5—Environment

5.0 PNNL's Environmental Mission

PNNL provides solutions to DOE's most critical national cleanup problems and will expand the application of our capabilities to address other national and international environmental challenges.

Several significant changes within DOE are affecting PNNL's environmental mission area. First and foremost is the change of cleanup focus to risk reduction through cleanup and removal rather than risk management through physical and institutional controls. The implication of this change is that the DOE's Office of Environmental Management (EM) is focusing on solving short-term problems and eliminating infrastructure with significant life-cycle surveillance and maintenance costs. A second significant change within DOE is the focus on establishing performance-based incentive-fee contracts with very aggressive performance targets for acceleration of cleanup baselines and the reduction of life-cycle costs. Lastly, there is a renewed emphasis on significantly increasing the participation of small businesses; many large contracts are being let as small-business set-asides. These changes signal a significant shift in environmentally related S&T investments—from longer-term S&T development to shorter-term S&T insertion.

As we begin to refocus PNNL's environmental mission area, we will drive leading-edge science to solutions that **restore**, **protect**, and **sustain** our global environment.

As the only national laboratory employed by Hanford Site contractors to use S&T to impact technical solutions to cleanup challenges, our performance history shows that we are DOE's leader at developing science-based solutions to critical environmental problems. As DOE's leading environmental laboratory, we will continue to fully support DOE's efforts to deal with its environmental legacies. In addition, we will draw upon our substantial multiprogram base to expand our support of key national and international environmental challenges that affect this country and the world.

Restore: Cleaning Up the Legacy of Nuclear Weapons Production

Our S&T contributions will substantially reduce the cost, time, and risk associated with restoring the environment by cleaning up the legacy of nuclear weapons production and enabling site closure decisions that have a sound, scientific basis.

Environment

We play a vital role in DOE's efforts to protect the Columbia River and transition the Hanford Site's Central Plateau into a modern waste management complex. Using our advanced environmental simulation capabilities to understand the groundwater systems, we have developed a system assessment capability that is rapidly becoming the risk decision tool at the Hanford Site. We are contributing to the development and demonstration of novel technologies for the retrieval, treatment, and disposal of high-level waste from underground storage tanks, as well as providing answers to key technical questions associated with the processing and disposition of spent nuclear fuels and sludge, and the closure of the contaminated fuel storage basins. Our S&T is instrumental in stabilizing the inventory of plutonium (Pu) and deactivating Pu facilities, as well as supporting the transuranic (TRU) waste retrieval and processing efforts at Hanford. Lastly, we are developing the new S&T necessary to address future environmental problems (Modules 5.1.1 through 5.1.5).

Protect: Protecting Workers, the Public, and the Environment

We will protect ecological and human health by ensuring the safety of the workers performing those cleanup activities as well as the protecting the public and the environment adjacent to cleanup sites.

Our efforts are contributing to the timely opening of a safe permanent storage facility for the nation's high-level nuclear wastes. We provide the scientific basis, along with credible data and models for monitoring and managing environmental and public risk resulting from residual contamination at DOE sites. Additionally, the leading-edge science, technology, and critical technical services that we provide to DOE helps ensure that cleanup is performed effectively while protecting the health and safety of the workers, public, and environment (Modules 5.2, 5.3, and 5.4). Our role in protecting workers, the public, and the environment goes beyond DOE cleanup challenges, however. For example, our work at the Marine Sciences Laboratory located in Sequim, Washington, is critical to developing U.S. Environmental Protection Agency (EPA) protocols to determine the effects of trace levels of contaminants on the endocrine and reproductive systems of organisms (Module 5.5).

Sustain: Renewing the Environment for Future Generations

Our S&T will help sustain the global environment by providing tools and technologies to address this nation's most challenging natural resource problems—ecosystem protection and management, carbon management, and water stewardship—in ways that are economic and enhance the quality of life.

We deliver basic and applied science to the EPA and the Army Corps of Engineers through R&D tools that allow jobs to be performed with greater confidence and effectiveness, and provide significant returns through technology transfer (Module 5.5). Our strategic alliance with the Mexican Petroleum Institute is working to deliver environmental S&T to the oil and gas industry, as well as developing joint research and development programs of mutual importance to the United States and Mexico that will address issues of ecosystem health in the Gulf of Mexico, the dynamics of climate change and the carbon cycle, and an understanding of methane hydrates for the future hydrogen economy (Module 5.5). We are developing technologies that use rapid heat and mass transfer at the microscale to improve performance, reduce cost, enhance safety and security, and minimize the environmental legacy for energy and chemical processes (Module 5.6). We are also developing innovative processes to convert biomass resources into higher-value chemical products and fuels, thus reducing the nation's requirements for petroleum and enabling the economic viability of DOE's biorefinery concept (Module 3.1.3).

PNNL is developing key technologies, such as those needed to retrieve and treat high-level tank waste, to protect the Columia River and surrounding environment.

Environment

5.0.1 Environmental Mission Funding and Staff

While maintaining the capabilities to support DOE-EM's ongoing needs, we are redirecting some of our environmental capabilities from completed DOE-EM cleanup projects to address emerging national environmental challenges and homeland security needs.

As DOE moves to performance-based, incentive-fee contracts, the need for long-term R&D is expected to decline, while the need for short-term S&T insertions is expected to increase. This new approach is resulting in major changes in the funding and staffing profiles for our environmental work. Because of the high priority of the EM mission, we are committed to ensuring that we have the capabilities in place to provide ongoing support and to be able to respond to additional needs that may emerge in the future. We are transitioning our capabilities to address emerging national environmental needs as well as environmentally related needs in homeland security.

Environmental Quality

As the figure shows, we expect EM funding to decrease to $68 million in FY 2004 and to further decline over the next 5 years to $45 million in FY 2008. This reduction reflects contract completions and the shifting of work away from national laboratories to small and commercial contractors. We also expect the EM support to safeguards and security of $9.6 million to shift to the DOE Office of Science (SC) in FY 2005. However, we are currently projecting that some of this reduction will be offset by increased funding expected from the newly established, performance-based contractors at the Hanford Site and other DOE sites. We expect funding from these sources to increase from $4 million in FY 2004 to $17 million during the 5-year planning period. This work will include science and technology insertion for waste remediation at other DOE sites, and S&T roles on new maintenance and operation contracts for environmental remediation and restoration.

Other DOE Missions

We expect to maintain modest support to DOE's Office of Environment, Safety and Health (EH) over this period and to increase our support to the DOE Office of Civilian Radioactive Waste Management (RW) repository program to $3 million or more per year. This support will entail laboratory waste form testing, performance assessments to predict environmental impacts, transportation planning, and support to NRC licensing activities.

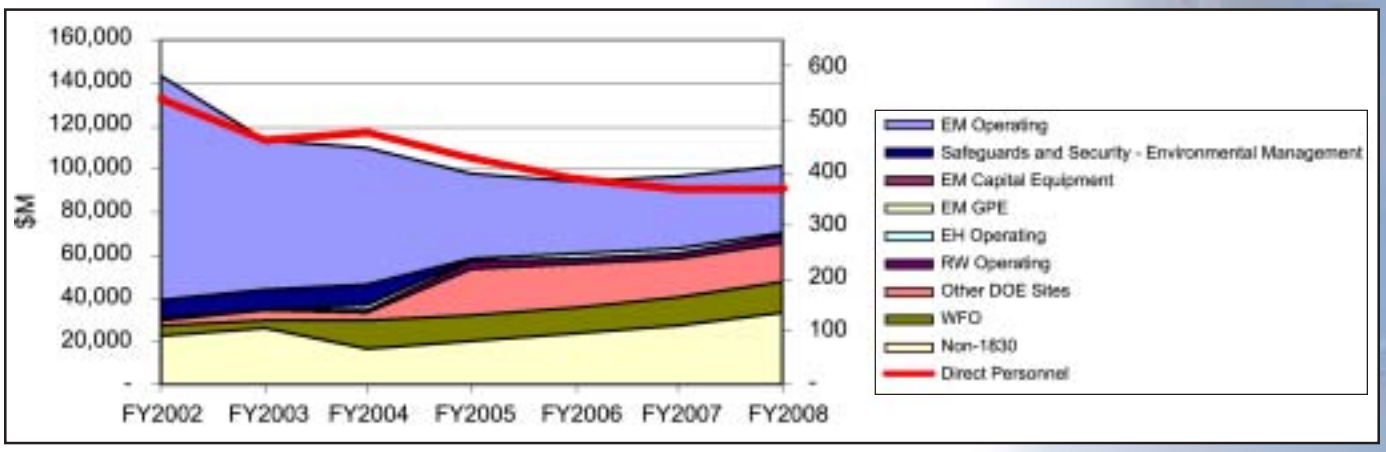
Environmental Research for Other Federal Agencies

We are projecting our environmental work for other federal agencies to increase to $5 million in FY 2004, and then increase further over the next 5 years to

$6 million. We expect this growth to occur with the EPA in the areas of computational toxicology and endocrine disruptors, multimedia/intermedia modeling, remediation technologies, water security and water resources, human-health and ecological risk, metals analysis, and homeland security and vulnerability assessments. Growth with the Corp of Engineers is expected in the area of sustainable management of ecologic systems, including endangered species. Also, over the planning period we expect our non-1830 work to increase from $17 million to more than $30 million.

Staffing

The additional programs for other federal agencies, as well as support for DHS and other associated homeland security agencies, will use many of the staff transitioning from completed EM research programs. Other staff from these completed programs are being used to support the growth envisioned in our energy programs, particularly in the areas of bio-based products and microtechnologies. We currently expect limited to no reductions of force over this time period due to the currently envisioned program changes.



Projected PNNL environmental mission funding and direct charged personnel through FY 2008. Near-term declines are projected as EM work declines and capabilities are redirected to non-EM work.

5.1 Technology Development and Deployment for DOE's Environmental Management Mission

PNNL leads the development of scientific and technical solutions to critical problem sets that advance effective cleanup at key DOE sites.

EM is accelerating its waste cleanup efforts by focusing on immediate results. EM contractors are developing risk-based, end-state cleanup and closure strategies that could result in higher levels of residual wastes at selected sites. Simultaneously, EM is reducing the role of centralized technical assistance and technology development projects in the cleanup program. Intractable[(a)] problems remain, however, and the accelerated cleanup program will require future R&D investments specific to individual site needs.

The Environmental Laboratory Consortium (ELC) consists of a collaborative forum of DOE national laboratories and site contractor representatives. The ELC is chaired by PNNL and addresses the issues of cross-site integration and collaboration to provide the best available capability to solve site-specific and national-level technical and baseline alternative problems.

Targeted R&D projects will be developed as needed by Hanford Site contractors using teams involving industry, national laboratories, and universities. These projects will include short-term technical assistance efforts to solve baseline technology problems and longer-term R&D efforts to make incremental improvements over existing baseline performance or to create breakthrough alternatives for intractable problems. In addition to solving specific problems, DOE site managers and their contractors need mechanisms to integrate R&D efforts and products across sites to leverage work done by others and to avoid redundant efforts to solve the same or similar problems.

We will use our relationships with other Hanford Site contractors to understand obstacles critical to EM mission completion. Where we believe our capability is the best to provide a solution, we will perform the work ourselves. Many problems, however, may require a select team of investigators from multiple organizations and disciplines. In these cases, we will use our established relationships through the ELC, consisting of representatives from 10 laboratories and two major cleanup contractors, to assemble a team of investigators appropriate to the problem. In addition, we will use our leadership position in the ELC to foster cross-site collaborations and information sharing to address integration issues to solve problems with the best available team.

Environment

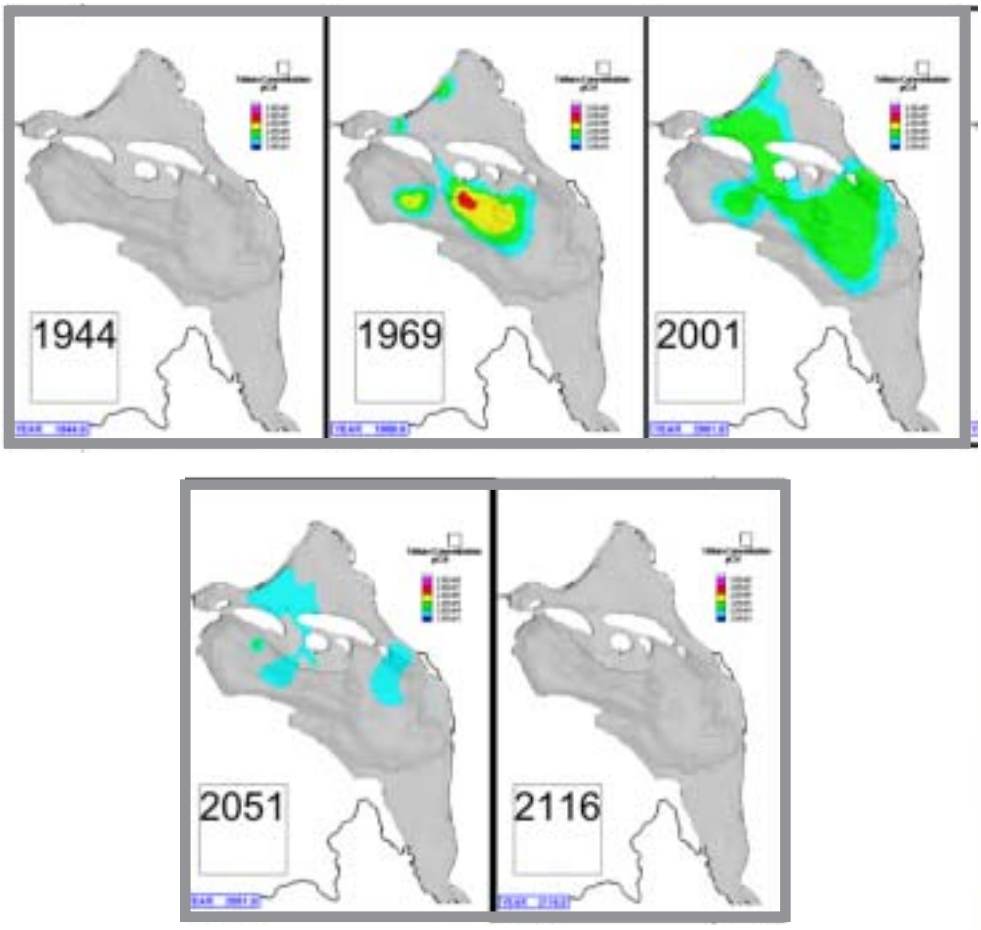
With our experience in tackling complex cleanup problems and outstanding scientific staff and facilities, we will continue our leadership role as a key provider of EMSP-funded science (see Module 2.2.3). At Hanford, research supported through fundamental science programs such as EMSP is helping to develop key scientific insights such as a molecular-level understanding of the surface chemistry and reactivity of environmentally important mineral phases. This knowledge can be

(a) Intractable problems are 1) problems for which the knowledge/technology does not exist to address them, 2) problems that cannot be addressed within available time or budget constraints, and 3) problems that cannot be addressed without exposing workers/public to unacceptable risk or violating other regulatory requirements (Crowley, Kevin D. 2002. National Academy of Sciences, Science for EM Cleanup? Presented to the Office of Science Biological and Environmental Research Advisory Committee. December 4).

incorporated into advanced contaminant transport models and will be essential in developing new strategies for controlling or mitigating the effects of subsurface contaminants. In the past 2 years, nearly 50 EMSP project reports by PNNL and other investigators have been cited in Hanford Site regulatory documents.

Our collaborative relationships with site cleanup contractors at Hanford, and our relationships with other national laboratories and contractors through the ELC, will enable us to continue to integrate alternative technologies and innovative solutions into the physical cleanup progress across the DOE complex.

The following modules illustrate the contribution of PNNL's S&T capabilities and collaborative approaches to provide solutions to key problem sets resulting in protection of the Columbia River and acceleration of cleanup activities at Hanford.



PNNL scientific research, such as understanding and modeling the movement of tritium in the groundwater, is addressing DOE's critical legacy problems by developing the scientific basis for cleanup activities.

Environment

5.1.1 Protecting Hanford Site Groundwater and the Columbia River

PNNL's S&T contributions provide the basis for optimizing Hanford Site cleanup efforts and our advanced environmental simulation capabilities will be used as the risk decision tool at Hanford.

Understanding Contaminant Transport

At most DOE Complex sites, the single most important environmental pathway for human and ecological exposure to existing and future residual levels of contamination is the soil-groundwater pathway. At the Hanford Site, human and ecological exposure may occur where contaminated groundwater discharges into the Columbia River. To aid cleanup efforts, DOE needs better knowledge of the biological, physical, and chemical conditions that explain and control the distribution of radiological and hazardous chemicals through this environmental pathway.

In addition to understanding the environmental pathways, DOE needs to be able to quantify and communicate the aggregate impacts of multiple waste sites on existing and future environmental and human health risks for diverse human and ecological populations. These risks need to be evaluated for multiple cleanup scenarios to optimize future risk reductions. Future remediation decisions at Hanford will rest upon the scientific understandings we develop that support an easy-to-communicate, credible, and acceptable risk statement of future conditions. To develop these scientific understandings, we will assemble an integrated multidisciplinary team—including geochemists, hydrologists, geologists, ecologists, risk and decision analysts, and mathematical and computational scientists—whose work will inform and influence environmental remediation and stewardship decisions.

We are developing the scientific understanding of physicochemical processes and geologic factors that control the fate and transport of radiological and hazardous chemicals through the soil-groundwater-river environmental pathway. Our program is an integrated approach involving both laboratory and field studies. Our scientific knowledge of contaminant transport supports recent cleanup decisions that avoid unnecessary cleanup, thus allowing cleanup dollars to be spent more effectively.

Estimating Risk

We are developing the conceptual and mathematical models describing the soil-groundwater-river pathway. Cleanup of the more than 700 waste sites at the Hanford Site will be addressed by a comprehensive new tool that will predict the movement and fate of contaminants through groundwater, the vadose zone (the soil above the groundwater) and the Columbia River. The System Assessment Capability (SAC) is an integrated system of computer models and databases that assesses the impact of contaminants on human health and the environment. Instead of showing each waste site in isolation—as has been done in the past—SAC shows each waste site in context of how they contribute to future impact, thus leading to more comprehensive solutions.

Two sets of computer models are at the heart of SAC. The first set—the environmental model—simulates how contaminants move through the environment. The second set estimates risk and impact from those contaminants based on a contaminant's persistence in the environment, its mobility, chemical form and toxicity, and where it appears in the accessible environment.

Our field and laboratory projects use applied and basic science resources to generate data and information to further both the scientific understanding needed to support decisions and actions, and the data gaps identified in the models. We leverage EM funds with EMSP-funded projects to address these critical issues and work as an integrated team with site contractors to "piggy-back" our science on their characterization and cleanup efforts. As a result, our scientific products have direct application to Site contractor project objectives and provide the scientific basis for environmental remediation and remedy selection. Our science-based advanced risk simulation project will be a key element for helping regulators and the public to determine whether the cleanup program has achieved its intended risk levels.

Our preliminary risk simulation models are now providing useful, but not perfect, information. However, the scenarios developed and modeled to evaluate alternative cleanup strategies are already supporting project decisions on Site priorities and cleanup approaches. Future work will broaden and deepen our scientific understanding of contaminant behavior in the Hanford Site environment and will refine our ability to simulate and predict future contaminant migration and subsequent risk.

PNNL's S&T is addressing key technical questions associated with the movement and cleanup of contaminated groundwater and the protection of the Columbia River.

Environment

5.1.2 Accelerating Hanford Site Waste Tank Cleanup

PNNL technical solutions for treating and disposing tank waste help reduce costs, technical and programmatic risks, accelerate schedules, and provide defensible technical bases for cleanup decisions to ensure protection of the public and environment.

DOE's Largest Environmental Challenge

The Hanford Site has the largest volume of high-level radioactive tank waste in the United States, with the highest life-cycle cost for cleanup of any other program area and site within EM. With 177 underground storage tanks containing 53 million gallons of waste and 200 million curies of radioactivity, the life-cycle cost for cleanup has been estimated at nearly $50 billion over 50 years. Technical, programmatic, and budget issues have slowed the pace of tank waste cleanup over the past two decades. DOE's challenge is to significantly accelerate the pace of cleanup, thereby reducing the environmental risks and life-cycle costs. Accelerating tank cleanup activities while ensuring protection of the environment, workers, and the public will require a solid foundation of S&T. We are providing that foundation through key technical and programmatic assistance to DOE and the Hanford Site cleanup contractors[a] in all major areas of tank waste cleanup, including waste tank safety and storage, waste retrieval, waste processing and immobilization, and tank closure.

Safely Storing Wastes While Accelerating Retrieval

DOE's aging waste tanks necessitate accelerated retrieval to reduce risks of future tank leaks and enable early tank closure and processing to significantly reduce environmental risks and costs. However, severely limited tank space necessitates a careful balance between retrieval and continued storage. We are providing a fundamental understanding of tank waste chemistry and rheology coupled with engineering capabilities in fluid dynamics, computational methods, and monitoring technologies to reduce technical and environmental risk associated with the storage, retrieval, and transfer of tank wastes.

Bringing Waste Treatment Capabilities Online

Paramount to completion of the tank waste cleanup mission at Hanford is the construction and start-up of the Waste Treatment Plant (WTP) to immobilize both high-level waste for disposal at a national repository and low-activity waste for disposal onsite (Module 5.1.3 provides additional information about spent nuclear fuel processing). In support of this effort, we will continue to provide critical engineering expertise in tank waste mixing, pretreatment, and vitrification along with a scientific foundation in chemistry, glass science, and materials in support of the WTP contractor. These capabilities support final processing system and flow sheet design, equipment selection, and operational planning to reduce technical risks.

(a) This work is funded by Bechtel through Battelle's 1831 use permit, and is included here because of its essentiality to the Hanford Site cleanup effort.

In addition to the WTP, the DOE's tank farm contractor is pursuing supplemental processing capabilities for low-activity, low-level, and mixed TRU wastes to obtain early disposition of selected tank wastes. This capability may also supplement the WTP and enable significantly accelerated low-activity waste treatment at reduced costs. Our scientists and engineers will continue to provide critical support in areas such as tank chemistry, safety, separations, immobilization, and long-term waste form performance and disposal to enable the selection of appropriate supplemental processing capabilities.

Closing Tanks and Disposing of Immobilized Wastes

Waste retrieval and processing enables closure of emptied waste tanks, final disposal of immobilized low-activity wastes, and significant risk reduction relative to continued storage of liquid high-level waste. Our capabilities in subsurface sciences, modeling, risk, and decision sciences are helping integrate tank closure and disposal risk and decision analysis with final waste disposition decisions across the entire Hanford Site cleanup mission. Our capabilities and tools will continue to provide a basis by which DOE and the Site cleanup contractors can identify and analyze the cumulative impact of waste disposition decisions relative to individual program and project decisions, such as a tank farm closure.

PNNL's S&T is supporting resolution of key technical issues within the WTP flow sheet and process design. Progress toward bringing the WTP online is evidenced by construction progress from January 2002 (top) and April 2003 (bottom).

Environment

5.1.3 Spent Nuclear Fuel Processing and Disposition

PNNL's S&T provide answers to key technical questions associated with the processing and disposition of spent nuclear fuels and sludge and the closure of the contaminated fuel storage basins.

The K Basins, located in the Hanford Site's 100 K Area, were used from the mid-1950s to the early 1970s for underwater storage of spent nuclear fuel generated by the site's K Reactors. In 1975, the basins began receiving spent fuel from N Reactor. Associated with the storage of 2100 metric tons of N Reactor fuel, particulate material—referred to as sludge—accumulated on the basin floor, in fuel canisters, and in the basin pits. The approximately 52 cubic meters of sludge (the majority of which resides in the K East Basin) is composed of a mixture of fuel corrosion products such as metallic uranium and fission and activation products, small fuel fragments, iron and aluminum oxides, concrete grit, sand, dirt, and operational and biological debris.

Our researchers are assisting Fluor Hanford's Spent Nuclear Fuel Program with the significant technical challenge of providing the underpinning science and data to establish defensible design and safety basis parameters for the retrieval, containerization, transportation, and storage of the sludge generated from metallic uranium-based spent nuclear fuel. As part of this support, we are performing laboratory- and bench-scale testing and conducting key studies and engineering evaluations, including determination of the uranium metal distribution and content in the various sludge types, determination of sludge thermal conductivity and shear strength, evaluation of corrosion-based volumetric expansion and gas retention during sludge storage, and formation and mitigation of vessel-spanning bubbles during sludge storage. Such studies will provide information needed to determine container fill levels, and to model and predict flammable gas generation and thermal stability of the sludge during containerization, transportation, and storage.

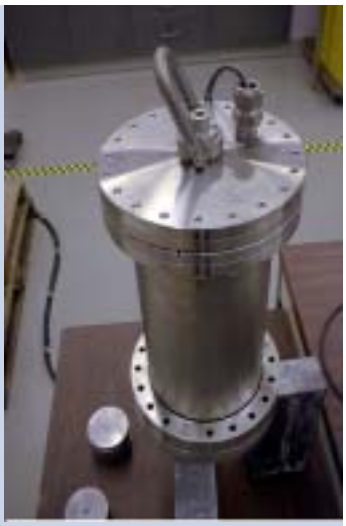
In tandem with the sludge characterization studies, our researchers are developing one-of-a-kind technologies for performing nondestructive evaluation of the highly contaminated fuel storage basins. Because radionuclides such as cesium can migrate deeply into the concrete walls, technologies are needed to determine the depth and extent of contamination before the basins can be decontaminated and decommissioned. A characterization system developed by PNNL has provided Fluor Hanford personnel with measurements of contamination from the floor area and the basin wall. These readings show significantly more contamination than originally estimated. Using our characterization data, Fluor Hanford is now proceeding with preparing its deactivation strategy.

As the K Basins approach sludge removal and deactivation, Fluor Hanford must develop documentation to define the project endpoint. The characterization data we provided is just one example of how the Laboratory is contributing to this endpoint decision process. Our risk and decision science capabilities will be instrumental during Fluor Hanford's consideration of all endpoint decision criteria, including regulatory approaches, cost effectiveness for remaining work, and worker

and public safety. This information will provide the technical basis for making distinctions between processing and disposition options, balancing risks against cost and schedule, and developing a sound framework for making programmatic decisions.

Our support to spent nuclear fuel processing and disposal activities at Hanford will come to completion in FY 2004. Existing and future national and international spent nuclear fuel packaging, transportation, and disposition challenges will benefit from our expertise and understanding of the chemistry and physics of spent nuclear fuels and sludge.

K Basin sludge settling and segregation testing using simulants.



Nondestructive evaluation basin characterization tool.

PNNL is conducting laboratory- and bench-scale studies that help establish defensible design and safety basis parameters for the processing and dry storage of spent nuclear fuel sludge, and developing one-of-a-kind technologies to perform nondestructive evaluation of highly contaminated fuel storage basins in support of basin closure activities.

5.1.4 Plutonium Stabilization and Facility Deactivation

Stabilizing and disposition of plutonium and deactivating and closing contaminated facilities will continue to depend, in part, on PNNL S&T.

The Plutonium Picture

The Plutonium Finishing Plant (PFP) at Hanford once contained over 4 metric tons of plutonium in 17.8 metric tons of bulk plutonium-bearing materials left from defense production. The material is in a variety of forms including metals, oxides, liquids, and polycubes (plutonium bound in plastic). Under the oversight of DOE and the Defense Nuclear Facilities Safety Board, Fluor Hanford has made significant progress in stabilizing these challenging waste streams. During the past five years, our researchers have provided testing and laboratory support necessary to further understand the behavior of these materials and have developed or optimized several stabilization processes. While most of the stabilization effort has been completed, some of the most technically challenging waste streams remain.

In addition, approximately 1.1 metric tons of scrap plutonium oxide—generated by pyrochemical operations at the Rocky Flats Environmental Technology Site—are stored at the PFP. Here, they await thermal stabilization in PFP's furnaces before packaging and eventual offsite shipment and disposal. A significant portion of this scrap plutonium is composed of high-chloride oxide material, which—according to DOE-STD-3013-2000, *Stabilization, Packaging, and Storage of Plutonium-bearing Materials*—must undergo moisture measurement to less than 0.5 weight percent (to mitigate overpressurization within storage containers) and stabilization at a temperature of 950°C for 2 hours. However, at this higher temperature, chloride salt vapors cause severe corrosion to furnace heating elements and ventilation components, and plugging in the furnace's off-gas lines.

Stabilization Progress

To address the challenges associated with the highly corrosive plutonium oxides, our researchers are conducting laboratory studies to evaluate whether the plutonium oxides can be stabilized at lower temperatures, thereby minimizing volatilization of the chlorides while still meeting moisture-content goals of the prescribed national standard. If determined feasible, this stabilization method will eliminate the need to wash chloride-laden plutonium prior to processing, resulting in significant cost savings and reduced risk to Hanford Site workers, the public, and the environment.

Environment

In addition to providing laboratory and research support to the plutonium stabilization efforts, we will provide technical expertise in support of facility deactivation efforts at the PFP. Because the plutonium contained in this facility is not easily retrievable, future deactivation work is expected to involve significant radiological and industrial risks to the workers. To mitigate exposure risks, our researchers will evaluate unique robotics and remote cutting techniques, and dust suppression and fixative technologies. Additionally, we are leading efforts to evaluate technologies related to plutonium characterization and decontamination, especially technologies that are chemically based.

Much of our deactivation and facility closure support, including plutonium-removal processes, is expected to continue through FY 2006. It is expected that PNNL's analytical and processing capabilities, developed in support of the Hanford mission, will be drawn upon as DOE continues efforts to disposition plutonium at the Savannah River Site. In addition, we believe there is direct applicability of our capabilities to other national and international nuclear fuel cycle challenges.

Low-chloride plutonium oxide powder

High-chloride plutonium

Furnace vent line failure due to thermal treatment of high-chloride plutonium

PNNL is working with Fluor Hanford to develop and optimize processes needed to stabilize some of DOE's most challenging plutonium legacy materials, including the corrosivity of high-chloride plutonium oxides.

5.1.5 Retrieval and Processing of TRU Wastes

PNNL's scientific and technical capabilities are integral to developing impactful solutions to challenges faced by the TRU waste program at Hanford.

The Hanford Site has the second largest inventory of TRU waste in the DOE complex. Past projections state that cleanup of this waste could cost up to $1.7 billion and take more than 35 years to retrieve, treat, and dispose of the more than 13,000 cubic meters of remote-handled and oversized TRU waste, along with remote-handled mixed low-level waste at the Site. DOE is making a concerted effort to accelerate cleanup and reduce overall costs, and the Washington State Department of Ecology is keenly interested in DOE efforts to address the TRU waste cleanup.

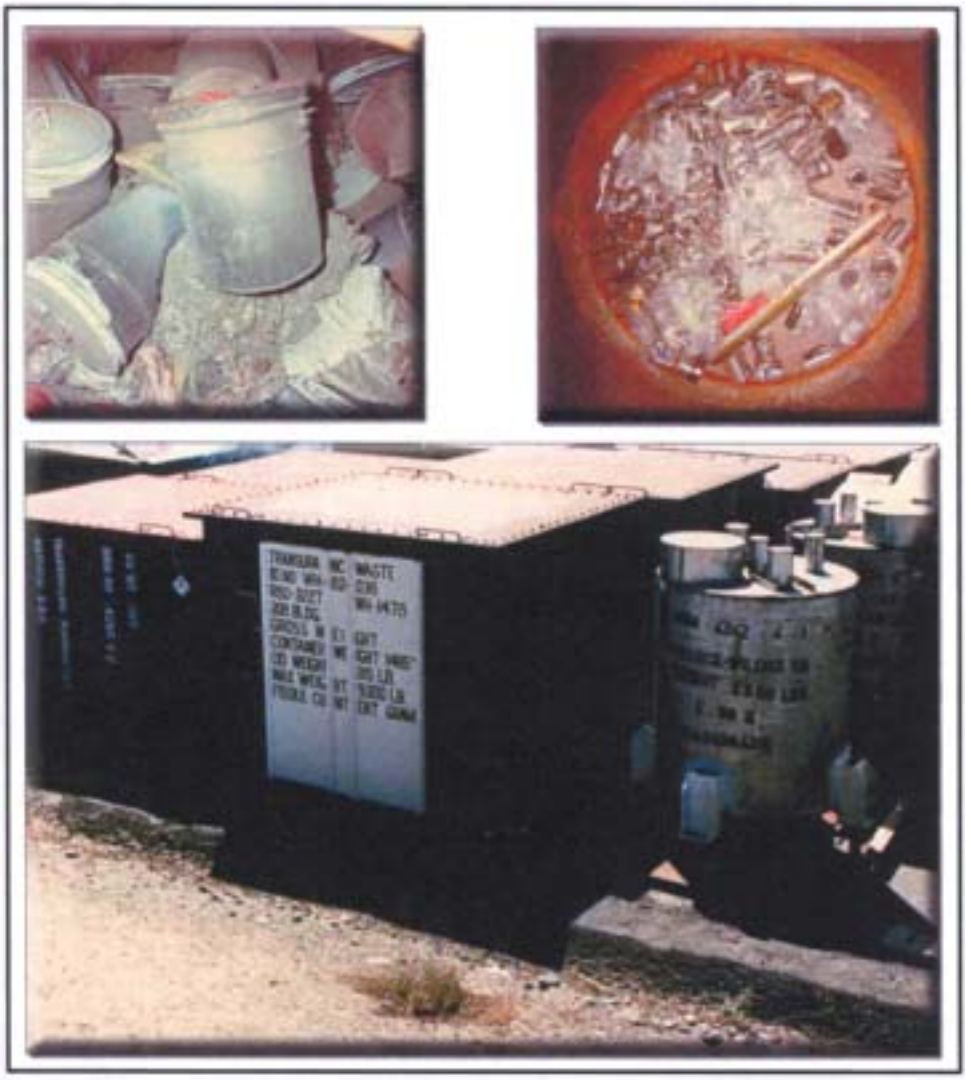
The current site cleanup contractor, Fluor Hanford, has responsibility for the Hanford Site's TRU waste programs, including characterization, retrieval, segregation, treatment, storage, transport, and disposal. The contractor's current emphasis however, is on contact-handled TRU, with most of the high-risk remote-handled work scheduled to occur in the out-years beyond DOE's current contract with Fluor Hanford.

The Hanford Site remote-handled TRU challenges include burial grounds that were operated for disposal of pre-1970 TRU and low- to high-level activity waste. Documentation of materials placed in the burial grounds is incomplete, but it is recognized that high-activity fission product, low-level, and mixed low-level radioactive waste, plutonium, uranium, and other TRU wastes exist in various waste forms. Capabilities for locating the boundaries of burial ground trenches are needed. Additionally, waste characterization and segregation technologies are needed to reduce cost and minimize worker exposure to radiation. We have the capability to provide key remote-handling and processing capabilities for this problem when DOE begins to address the TRU challenges. We are engaged in workshops to identify technical options and are viewed as a valued contributor to these solutions.

Through application of the SAC model (described in Module 5.1.1), our researchers are working with Fluor Hanford to identify the environmental and human health risks associated with TRU waste. The SAC technology shows each of Hanford's waste sites in the context of how they contribute to future impact. This work will provide critical information necessary to reduce the risk to Site workers, the public, and the environment.

Our current and future focus is to apply our core technical competencies to address DOE and Site contractor challenges associated with risk identification and mitigation. Through the application of our core competencies in sensor/characterization development and application, robotics applications, radiochemical processing, and waste form development, we will drive S&T to application in support of the TRU waste retrieval and processing efforts at Hanford.

Environment



PNNL is providing environmental risk and decision science capabilities and technologies to address the significant worker health and safety risks associated with the storage and retrieval of high-level TRU. This figure provides examples of remote-handled and large-packaged TRU waste containers.

5.2 Disposal and Safe Storage of High-Level Wastes at Yucca Mountain

S&T contributions from PNNL help to ensure timely opening of a safe permanent storage facility for the nation's high-level nuclear wastes.

PNNL's past support to the Yucca Mountain site included environmental analyses and transportation and total system performance assessments that led to the selection of the Yucca Mountain site.

The timely opening of a permanent waste repository that will accept high-level nuclear waste from EM cleanup programs is vital to the completion of the legacy cleanup mission. It is also vital to the continuation of the nation's nuclear electric power generation because some of the nation's commercial nuclear power and defense wastes require isolation from the environment for 10,000 years or more. Temporary storage of these materials at many current surface sites is costly and does not provide the long-term isolation necessary to reduce the risk of exposure to the public and the environment.

The Office of Civilian Radioactive Waste Management is currently focusing its efforts on the preparation of the NRC license necessary to operate the Yucca Mountain Repository, with submission of the license application planned for December 2004. Repository operations and the acceptance of the first high-level wastes are planned to begin in 2010. Our work in waste form performance provides strong support to this program objective.

Waste Form Performance Testing

Our outstanding scientific and engineering expertise in high-level nuclear waste spans the commercial nuclear power industry, reactor R&D, and nuclear defense activities. Key aspects of this expertise include an understanding of the long-term behavior of spent fuel and nuclear waste forms, the long-term behavior of radioactive materials in the environment, and the long-term impacts of radioactive contaminants on human and ecological health. In addition, an understanding of the development of innovative materials for the long-term containment of radionuclides; the insertion of technologies for the improvement of repository cost and schedule; and the development of safe, secure, and efficient transportation systems are also critical to solving high-level nuclear waste issues.

Environment

We have conducted waste form testing of commercial spent nuclear fuel and high-level nuclear waste for 17 years in the Radiochemical Processing Laboratory (RPL). Data generated in the RPL are being used to develop the performance assessment models that will be used to define how these waste forms will perform over the expected life of the repository. These models will also be used to evaluate the long-term safety of the repository itself.

PNNL Awarded Pilot Study from RW Science Program

The Office of Civilian Radioactive Waste Management has established an RW Science Program to broaden and deepen the repository scientific base. It is expected that this program will strengthen the safety and cost performance of the repository by allowing insertion of new scientific information during licensing, and new technologies during site construction and operations. As the recipient of a pilot study in the initial round of awards in the RW Science Program, our study focuses on the development of nanoporous "getters" for radionuclide containment. Getter materials have the potential to provide a cost-effective safety margin in addition to the waste package and natural barrier systems.

The application of PNNL's S&T to the disposal and storage challenges posed by the Yucca Mountain site will help the site to become the nation's repository for the permanent safe storage of high-level nuclear wastes from electric power generation and nuclear defense cleanup activities.

PNNL's expertise in long-term behavior of spent fuel and nuclear waste forms, the long-term behavior of radioactive materials in the environment, and the long-term impacts of radioactive contaminants on human and ecological health will help DOE address problems associated with the transportation and long-term storage of high-level nuclear wastes at the Yucca Mountain High-Level RW Repository.

Environment

5.3 Monitoring Environmental and Public Health Risks

PNNL provides the scientific basis and credible data and models for monitoring and managing environmental and public risk resulting from residual contamination at DOE sites.

PNNL Monitoring Programs form the Scientific Basis for Demonstrating Public and Environmental Safety

DOE national laboratories and small and large cleanup sites are the stewards for significant pieces of real estate across the United States. These land holdings include sensitive ecological areas, are often located near major metropolitan areas, and are often perceived by surrounding communities as major sources of environmental contamination posing offsite human health and ecological risks. The need for science-based environmental characterization and monitoring efforts will continue indefinitely at sites with continuing missions, as well as at sites with residual contamination that are remediated to some risk-based end-state condition and released for alternative post-cleanup use. These characterization and monitoring programs form the scientific basis for communication programs seeking to credibly demonstrate public and environmental safety.

Ongoing monitoring programs supported by an adequate scientific understanding of environmental processes, risk assessment simulation, and prediction capabilities (see Module 5.1.1) form the scientific basis for determining risk-based end-states that describe the achievable endpoint of EM's cleanup programs. That is, the data and information generated by these programs and capabilities form the credible scientific base for evaluating acceptable residual contamination levels for optimal future alternative land use.

Site Monitoring Programs Provide Data to Enhance Development of New Monitoring Technologies

Our near-term stewardship monitoring programs at the Hanford Site are integrated with our ongoing field and laboratory environmental R&D projects that develop and model the scientific information on the future public health and environmental risk of post-cleanup residual contamination. These programs encompass the detection of radiological and hazardous chemicals related to site operations in soil, biota, surface and groundwater, air, and foodstuffs from the regional environment. In addition, our programs also monitor natural and cultural resources. The monitoring programs provide characterization information to the R&D projects and in turn use the scientific and technological outcomes of the R&D to refine monitoring approaches. The outcome is an optimally scoped credible monitoring program that increases public assurance of human health and environmental safety.

Future R&D, focused on monitoring program-derived needs, will lead to more effective, cost-efficient, long-term monitoring programs by developing new monitoring technologies and protocols and an improved scientific basis for what to monitor, how to monitor, and where to monitor. One innovative example currently under development is the environmental sentinel initiative. Essentially highly sensitive, highly contaminant-selective detectors, environmental sentinels will detect and identify biological community responses to contaminants at levels below those deemed harmful, thus providing an early warning mechanism to trigger remedial intervention.

To meet our customers' future needs, including the need to accelerate the Hanford Site cleanup schedule, we will develop monitoring capabilities required for cost-effective stewardship of residual wastes present at DOE sites, targeting ecological resources rather than the chemical inventory itself.

PNNL provides scientific leadership for developing effective, cost-efficient site monitoring programs. Our Hanford Site monitoring programs encompass the detection of radiological and hazardous chemicals related to site operations in soil, biota, surface and groundwater, air, foodstuffs from the regional environment, and natural and cultural resources.

Environment

5.4 PNNL's Role in the Health and Safety of Hanford Site Workers, the Public, and the Environment

Through its technical services and applied research, PNNL creates technologies and solutions leading to a healthier workforce and more sustainable environment.

We provide S&T and critical technical services to DOE to ensure that Hanford Site cleanup is performed effectively while protecting the health and safety of the workers, public, and environment. We leverage our fundamental research in biosciences to address worker monitoring and to predict possible health effects from environmental exposures. Our support is critical because it is based on federal requirements, meets DOE liability issues, addresses concerns raised by workers, and ultimately reduces cleanup life-cycle costs.

Personnel Monitoring

We provide the personnel radiation dosimetry services for the entire workforce on the Hanford Site. These services, which meet the federal requirements as stated in 10 CFR 835 and certified by the DOE Laboratory Accreditation Program, have allowed us to develop a deep understanding of technical issues surrounding personnel monitoring. This understanding has led to S&T programs that have resulted in fundamental advances in health physics and radiation dosimetry. For example, we recently created an entirely new approach to radiation dosimetry using Optically Stimulated Luminescence. This new technology was successfully transferred to industry.

The next Grand Challenge in personnel monitoring is in the area of chemical dosimetry. As cleanup begins in earnest within the DOE complex, an area of great concern is chemical exposures to the workers. With thousands of chemicals in the DOE complex, determining individual exposures to a wide variety of chemicals is extremely difficult. We are meeting this challenge by integrating expertise in personnel dosimetry, chemical toxicology, biomarker research, and microtechnology to develop real-time, noninvasive personnel monitors for chemical exposures. We are partnering with the cleanup contractors and the onsite medical provider, Hanford Environmental Health Foundation, to develop and demonstrate new technologies that can eventually be used as part of the worker medical surveillance program.

We calibrate and test portable radiation survey instruments for the Hanford Site. These onsite services have enabled the Site contractor to have immediate access to qualified equipment in a cost-effective manner. The calibrations are performed in a National Institute of Standards and Testing-certified calibration facility in the 300 Area, the only such certified facility in the DOE complex. The specialized testing that occurs in this facility has led to enhancements on current instruments and novel developments for new instruments. Most of the testing has been with ionizing radiation instrumentation, but some industrial hygiene instrumentation has also been tested. As chemical monitors are developed, this facility will be used to test and enhance those as well.

Radiation Records and Dose Reconstruction

We maintain personnel radiation dosimetry records for all past and present workers on the Hanford Site. More than 100,000 records are kept on file in an easily retrievable system that has been instrumental in Hanford's ability to successfully respond to the National Institute for Occupational Safety and Health's request to the DOE for radiation exposure records as part of the Energy Employees Occupational Illness Compensation Program Act. We provide the necessary health physics expertise to interpret and analyze these records for the client.

We are recognized internationally in radiation dose reconstruction. We are supporting the EH by performing dose reconstruction for workers and the public near Mayak's processing facility in the former Soviet Union.

Health Risk Assessment: By integrating our expertise in fate/transport modeling, exposure characterization, dose assessment, and health effects studies, we are able to better determine the overall health risk attributed to an individual due to multiple exposures. For instance, we are conducting chemical toxicology assessments of vapors in the Hanford Site tank farms and their potential effects on workers and the public. In the future, we plan to build upon our knowledge in the biological sciences to study the effects of these chemicals on individual cells, extrapolate that data to whole organs, and eventually determine health outcomes to individuals and sets of subpopulations. This research will lead to better decisions regarding cleanup levels and exposure standards.

The Hanford Site contains 177 underground radioactive waste tanks, the contents of which are routinely monitored by highly trained workers. PNNL provides radiation measurement tools to protect Hanford Site workers by monitoring their exposure to radiation.

5.5 PNNL's Environmental R&D WFO

PNNL delivers additional value to DOE by conducting environmentally related research and development for other government agencies and private clients.

Environmental Protection Agency

We conduct a variety of research to assist the EPA in its central role of developing, implementing, and enforcing environmental regulations. This research includes modeling and analyzing hazardous waste transport and fate in soil, water (both fresh and marine), air, and biota; developing human health risk assessment information, methods, and guidance, as well as improving the science and practice of risk assessment; and developing innovative compliance information tools for government and industry.

Our work for the EPA is directly related to, and complements, our environmental science research for DOE. This work includes assessing the technologies and economic impacts of selected international strategies to reduce greenhouse gas emissions; developing innovative pollution prevention design, management tools, and methods; integrating disparate databases, and models, multiple-media models, and software-assessment frameworks; assessing the impacts of global climate change; and developing and supporting new and innovative techniques for metals analyses and bioassays.

We intend to be involved with the newly formed EPA National Homeland Security Research Center, whose mission focuses on methods to clean up contaminated buildings, protect the nation's drinking water supplies, and improve risk assessment methods that protect emergency responders and inform local decision-makers. The new center works with other federal agencies, the academic community, and the private sector to incorporate all available technical expertise and technological advancements into its research programs. We anticipate coordinating the efforts of EPA's Environmental Technology Verification program with those activities associated with the PNNL's Homeland Security Initiative.

Army Corps of Engineers

During the last 20 years, we have performed in-depth research and technology development to help resolve critical decisions affecting water resource management, especially hydroelectric dam operations in the Pacific Northwest. These decisions, which often involve the conflicting needs of industrial and agricultural development versus the safeguarding of fish and wildlife species, continue to be major issues faced by the Army Corps of Engineers and DOE. Our work for the Corps of Engineers (primarily in the Portland, Oregon, and Walla Walla, Washington, Districts) provides the scientific basis for many key decisions faced by managers and operators at hydroelectric dams located in the Columbia and Snake River Basins. The key issue at these dams is the safe passage of juvenile salmon moving downstream.

Environment

The Corps of Engineers program draws on our capabilities in earth sciences (hydrology, biology, ecology); engineering (civil and environmental); chemistry; statistics; and information science.

The Corps of Engineers work is the major component of a larger regional water management program that also includes work for DOE's BPA and Wind/Hydro Power program, as well as regional private utilities. The Corps of Engineers provides substantial programmatic support to develop facilities and equipment that directly benefit these DOE programs.

We are working with the Mexican Petroleum Institute to deliver science and technology to Pemex, the Mexican national oil company, to help them better understand the impacts of aggressive oil and gas development in terrestrial Mexico and the Gulf of Mexico.

Oil and Gas Industry

The international oil and gas industry as a whole faces significant environmental and safety issues. Included in this list are the need for environmental assessments, pipeline integrity and management (natural gas and oil pipelines), pipeline transmission, refinery operations, well logging and drilling, extraction, exploration, sustainability, production, health and safety, and emergency planning and operation systems. These issues are critical to understanding ecosystem health in key areas such as the Beaufort Sea (Alaska) and the Gulf of Mexico, among many others. Oil and gas exploration and production practices will have a direct impact on climate change and the carbon cycle. In addition, as the United States moves toward the future hydrogen economy, DOE, other resource agencies, and multinational oil companies will be interested in the potential role of methane hydrates in the carbon cycle and as an energy source.

Many of the tools and techniques we have developed and applied to environmental challenges at the Hanford Site (and the larger weapons complex) and elsewhere in the Pacific Northwest apply directly to the needs of the oil and gas industry. These capabilities include environmental chemistry, remote sensing, bioassays of sediment and water, fisheries monitoring and population modeling, and socioeconomic development analyses.

In collaboration with the Mexican Petroleum Institute, we will identify joint research activities to address key issues associated with the long-term cumulative impact of exploration on the Gulf of Mexico ecosystem, the dynamics of climate change and the carbon cycle (a deep drilling hazard) in the Gulf. The results of this work could be of significant benefit to SC, the DOE Office of Fossil Energy, EPA, the National Oceanic and Atmospheric Administration, and the Minerals Management Service, the latter which is responsible for the U.S. outer continental shelf oil- and gas-leasing program.

PNNL developed sensor-packed synthetic salmon that are making their way through the turbines at Bonneville Dam and other hydroelectric projects to measure the conditions that real fish encounter as they pass through turbines at hydroelectric dams on their way to the ocean. The information they collect could lead to more fish-friendly turbines in the future. Photo credit: Bonneville Dam and salmon smolts are courtesy of the U.S. Army Corps of Engineers.

5.6 Microscale Phenomena for Sustainable Environmental Quality, Energy Delivery, and National Security

Through technologies that use rapid heat and mass transfer at the microscale, PNNL is improving performance, reducing cost, and enhancing safety and security for energy and chemical processes.

Using Microscale Phenomena

More than a decade ago, our researchers began exploring the potential advantages of engineering systems to take advantage of the rapid heat and mass transfer that can occur over short length scales (nominally, 5 to 100 microns). The advantages of process engineering using microscale phenomena are now being realized over a wide range of applications, for DOE as well as other federal agencies and commercial groups. However, the challenges associated with widespread development and use of microscale phenomena require the development of a body of scientific and technical knowledge, and skilled practitioners of that knowledge. We will continue to explore and develop the body of knowledge associated with microscale phenomena and apply that knowledge to major challenges facing the nation.

Microproducts Breakthrough Institute

We teamed with Oregon State University (OSU) to form the Microproducts Breakthrough Institute. This Institute will advance scientific and technical knowledge in microtechnology, and when possible, the transfer of related technology to Northwest industry. With OSU, we will use our respective facilities, education, and training programs to conduct research and form multidisciplinary teams. The Institute will facilitate more rapid exploration of the science and engineering of microscale phenomena, and technology development and commercial deployment to meet national needs. It will also enhance the translation of scientific and engineering discovery related to microscale phenomena into a body of knowledge and focused educational curricula to rapidly disseminate that knowledge.

Examples of the application of microscale process engineering follow.

Environment

Fueling Hydrogen Transportation

We are developing fuel processors and reformers for use in automobiles. These reformers take advantage of the rapid transport achievable at microscales to achieve more selective and energy-efficient conversion of hydrocarbon fuels to hydrogen and carbon dioxide. The dramatic reductions in size (factors of 10 to 100) are particularly important for transportation applications. Additionally, the development of heat exchangers employing microscale heat transfer phenomena allows

Fuel vaporizer for automotive fuel cells.

extremely high process intensification (heat transfer density exceeds that associated with a commercial nuclear reactor) and associated miniaturization. Work is under way to complete component development and then achieve integrated designs that will further improve performance.

While particularly well suited for onboard reforming of hydrocarbon fuels, the technologies provide advantages associated with process efficiency, footprint, safety, and cost for stationary fuel processing as well.

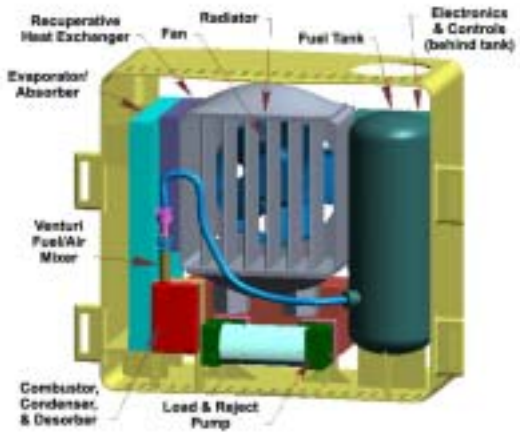
Small power

High process intensification, integration, and miniaturization have substantial potential to dramatically enhance development of small power systems. We have developed systems ranging from 30 megawatts to 200 watts for applications in sensor and man-portable power, primarily to replace battery power. These developments have principally been in support of the Defense Advanced Research Projects Agency and Army/Marine Corps programs. In general, miniature fuel reformers have been developed to provide hydrogen for fuel cells. The integrated systems have been projected to have over five times the power density of advanced batteries for missions of interest to the military.

Our integrated fuel reformer, the smallest in the world, is an example of the type of miniaturization of integrated chemical and thermal processes that is possible through exploitation of microscale phenomena.

Absorption Heating and Cooling

We are using integrated microscale chemical and thermal processes to develop absorption cooling technology for man-portable cooling. Such technology would dramatically ease the challenges of conducting either armed conflict or emergency response in hazardous environments, particularly for chemical and biological hazards. Through funding from the Army, we are teaming with OSU to use distinctive capabilities in the development of man-portable cooling systems. The development of such systems requires microprocess engineering skills and use of advanced simulation tools employing lattice-Boltzman techniques for simulation of absorption and desorption phenomena at microscales. This technology also holds great potential for improving efficiencies in thermally activated cooling systems for automotive, residential, and commercial building heating and cooling units.



Man-portable cooling system using microscale chemical and thermal process miniaturization.

Enhancing Space Exploration

We are developing several technologies for NASA that will dramatically enhance manned and unmanned exploration of space. Technologies that will improve fuel cell performance, provide for liquid vapor separations in zero-g, and do chemical production of propellants from indigenous materials on Mars are the topics of current research. The development of these technologies will have significant terrestrial applications, augmenting development described earlier for application in transportation, stationary energy, and national security missions.

Environment

5.7 Extending PNNL's Environmental Reach

PNNL is expanding its environmental reach into new areas including the development of biobased products and processes that will develop innovative processes to convert biomass resources into higher-value chemical products and fuels, coastal security, and key environmentally related transportation issues.

Bio-Based Products and Processes

Through our Bio-Based Products and Processes program, we develop innovative processes to convert biomass resources into higher-value chemical products and fuels, thus reducing the nation's requirements for petroleum and enabling the economic viability of DOE's biorefinery concept. We draw upon our distinctive chemical and biological catalysis capabilities to support R&D of processes that would allow readily available biomass resources to displace petroleum as a feedstock for chemicals and ensure the financial viability of ethanol production in large, integrated biorefineries.

We are the lead DOE laboratory for developing chemical intermediates and other industrial products in conjunction with industry partners via cost-shared Cooperative Research and Development Agreement projects that focus on rapid technology proofs-of-concept and demonstration of commercial viability. Building upon fundamental knowledge of catalytic processes and formulation, including advanced biocatalysis techniques, we will capitalize upon both SC and the DOE Office of Energy Efficiency and Renewable Energy (EERE) assets to develop the next generation of conversion processes, leading to new families of industrial and consumer products, reducing the nation's dependence on imported petroleum, and helping create a new bioindustry. We will continue to develop and demonstrate innovative, breakthrough catalyst formulations and catalytic systems and we will provide leadership in assisting DOE in setting programmatic direction focused on the next generation of biofuel and bioproducts technologies. More information about our Bio-Based Products and Processes program can be found in Module 3.1.3.

Sequim Growth Agenda and Coastal Security

Our Marine Sciences Laboratory, located in Sequim, Washington, provides a nationally recognized analytical capability in the fields of marine chemistry, ecotoxicology, and coastal restoration. Because current facilities at the Marine Sciences Laboratory are limited, a new multi-use laboratory and office facility are proposed that can accommodate new business. The new facility will capitalize on the outstanding environmental assets of this location. The new laboratory will use "sustainable technology" to minimize waste production and emphasize the use of such things as ambient light, solar heating, recycling/reuse and other "green technologies." This state-of-the-art research laboratory will meet DOE and DHS needs for the next 10 years.

Washington State Department of Transportation

Our activities in the growing transportation sector serve to meet the needs of America's transportation systems. Our major focus is helping Washington State solve major environmental and natural resource problems for local highway systems and the Puget Sound. Our relationship with the Washington State Department of Transportation (WSDOT) leverages our work with other key Northwest clients, such as the Army Corps of Engineers and BPA, to help resolve some of the region's most difficult energy, transportation, water resource, and ecological issues.

A key example of this work is finding a more fish-friendly design for future stream crossings and for the thousands of culvert retrofits expected to be completed in coming years. The WSDOT, representing a consortium of West Coast transportation agencies, has contracted with us to design and install a culvert test bed in southwestern Washington. The full-scale, one-of-a-kind culvert test bed system allows scientists to adjust and measure the hydraulic conditions—water velocity, turbulence, and depth—of various culvert designs. By assessing different slopes and flow regimes, scientists can determine how these conditions influence fish behavior and the ability of the fish to pass through a variety of culvert designs being considered as retrofits.

On a larger front, our U.S. Department of Transportation (DOT) business also provides solutions to some of the nation's major transportation problems involving safety, efficiency, and environmental acceptability. Key clients include the DOT, its several agencies, other federal and state transportation agencies, and the commercial air-land-sea transportation industry.

Visitors inspect the full-scale, one-of-a-kind culvert test bed system located at the Washington Department of Fish and Wildlife Skookumchuck Hatchery near Tenino, Washington. Impacts to juvenile salmon during passage through culverts represent a significant Endangered Species Act (ESA) issue for Pacific states. The test bed enables controlled experiments that will yield the behavioral and hydraulics data to address this ESA issue.

Environment

5.8 Infrastructure Needed to Support the Environmental Quality Mission

Targeted facility investments will enable PNNL to continue to provide expertise in radioanalytical processes and ecological research, and to support bioproducts science and engineering efforts.

Infrastructure Needs

To maintain capabilities critical for supporting DOE's environmental quality mission, targeted facility investments are needed. We currently have key facility needs in three areas: radiological and environmental laboratories; the Marine Sciences Laboratory in Sequim, Washington; and the proposed Bioproducts, Sciences, and Engineering Laboratory (BSEL).

Radiological and Environmental Laboratories

Underground tanks at the Hanford Site contain some of the most highly concentrated radiological waste in the nation. To ensure future environmental and public health protection, these materials must be isolated from the environment for thousands of years. To immobilize contaminated tank contents into a glass matrix, the design and construction of EM's WTP relies heavily on work performed in the RPL.

Contaminants already released to the soil and groundwater at Hanford represent the most likely potential environmental and public health risk. Understanding the fate and transport of these contaminants through the soil-groundwater pathway is key to helping complete EM's mission to remediate the groundwater and protect the Columbia River for future generations. Environmental laboratories in the RPL provide the sophisticated radioanalytical capabilities necessary to understand the subsurface biogeochemistry that controls the fate and transport of radionuclides in the soil.

To ensure the availability of this important capability as the 300 Area transition takes place, we plan to add new facilities with state-of-the-art radiochemical and analysis laboratories. See Module 7.3.2 for more information.

Marine Sciences Laboratory

Our Marine Sciences Laboratory is performing a national-level study, funded by the EPA, on environmental endocrine disruptors. Endocrine disruptors are chemicals found in the environment that mimic hormones that control reproduction and other physiological processes in humans and other vertebrates. Environmental exposure to these compounds can have serious ecological and human health implications.

To accommodate projected growth in ecological restoration research and coastal security work, a new multiuse laboratory and office facility are proposed. The new facility will capitalize on the outstanding environmental assets of the location. More information about these proposed facilities can be found in Module 7.3.

Bioproducts, Sciences, and Engineering Laboratory

Our staff are developing innovative processes to convert biomass resources into higher-value chemical products and fuels. This will reduce the nation's requirements for petroleum and enable the economic viability of DOE's biorefinery concept. To support these activities, PNNL and the State of Washington are working together to fund a new BSEL on the WSU, Tri-Cities campus. More information about this facility can be found in Module 7.3.3. Additional information about the Bio-Based Products and Processes program at PNNL can be found in Module 3.1.3.

To accommodate projected growth related to homeland security and coastal restoration activities, a new facility will be constructed at the Marine Sciences Laboratory in Sequim, Washington.