheaper when waste solidification and disposal costs are included for low-level radioactive waste.

The P2 assessment team recommends that the BGRR project team further evaluate the use of diamond-wire cutting with liquid nitrogen for cooling.

6.2.4 *Use of a Diamond Concrete Shaver for Scabbling the Inside and Outside of the Ducts*

The Above Ground Ducts Removal Action may require the removal of the surface of the concrete ducts (inside and outside surfaces) in order to remove radiological contamination and a painted coating (containing PCBs and/or heavy metals) on the surface of the exterior of the ducts. This would be desirable in order to treat the remainder of the concrete as sanitary/industrial waste for disposal or reuse. The baseline technology is to use a typical concrete scabbling tool.

The use of a successfully demonstrated (by EM-50) diamond concrete shaver can reduce worker fatigue due to lower vibration, is five times faster than the baseline technology, and leaves a smoother surface for more reliable radiological release surveys. The diamond concrete shaver is 50 percent less costly to operate due to increased productivity. The diamond concrete shaver is a self-propelled, electrically-driven system. It contains a vacuum port for dust extraction (collected in a HEPA filter) and a 10-inch-wide shaving drum which is suitable for flat or slightly curved floors.

The cutting depth of the shaver can vary from 0 to 0.5 inch. The diamond concrete shaver also generates less waste than the baseline technology.

The chosen contractor may wish to evaluate the use of the diamond concrete shaver for decontaminating and removing the surface of the concrete ducts.

6.2.5 Send Mixed Waste (scabbled lead paint with contamination) to Approved Disposal Facility in Texas

The exterior of the Above Ground Ducts is coated with a paint containing lead and PCBs and may also contain some radioactive contamination making the material mixed waste. If the paint or outside surface of the ducts is scabbled, the material will most likely have to be treated and disposed as mixed waste. The P2 assessment team suggested that the BGRR team evaluate the use of a vendor in Texas who can be accessed through the Oak Ridge Broad Spectrum Contract. All DOE facilities can utilize this contract vehicle through Bechtel-Jacobs at ORNL. The facility can accept U.S. DOE radioactive and mixed wastes containing levels of radioactive material that are considered exempt under Texas regulation and that do not have to be shipped as LLW. The cost would be less than for mixed-waste treatment and disposal.

Waste Control Specialists in Texas is authorized to dispose of waste under DOE directives that allow exemption of certain radioactive and mixed waste as residual radioactive material and under the regulatory authorities that exist in Texas. DOE has issued two memoranda that address the issue of reclassifying radioactive waste as residual material and approving disposal at nonlicensed facilities: January 7, 1997, "*Establishment and coordination of authorized limits for release of hazardous waste containing residual radioactive material*" and November 17, 1995, "*Application of DOE 5400.5 requirements for release and control of property containing residual radioactive material*." The January 7, 1997, memorandum is included as Appendix C.

Both memoranda contain similar procedures that allow DOE sites to ship waste (hazardous and non-hazardous) containing low levels of radioactivity as residual materials to unlicensed offsite disposal facilities after performing an ALARA analysis which shows that the impacts will be minimal. These procedures are as follows:

1. The authorized limits are selected and approved by DOE based on an ALARA assessment that insures that individual doses to the public are less than 25 mrem per year with a goal of a few millirem per year or less. If it can be shown that the maximum individual dose is less that 1 mrem per year with a collective dose of less than 10 person-rem per year, then DOE Field Office managers can authorize disposal without EH-1 approval.

2. The authorized limits ensure that groundwater will be protected consistent with state requirements.

3. The authorized limits are assessed to ensure that release of the disposal facility property would not be expected to require remediation under DOE 5400.5 or other applicable requirements.

4. The activities are coordinated with and acceptable to the disposal facility operator and appropriate state regulators.

The P2 assessment team recommends that the BGRR project team review the attached memoranda and evaluate the disposition of any hazardous waste which contains minimal amounts of radioactivity. Regardless of the method chosen for the Above Ground Duct removal, other BGRR project wastes could be dispositioned via the WCS route and could save project dollars.

6.3 P2 Opportunities for BGRR Metals and Materials

NOTE
7/20/00 Update and Clarification

> *During the original development and drafting of this section of the report, the July 13, 2000 Secretary's Office Announcement regarding the release of scrap metal from radiologically controlled areas had not been issued. While this Secretarial Announcement effects the release of scrap metal to general commerce, it is unclear at this juncture what degree it will effect the BGRR P2 metal recycle recommendations. Consideration will need to be given to several factors including; the DOE Headquarters requirements for the release of clean scrap metal from radiological areas, the BNL schedule for implementing those DOE requirements, and the BGRR project teams schedule for the release of scrap metal. However, based on current guidance at this time, the restricted internal shield block reuse option detailed in this section is not only viable but now endorsed through the Secretary's direction as outlined in the July 13 memo. The Secretary states that, "All DOE programs and sites should expand and promote the internal reuse and recycle of materials within the department."*

The analysis of the BGRR metal recycle opportunities was conducted by the DOE National Center of Excellence for Metals Recycle (NMR) as part of the BGRR P2 Assessment Team. NMR's goal is to facilitate metals recycle throughout the DOE complex in order to reduce cost, accelerate schedule, and provide additional environmental stewardship to DOE programs. The alternative and cost analysis for the equipment and metal recycle in the BGRR was conducted with the NMR vision in mind that:

> "DOE should implement a culture that considers the reuse/recycle of materials as the first and primary disposition option and burial as the last option while reducing environmental health risk and life-cycle costs."

This cost analysis is based on data generated and provided from the project team during the P2 assessment and from the Brookhaven Graphite Research Reactor Decommissioning Project Draft Removal Action Alternative Study (dated 1/28/00). Some generic data elements were used based on the experience and information collected across the complex by NMR when specific project BGRR data estimates were not available.

BNL personnel identified a specific waste stream for assessment consisting of the various personal or non-real property in the form of equipment and metal components located within the BGRR Building and reactor area. Some areas in the facility are known radiological contamination areas, as discussed in Section 4. Others are considered suspect radiological and require radiological surveys to determine the presence and extent of potential radiological contamination. The primary isotopes of concern when dealing with metal and equipment at the BGRR are mixed fission products and tritium as surface contamination. Tritium is extremely challenging to detect in the field due to its low detection limits. For the purposes of this analysis, even though a large amount of the surface-contaminated material could be decontaminated and released, it is assumed to be cost prohibitive for the BGRR project to do so in order to demonstrate that the tritium is within surface release guidelines.

With the above considerations, this portion of the assessment and analysis assumed BNL (and more specifically the BGRR project team) would have only two dispositions available for metals and equipment. The first is for "impacted" equipment and metals that are known to have or are suspected to have radiological contamination. This lot of material, due to the nature of the contamination and the challenges of onsite release, is treated as scrap metal. The reasoning is based on the fact that all reusable equipment would have inaccessible areas and could not be effectively surveyed and released on site within the budgetary constraints of the project.

The second disposition available is for "non-impacted" metal and equipment not suspected to be radiologically contaminated. This material is segregated onsite by physical and administrative controls and verified as clean by process data, historical knowledge, and verification surveys. The metal is then sent to an offsite vendor for recycle.

The current BGRR estimate for excess metals and equipment consists of approximately 500 tons of potentially radiologically impacted material and 27 tons of clean or non-impacted material.

6.3.1 TSCA-contaminated Metal and Materials

In past DOE decommissioning activities, the two BGRR metals waste streams would be sub-divided into Toxic Substances Control Act (TSCA) contaminated materials and non-TSCA materials. The BGRR project staff identified that it had limited TSCA spill- impacted materials (Refer to Appendix B for detailed definitions) but had a potentially large quantity of equipment and metal surfaces painted with PCB-containing paints. These materials would typically require additional characterization, laboratory analysis, and processing with costly thermal or chemical treatment. These requirements would increase the BGRR project costs and schedule due to extended analytical turn-around times for PCB analysis and additional segregation of materials. Once segregated, the TSCA-regulated materials would require treatment and disposal as a TSCA waste, which would have enormous cost impacts to the project.

However, in many cases, treatment and disposal is not available for TSCA-contaminated, radiologically-contaminated material and long term regulated storage would be the only option.

The original intent of the EPA TSCA regulations included the strict reduction and ultimate elimination of manufactured PCBs. However, EPA has recognized the problem and has gradually shifted from the regulation of manufacture and distribution of PCBs to the regulation of disposal and remediation. Therefore, EPA promulgated the "Megarule" or amendments to the PCB regulations in August of 1998. Questions over interpretation of the Megarule required the Agency to issue a technical clarification in June of 1999. The result is a completely revamped system that includes major changes to every aspect of PCB management, including characterization, notification, disposal options, approvals, storage, shipment, etc.

The TSCA Megarule became effective in January, 2000, just prior to the BGRR P2 assessment. Since the rule is so new, not only do DOE sites not appreciate its impact, but many regulators and disposal facilities are completely unaware of its application as well. Therefore, as part of the BGRR P2 assessment and in order to assist BGRR in handling its PCB-contaminated material, clarification on the application of the Megarule has been provided in this report. Refer to Appendix B, Overview of the TSCA Megarule Regarding PCB Management. It is hoped that the BGRR project team will take advantage of these new provisions in their materials and waste management actions. The P2 assessment team did not attempt to calculate the cost impact of applying the Megarule to BGRR metals and equipment since it is not clear how much material is actually impacted at the project.

The TSCA Megarule allows generators much more freedom to initiate cleanup of contamination without the need to obtain prior TSCA approval, a process that usually takes over a year. Many methods of decontamination, such as scraping paint formulated with PCBs off of metal surfaces, could not be done without a TSCA approval until promulgation of the Megarule. EPA acknowledged the difficulty faced by generators in obtaining approvals and in locating available treatment capacity for the previously limited options under the old rules. EPA now allows facilities such as smelters to simply notify the Agency of their intent to dispose of PCBs with the facility's assertion that the operation meets the requirements specifically designated in the Megarule. EPA also allows coordinated approvals based on other enforcement documentation from State or Federal agencies. This allows the generator to be more efficient and promotes interaction between the State and Federal agencies. EPA included a waiver of the anti-dilution clause, which requires PCBs to be disposed of at the original concentration, for wastes such as PCB remediation waste and certain decontamination wastes. For instance, a PCB plume in soil can be remediated and disposed of based on the actual concentration of the PCBs in the soil, rather than at the concentration of the oil spilled there historically. The anti-dilution provision prevents generators from diluting wastes for the purpose of avoiding disposal requirements. In the case of remediation, the release has already occurred.

The most important allowance for BGRR involves the designation of PCB bulk product waste, such as paint formulated with PCBs applied to a non-porous surface such as metal. Generators now have a variety of options available to dispose of this material. The material can go to a State permitted municipal or non-municipal, nonhazardous waste landfill provided specific notifications are made to the state regulatory agencies **or** the paint can be scraped off the metal (without a TSCA approval) under the PCB decontamination standards. The two waste items can then be dispositioned separately. The metal can be reused or distributed in commerce, depending on a visual inspection conducted in accordance with the applicable standard to ensure the paint is removed. The removed paint can be dispositioned as a PCB Bulk Product with all of the options allowed, including disposal in a State permitted municipal or non-municipal, nonhazardous waste landfill. A more complete regulatory analysis has been provided in Appendix B for the BGRR project teams consideration.

6.3.2 Metals and Materials Cost Analysis

The cost analysis that was performed for the BGRR metals and materials considered not only the disposal fee but the potential asset value to the Office of Science for the manufacture of shield block made from the metals. The logistical factors in staging, sizing, and characterizing the metal where calculated in the analysis to determine the total cost associated with straight disposal. Many of these same common costs are also required in the other disposition alternatives developed during the BGRR P2 assessment for the free-release or restricted release of the metal from the site.

All of the disposition alternatives have certain fixed common costs associated with them. These fixed costs include characterization, removal, initial sizing, and radiological survey, no matter which material disposition option is chosen. However, it is recognized that disposal or restricted recycle would require a much less rigorous radiological survey. The costs reflected in the attached cost analysis spreadsheets only reflect the cost differentials associated with the metal after the decommissioning operations have removed the metal from the building, initial sizing has taken place, and the material has been staged for packaging. Additionally, the cost to load metals into open top trucks or rail cars was considered an even cost and not included in the analysis.

The cost analysis conducted for the metal included several factors, one of which is the asset value of the material. While clean or non-contaminated scrap metal can be sold in the commercial market and the revenue retained by the site, the limited amount of clean metal in this analysis does not lend itself to a significant credit or value. The generic value of this type of scrap metal on the commercial market is approximately $70/ton. The entire asset value of the non-contaminated 27 tons of metal is less than $2,000. Therefore, the potential asset value was not significant enough to include in this analysis.

The real asset value of the BGRR metals and materials to DOE is the use of the contaminated metals and materials as feed stock for the manufacture of shield block for the DOE Office of Science. Currently, the DOE Spallation Neutron Source (SNS) Project in Oak Ridge is receiving shield block from GTS Duratek for the price of one dollar for each 10- ton shield block received. Based on discussions with the SNS Project staff, this is a value of $.50 to $.75 per pound or $10K to $15K per shield block, if SNS was required to buy virgin steel for this purpose. In this cost analysis, the conservative value of $.50 per pound has been utilized. This value has been included as a separate cost element in the analysis since this value is not directly realized by the BGRR Project.
For the purpose of this cost analysis and the use of the TSCA Megarule, two metal/material types (clean and contaminated) and two final disposition alternatives (disposal and recycle) were chosen. The process of determining the appropriate disposition alternative for a piece of metal or equipment is depicted in the attached flow chart, Figure 6-4, BGRR Metal/Material Disposition Utilizing the TSCA Megarule.

6.3.2.1 Clean Metal (See Note 7/20/00 Update and Clarification at beginning of Subsection 6.3)

Alternative 1: Disposal as Industrial Waste

In this alternative, all the metal equipment is assumed to be non-contaminated, therefore disposed in an off-site regional industrial landfill. The steps involved to dispose of this equipment consist of characterization, removal, size reduction, transport, and disposal.

Alternative 2: Utilize Existing BNL Clean Metal Scrap Contracts

In this alternative, all the non-contaminated metal is sold under existing scrap metal contracts at BNL. The vendors will sort the various metal types and sell the metal as scrap. The steps involved to provide this metal to the scrap vendor are characterization and removal. It is assumed that the vendor will load, transport, and disposition the metal at their own expense. Therefore, all cost analysis values are zero cost to the BGRR project beyond the common costs of staging the material.

<u>*Analysis Results*</u>: *Disposal as Industrial Waste vs. Utilize Existing Clean Metal Scrap Contract*

In the analysis for disposing of the clean metal as industrial waste, it was assumed the BGRR project team would use local transportation and pay regional landfill fees for disposal with no additional sizing requirements beyond the initial removal. The total cost for disposal of the clean metal as industrial waste is estimated at $ 20,000.

Under the clean metal recycle alternative, the BGRR project team would utilize existing recycle contracts at BNL and would incur no additional cost for the metals ultimate disposition beyond the initial staging.

Refer to Spreadsheets A and B for cost analysis details.

Figure 6-4

Spreadsheet A

Spreadsheet B

6.3.2.2 Contaminated Metal

Alternative 1: Disposal as Low-Level Radioactive Waste

In this alternative, all the radiologically contaminated metal is sized to less than 10 inches wide and 8 feet long and disposed of utilizing the existing DOE Ohio, Envirocare of Utah contract. This alternative is based on Envirocare accepting and implementing the Mega-rule provisions. If not, additional expense for characterization and processing will be incurred. The steps involved to dispose of the metal in this alternative consist of characterization, removal, additional size reduction, transport, and disposal.

Alternative 2. Recycle (Beneficial Reuse) the Metal as Shield Block

In this alternative, all the equipment is processed through the existing BNL GTS Duratek metal processing contract. This alternative is based on GTS Duratek accepting and implementing the Megarule provisions. If not, additional expense for characterization and processing will be incurred. The steps involved in this alternative include characterization, removal, and transport. Additional sizing is not required in this alternative as in the disposal alternative. Additionally, as discussed in Subsection 6.3.2, a credit value of $.50/lb has been included as a credit to the Office of Science for the value of the material as shield block to the SNS Project in Oak Ridge.

The week directly following the onsite BGRR review for this P2 assessment, both DOE Headquarters P2 and NMR Staff met with GTS Senior Operations Staff at the Waste Management Conference in Tucson, Arizona. During that meeting, discussing recycle in general, Duratek expressed its interest in more aggressively pursuing restricted reuse (beneficial reuse) opportunities within DOE in both its existing and future contracts. As part of that effort, Duratek has proposed reducing the BNL metals processing costs from the original $1.70/lb. to a $1.50/lb, with additional discounts based on the condition of the metal. Based on this discussion, an offer letter was transmitted to BNL from GTS Duratek under separate correspondence listing an average unit price of $1.34/lb, with the assumption that the BGRR metal would be generally clean of rust and dirt with low contamination levels present.

<u>Analysis Results</u>: *Disposal as Low-Level Radioactive Waste vs. Beneficial Reuse of the Metal as Shield Block*

In the analysis for disposal of the metal as low-level waste, it was assumed that the BGRR project would purchase 20 Sea/Land containers to package the 85 shipments of metal for disposal. The containers are assumed to be filled at 80 percent of capacity, based on past NMR experience at multiple DOE sites. An additional $.40/lb. sizing cost was calculated for this alternative in order to avoid the $14/cubic foot surcharge ($.70/lb. at 20 lbs./cubic foot) for oversized debris in the Ohio Envirocare Contract for items greater than 8 feet in length or 10 inches in diameter. The total cost to the project for this alternative is approximately $3M including round trip shipping.

The beneficial reuse (metal melt) alternative was calculated using $1.34/lb. with a turn-key transportation brokerage fee of $.15/lb. to GTS Duratek. The $1.34/lb. is based on two additional discounts off of the $1.50/lb. base fee stated by GTS Duratek. The two discounts which can be applied are for the absence of rust/dirt ($.08) and for low radiation levels ($.08). Additional discounts for sizing to two foot dimensions and high density metal where not included, but could be applicable to at least some portions of the BGRR metal and equipment. The total cost to the BGRR project for the recycle/reuse alternative is approximately $2.9 M, without the credit for shield block being considered. If the credit to the Office of Science for shield block is factored into the analysis, the total cost to DOE is approximately $1.9 M.

Refer to Spreadsheets C and D for cost analysis details.

While not calculated, it should also be noted that some cost savings could occur from general waste volume reductions and from employing transportation efficiencies such as densification of non-ferrous metals at $0.92/lb. at the GTS Duratek Facility prior to burial.

Spreadsheet C

Spreadsheet D

7.0 Conclusions and Recommendations

The P2 assessment methodology applied at the BGRR decommissioning project provided an excellent arena for the identification of P2/WMin opportunities which could be deployed readily and effectively during the planning phase of a decommissioning project. The positive interaction with the BGRR project staff allowed the P2 assessment team to brainstorm and hypothesize opportunities and results regarding various alternatives to the project baseline. The BGRR project team should be commended for the use and integration of value engineering principles and waste reduction initiatives during the planning of the project and for continuing to investigate and explore waste minimization and cost-saving techniques.

The large waste volume estimates for soil and debris (approximately 187,000 cubic feet of radiologically contaminated and 23,000 cubic feet of clean) are, by far, the largest waste types by volume to be generated during the decommissioning activities. The contaminated metal waste estimate of approximately 2 million pounds also provided the P2 assessment team an opportunity for P2 alternatives. The majority of the soil and debris at the BGRR is estimated to be generated from the soils around the BGRR facility, the Below Ground Ducts, and the canal house removal actions. The majority of the contaminated metals and materials (equipment) is estimated to be generated from the fan removal, equipment and systems removal, and the Below Ground Ducts Removal Actions. The metal and soil/debris waste streams alone account for over 85% of the forecasted waste volumes from the BGRR. The P2 assessment team targeted these waste streams and concentrated their expertise on identifying methods and techniques to reduce the amount of these wastes being shipped offsite as low-level waste.

The following opportunities were identified during the BGRR P2 assessment and are recommended by the P2 assessment team for further evaluation and implementation by the BGRR project team.

7.1 General P2 Opportunities

These opportunities were general in nature and pertained to the general type of activities taking place at the BGRR. These opportunities would provide greater savings (return-on-investment) in costs, efficiencies, and waste volumes if they were deployed on every cleanup action taken at BNL and if required by subcontractors during cleanup tasks. These opportunities do not have direct cost savings to the BGRR project identified because the applications and cost savings would vary depending on the activity, waste type, work plan, and waste volume. A direct correlation could easily be made between the use of these techniques and reduced cost to the project, as well as increased worker productivity if a cost analysis was performed on a particular activity. The P2 assessment team recommends that the BGRR project team more fully evaluate the use of the following techniques/technologies during the BGRR project:

- *Personalized Ice Cooling System (PICS)* - Numerous tasks will be performed at the BGRR during the summer months which require personal protective equipment. PICS is a self-contained, core body temperature control system demonstrated at Fernald by EM-50, which reduces worker heat stress and increases worker efficiency by increasing worker stay times. Cost savings are accrued based upon efficient labor, equipment, and disposable PPE reduction.

- *Heat Stress Monitoring System* - The MiniMitter VitalSense Telemetry System was demonstrated at DOE Hanford by Bechtel Hanford Inc. and EM-50 and provided improved worker efficiency (increases stay times) and improved worker safety by providing real-time monitoring of workers vital signs and eliminating heat-stress situations. The system can be justified purely on the basis of safety but can pay for itself by reducing time lost by work-related heat stress.

- *Launderable PPE* - The use of launderable PPE over disposable PPE can reduce project costs for PPE by 60 percent. BNL has set up a PPE committee to develop a site standard for the use of launderable PPE and to re-compete the offsite laundry contract. The BGRR team should supply the BNL PPE committee with BGRR-specific requirements and survey specifications in order to include them in the new contract.

- *Define Soil/Debris Segregation Limits* - The BGRR project has developed a soil management strategy that minimizes the amount of soil removed for disposal by using ISOCS. The P2 assessment team recommends that soil and debris be further segregated into lots based upon approved site cleanup levels. Soil/debris above 23 pCi/g Cs-137 could be shipped offsite as low-level waste. Soil/debris between background and 23 pCi/g Cs-137 could be used as onsite fill, and soils/debris not above background could be used as off-site fill for road beds. Segregation of these soils could potentially save the BGRR millions in terms of reduced waste management and disposal costs.

- *Sequence Offsite Waste Disposal Transportation with PPPL* - The P2 assessment team encourages the BGRR project to investigate potential teaming arrangements with PPPL and the TFTR decommissioning project when shipping low-level waste to a commercial disposal facility. Sequencing waste shipments by rail from the two DOE sites could provide a savings to DOE in transportation and disposal costs by utilizing an economies-of-scale approach. Sharing rail transportation costs between the two DOE sites could offer both sites cost efficiencies.

7.2 Above Ground Ducts Removal Action

The Above Ground Ducts Removal Action is estimated to generate approximately 9,200 cubic feet of radioactive concrete. Even though the BGRR project team has recently awarded the removal action work scope to a subcontractor, the P2 assessment team felt that the P2 opportunities identified were still viable and should be considered, even by the subcontractor.

- *Recycle/Reuse Crushed Concrete Onsite as Fill* - The concrete ducts could be cut into manageable sections using a diamond-wire cutting method with liquid nitrogen cooling for handling purposes. The ducts could then be processed at the BGRR project site, rather than shipped to an offsite waste processor. The outside surface of the ducts could be scabbled, using a diamond concrete shaver to remove the PCB paints and hazardous materials adhering to and embedded into the painted surface. The scabbled residuals would then be characterized and shipped offsite for disposal as hazardous/TSCA waste. The concrete ductwork could then be reduced to rubble onsite using a concrete crusher transferred and borrowed from the Ohio Field Office (which supports this idea and is performing similar activities at a cost savings). If authorized release limits are approved, the crushed concrete meeting the cleanup limits could be used as fill onsite, possibly as fill for the Below Ground Ducts Removal Action. The savings to the BGRR project would be from reduced waste transportation and processing costs, which could be substantial.

- *Spectro Xepos X-ray Fluorescence (XRF) Analyzer* - Use of the XRF Analyzer for PCB and heavy metals sample collection, preparation, and analysis was demonstrated at DOE's INEEL site by EM-50. The XRF analyzer was six percent of the cost of traditional laboratory analysis and provides results in minutes, rather than the 90 days typically needed for laboratory analysis results. The BGRR project should examine the benefits of using this technology during the characterization phase of the Above Ground Ducts Removal Action.

- *Diamond-Wire Cutting with Liquid Nitrogen Cooling* - Diamond-wire cutting for reinforced concrete is the typical technology utilized by demolition companies. Using liquid nitrogen for cooling the wire instead of water was demonstrated at PPPL's Tokamak Fusion Test Reactor by EM-50. The demonstration showed that liquid nitrogen generates no secondary wastes (such as contaminated water) which must be treated. The liquid nitrogen can cost a bit more in up-front costs (to purchase the liquid nitrogen and equipment) but is cheaper when waste treatment and disposal costs are factored into the analysis. Workers may need to wear respiratory protection due to particulate emissions. The BGRR team should evaluate the use of liquid nitrogen for cooling during diamond-wire cutting operations.

- *Diamond Concrete Shaver* - The use of the diamond concrete shaver was successfully demonstrated at Hanford by Bechtel Hanford and EM-50. The diamond concrete shaver reduced worker fatigue, was five times faster than traditional scabbling tools, and left a smoother surface for more reliable radiological release surveys. The diamond concrete shaver was also 50 percent less costly to operate due to increased productivity. The

BGRR project team should evaluate the use of the shaver for the inside and outside surfaces of the Above Ground Ducts.

7.3 BGRR Metals and Materials

The P2 assessment for the BGRR metals and materials assumed the BGRR project team would have only two disposition alternatives for metals and equipment. The first alternative being equipment and metals which are known to have or are suspected to have radiological contamination. This lot of material, due to the nature of the contamination and the challenges of onsite release, is treated as scrap metal. *(See Note 7/20/00 Update and Clarification at beginning of Subsection 6.3)* The second alternative is metal and equipment not suspected to be radiologically contaminated. This material is segregated onsite by physical and administrative controls and verified as clean by process data, historical knowledge, and verification surveys.

The current BGRR estimate for excess metals and equipment consists of approximately 500 tons of potentially radiologically contaminated material and 27 tons of clean material. Some of this metal and equipment is coated with a paint formulated with PCBs. The P2 assessment team has provided the BGRR project team with an overview of the new TSCA Megarule (Appendix B) which allows these coated metals and equipment to be treated as PCB Bulk Product Waste with allowances that will save the BGRR project time and waste management costs. The TSCA Megarule amendments provide the BGRR with several disposition alternatives for this PCB-painted material rather than full characterization, laboratory analysis, thermal or chemical processing, and disposal of the residuals as TSCA waste. The BGRR project team can now send the material to a state permitted municipal or non-municipal, nonhazardous waste landfill if notifications are made or the paint is scraped off the metal surface (without a TSCA approval) under the PCB decontamination standards and the two waste streams can be dispositioned separately. The metal can then be reused depending on a visual inspection of the surface and the removed paint sent to a nonhazardous municipal landfill. Smelters can now take metals and equipment with PCB-formulated paint on the surface and simply notify the EPA of their intent to dispose of PCBs with the facility's assertion that the operation meets the Megarule requirements. The BGRR project is encouraged to utilize these new provisions for the metals and equipment coated with the PCB-formulated paint.

The BGRR metal and equipment can then be dispositioned using the Megarule as either clean or radiologically contaminated, eliminating the need to manage the metals or material as TSCA waste. The four disposition alternatives for BGRR metals and materials are: *(See Note 7/20/00 Update and Clarification at beginning of Subsection 6.3.)*

1) Send clean metal/material to an industrial landfill;

2) Send clean metal/material to existing BNL scrap metal contractor for recycle;
3) Send contaminated metal/material to a low-level waste disposal facility; and
4) Send contaminated metal/material to smelter for beneficial reuse as shield block.

The following are the results and recommendations for the metals and materials from the BGRR.

Clean Metal: Disposal as Industrial Waste versus Utilizing Existing Clean Metal Scrap Contract - In the cost analysis it was assumed that the BGRR project would use local transportation and pay regional landfill fees for disposal with no additional sizing requirements beyond the initial removal. The total cost for industrial disposal is estimated at $20,000. Under the recycle alternative, the BGRR Project would utilize existing recycle contracts at BNL and would incur no additional cost for its ultimate disposition beyond the initial staging. The recycle option of the clean metal allows BGRR to utilize the asset value of the material to achieve its disposition in an environmentally sound manner while achieving a project cost reduction of approximately $20,000.

Contaminated Metal: Disposal as Low-Level Radioactive Waste Versus Beneficial Reuse as Shield Block - When considering the two alternatives for the contaminated metal, the results are so close they can be considered equal to the BGRR project baseline of $3M, when considering a number of assumptions in the analysis. However, the net benefit to the DOE Office of Science for the shield block (credit of approximately $1M at $.50/lb) pushes the decision in favor of the recycle option, both in terms of cost and net environmental benefit. It is the hope of the P2 assessment team that this consideration will be taken into account when the BGRR project team makes its final determination on which contaminated metal/material disposition alternative to pursue.

The P2 assessment has provided the BGRR project team with the initial information necessary to perform a quantified analysis of the identified P2 opportunities in order to determine the true life-cycle cost of the P2 alternatives. It is recommended that the project team conduct a more thorough evaluation of the alternatives and involve the stakeholders and regulators in the decision process.

The results of any pilots, demonstrations, or implementation successes resulting from the opportunities identified during this P2 assessment should be published on the DOE's Lessons Learned website as well as on EM-50's technology websites. This will ensure that other DOE sites are made aware of successful applications of P2/WMin techniques and technologies.

8.0 References

1. Bechtel International, BGRR-001, Rev. 1 Draft, “*BGRR Project Management Plan*”, September 1999.

2. Brookhaven Sciences Associates, BGRR-015, Rev. 1, “*BGRR Decommissioning Project Draft Removal Action Alternatives Study*”, January 28, 2000.

3. DOE’s Office of Science and Technology (OST), Innovative Technology Summary Reports. Including: *Concrete Shaver* (DOE EM-0397), *Spectro Xepos XRF Analyzer* (Draft), *Heat Stress Monitoring System* (DOE EM-0391), *Personal Ice Cooling System* (DOE EM-0393), and *Diamond Wire Cutting of the Tokamak Fusion Test Reactor Vacuum Vessel* (Draft).

4. U.S. DOE, *Accelerating Cleanup: Paths to Closure*, June 1998, and *Status Report on Paths to Closure*, March 2000..

5. U.S. DOE, *DOE Strategic Plan.*

Appendix A

Pollution Prevention Assessment Methodology

The assessment methodology consists of three phases:

- Training site environmental personnel (ER project managers and project teams) on the applications of P2/WMin to cleanup activities,

- Identifying and formulating an expert team and performing the assessment, and

- Writing a final report on the potential opportunities to reduce project wastes and costs.

Figure 1 is a flow diagram of the steps in the P2 Assessment Methodology. Each step in the flow diagram will be briefly discussed below.

Step 1 - Select Site or Activity with Established Baseline Costs

Site selection was discussed previously and is extremely important to the deployment of the methodology. Actual project selection is just as important. The more discrete and focused the cleanup project, the more chance for success in identifying and deploying an opportunity. The availability of forecasted waste volumes, waste types, and cost data is essential. Without this information, it is impossible to track and measure the success of a P2/WMin action on the projects baseline. Fiscal year baseline data on waste volume and project costs are reviewed for accuracy and completeness by the site project personnel. A final attribute is the acceptance of the assessment by the project manager and all the personnel involved in the selected cleanup project. Their help is critical in defining the assessment limits, the baseline and cost data, providing site-specific data, and addressing any questions the expert team may have during the course of the assessment. Their willingness to work with the expert team and is essential to the success of the DOE's expert team approach.

Step 2 - Determine/Define Waste Streams, Volumes, and Forecasted Disposition Costs and Review for Accuracy

This step has been discussed briefly in Step 1 and must be done in order to track and measure the effect a P2/WMin action has on a projects waste volume and baseline cost and provides a benchmark for assessing potential P2 opportunities. This step also provides the expert team with the waste stream data needed to begin the assessment process.

Step 3 - Select Team Members with Expertise in Areas of Concern

The expert team approach was developed by DOE to utilize experts from across the complex to assist ER project managers and teams with innovative ideas and approaches used at other DOE sites with similar problems. Each site or project has very specific contaminants and waste matrices to deal with during cleanup projects as well as site specific policy, regulatory, logistical, and administrative concerns. This must be taken into account when selecting experts for the team.

Step 4 - Site Provides Baseline Activity Flow Diagrams

The project manager is asked for brief and simple material process flow diagrams for each forecasted waste stream generated by the project (this includes the forecasted waste stream volume, baseline cost for that waste stream, and disposition alternative chosen as well as the path from the point of generation to final disposition). The flow diagrams are used during the actual site visit/assessment as a starting point for the opportunity identification.

Step 5 - Gather Preliminary Site Information

The next step is to assemble project information. Information gathered may include: project waste volume estimates and baseline cost data, work plans, schedules and milestones, technical baseline documents such as risk assessments, RI/FS reports, cleanup criteria, facility end use reports, stakeholder meetings/comments, residual radioactivity analysis, etc. Basically, whatever background data available on the project is assembled and transmitted to the expert team members.

A series of conference calls between the expert team members, DOE HQ and site personnel are conducted prior to the site visit to clarify issues and ask any questions prior to the assessment.

Step 6 - Tailor Training

This step involves the modification of existing training modules for ER personnel based upon information gathered in Step 5. This step is performed only if the site requests the training. The training modules "P2/WMin Training Modules for ER Personnel" developed by EM-40 are the basis for each training session.

Step 7 - Conduct Training; Perform Onsite Assessment

The assessment begins with an initial screening of alternatives utilizing the activity baseline flow diagrams (for each project waste stream) generated by the project personnel prior to the visit. Using the site FY baseline waste stream data and the activity flow diagrams, the team and the site personnel evaluate each project waste stream for alternatives to the projected baseline action. A chart is developed for each project waste stream including: waste stream, forecasted waste volume, baseline cost, waste type, baseline activity, the potential P2/WMin opportunity, schedule or milestone impacts, and any actions or challenges associated with the activity. The team, as well as site personnel, brainstorm ideas/opportunities and discuss feasibility.

Step 8 - Identify Potential P2/WMin Opportunities

The opportunities termed "feasible" are split between the team members (based upon area of expertise) for more extensive evaluations.

Step 9 - Research/Collect Additional Information/Refine Assumptions/Draw Flow Diagrams

Following the site visit, the team members perform more detailed feasibility analysis of the selected opportunities and develop a material flow diagram (mirroring the baseline flow diagrams) for the opportunity. The opportunity flow diagram includes the waste stream, the baseline waste volume, and the material flow based upon the alternative to the baseline. Each box in the flow diagram includes what happens during that step and the expected impact on the waste volume. Cost data (unit and total cost) is plugged into the steps in the flow diagram based upon the costs used in the baseline flow diagrams in order to compare the alternatives by unit costs and total waste generation. All assumptions for each opportunity are clearly defined. The opportunity flow diagrams also include waste volume reduced and baseline cost reduction, where appropriate.

Step 10 - Evaluate Opportunities

After the team members develop the opportunity flow diagrams and the anticipated cost reduction, a simple, qualified analysis or preliminary life-cycle analysis (LCA) is performed on the opportunity to determine if the opportunity is worth pursuing**.** The preliminary LCA is also done to compare the alternatives (the baseline versus the opportunity) and select a preferred alternative (which may be the baseline activity).

The LCA approach helps people understand the problems they face, construct decision alternatives to solve the problem, specify criteria (attributes) to judge decision alternatives, and make trade-offs among decision alternatives and criteria to arrive at reasonable and defensible decisions. The LCA approach considered each of the alternatives and each relevant attribute in order to ensure that all effects are considered to make decisions and reduce the likelihood of unintended consequences. Specific evaluation criteria for the LCA will included: total cost to the government (project and program), environmental impacts, health and safety impacts, pollution prevention, schedule impacts, regulatory requirements, and local economic impacts (the number of jobs to be created and/or retained in the community that can be attributed to the alternative).

In performing the qualified LCA analysis, the basic principle used in determining the appropriate level of the evaluation effort was that the resources expended should be commensurate with the value of the information in supporting a management decision. Team members, as well as the site personnel supplied information needed to support the preliminary analysis. The end result of the qualified analysis was an attribute table showing which alternative (no action, baseline approach, or P2 alternative) is best or worst within each evaluation criterion, supported by cost tables, flow diagrams, and decision comments.

The preliminary LCA is performed using a modified approach of the LCA Analysis developed by the Oak Ridge National Laboratory. A true (quantified and qualified) LCA may need to be performed on each alternative if the site decides to pursue the implementation of an alternative.

Step 11 - Write Report

The final P2 assessment report is then written and includes the material flow diagrams for both the baseline activity as well as the alternative. The preliminary life-cycle analysis including qualitative attribute analysis, is presented in a matrix format which is easily interpretable. The alternatives to the baseline activity are expressed so that specific attributes will be easily identified as being either positively or negatively affected.

The report also includes any case studies from other DOE sites which are relevant to the alternative as well as performance data, cost of implementation, waste reduced, cost avoided etc, from the implementation of the activity.

<u>Step 12 - Assist Site with Proof-of-Concept, if Needed</u>

The final report also includes a simple implementation plan for the deployment of the selected alternatives. The implementation plan lays out a path forward for each alternative with steps identified for the project managers. If an alternative needs a “proof of principle” study performed to determine feasibility, the report also specifies a path forward to investigate such a study such as, technology contact person, issues to be addresses, amount of waste needed to perform the study, cost, time needed for the study, and a schedule.

Appendix B

Overview of the Toxic Substances Control Act Megarule Regarding PCB Management at the BGRR

Appendix C

DOE Memoranda January 7, 1997, "Establishment and Coordination of Authorized Limits for Release of Hazardous Waste Containing Residual Radioactive Material"