



**U.S. Department of Energy
Office of Science, Office of Biological and Environmental Research
Environmental Remediation Sciences Division**

**Environmental Remediation Sciences Program
(ERSP)
Integrated Field Challenge (IFC) Project and
Oak Ridge Field Research Center (ORFRC)
Management Plan**

ORNL/TM-2000/267

Revised: April 2001; August 2004; October 2007



Environmental Sciences Division

Environmental Remediation Sciences Program (ERSP) Integrated Field Challenge (IFC) Project and Oak Ridge Field Research Center (ORFRC) Management Plan

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**ORNL/TM-2000/267
Revised: April 2001; August 2004; October 2007**

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Managed by
UT-BATTELLE, LLC
for the U. S. Department of Energy
under contract number DE-AC-05-00OR22725

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ACRONYMS

| | |
|----------|---|
| BER | Biological and Environmental Research |
| BJC | Bechtel Jacobs Company |
| CAP | Capacity Assurance Plan |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| DOE | Department of Energy |
| DOT | Department of Transportation |
| EM | Environnemental Management |
| EPA | Environmental Protection Agency |
| EQUAB | Environmental Quality Advisory Board |
| ERSD | Environmental Remediation Sciences Division |
| ERSP | Environmental Remediation Sciences Program |
| ESH&Q | Environment Safety, Health, and Quality |
| FONSI | finding of no significant impact |
| FREC | Field Research Executive Committee |
| GTL | Genomes to Life |
| HASP | Health and Safety Plan |
| HAZWOPER | Hazardous Waste Operations and Emergency Response |
| IFC | Integrated Field Challenge Project |
| ISMS | Integrated Safety Management System |
| ITRC | Interstate Technology Regulatory Cooperation |
| ITRD | Innovative Technology Remediation Demonstration |
| LIRP | Local IFC Review Panel |
| LOC | Local Oversight Committee |
| LTS | Long Term Stewardship |
| MOU | Memorandum of Understanding |
| NABIR | Natural and Accelerated Bioremediation Research |
| ORFRC | Oak Ridge Field Research Center |
| ORIFC | Oak Ridge Integrated Field Challenge Project |
| ORNL | Oak Ridge National Laboratory |
| ORR | Oak Ridge Reservation |
| PI | Principal Investigator |
| QAPP | Quality Assurance Project Plan |
| RCRA | Resource Conservation and Recovery Act |
| RMO | Reservation Management Organization |
| RSS | Research Safety Summary |
| SSAB | Site Specific Advisory Board |
| TDEC | Tennessee Department of Environment and Conservation |
| USGS | United States Geological Survey |

1. INTRODUCTION

The Environmental Sciences Division at Oak Ridge National Laboratory has established the Oak Ridge Field Research Center (ORFRC) (see website at <http://public.ornl.gov/nabirfrc/>) for the U.S. Department of Energy (DOE) Office of Science. This facility, located on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee, supports the mission of the DOE Headquarters Office of Biological and Environmental Research (BER) in its execution of the Environmental Remediation Sciences Program (ERSP) (see website at http://www.sc.doe.gov/ober/ERSD_top.html). The current major focus of activities at the ORFRC is the Oak Ridge Integrated Field Challenge (IFC) project entitled *Multi-scale Investigations on the Rates and Mechanisms of Targeted Immobilization and Natural Attenuation of Metal, Radionuclide, and Co-Contaminants in the Subsurface*.

The long-term goal of the IFC project, which began in 2007, is to provide a mechanistic understanding of the linkages among ground water flow, lithology, biogeochemical processes, and the metabolic activity of microorganisms that limit the fate and transport of metal and radionuclide contaminants in the subsurface of DOE sites. IFC research is motivated by the need to (a) understand the limits of natural processes in attenuating contaminant plumes, (b) delineate uncertainties in how recharge events affect subsurface transport of contaminants, and (c) define the level of source zone mitigation that is required to protect human health and the environment. Because the results of this research will improve the ability to predict the feasibility of natural attenuation of contaminant plumes and the impact of source zone remediation at multiple scales, the research will provide information to aid decision-making about remediation measures that may be required for effective long-term stewardship at DOE sites. The IFC project will be conducted over 5 years, and is presently funded at \$ 3 million per year. The Lead Principal Investigator is Philip Jardine of Oak Ridge National Laboratory; external investigators are from major universities, national laboratories, and other scientific organizations across the United States.

1.1. ERSR OVERVIEW

For more than 50 years, the U.S. created a vast network of more than 113 facilities for research, development, and testing of nuclear materials. As a result of these activities, subsurface contamination has been identified at over 7,000 discrete sites across the U.S. Department of Energy complex. With the end of the Cold War threat, the DOE has shifted its emphasis to remediation, decommissioning, and decontamination of the immense volumes of contaminated groundwater, sediments, and structures at its sites.

It is estimated that more than 60% of DOE facilities have groundwater contaminated with metals or radionuclides, the contaminants found with the highest frequency in soil at all DOE waste sites. Indeed, while virtually all of the contaminants found at industrial sites nationwide can also be found at DOE sites, many of the metals and especially the radionuclides found on DOE sites are unique to those sites (DOE 2004, http://www.sc.doe.gov/ober/ERSD/ersd_nabir.html). DOE's Office of Environmental Management (EM), which is responsible for the cleanup, has stated that advances in science and technology are critical for DOE to reduce costs and successfully address these long-term problems.

The ERSR is an interdisciplinary program in the Environmental Remediation Sciences Division of BER within the Office of Science. ERSR consolidates two former research programs—the Natural and Accelerated Bioremediation Research (NABIR) program and the Environmental Management Science Program (EMSP). The mission of ERSR (DOE 2006) is to “advance our understanding of the fundamental biological, chemical and physical processes that control contaminant behavior in the

environment in ways that help solve DOE's intractable problems in environmental remediation and stewardship." ERSP recognizes the importance of natural processes and their interactions at different scales in controlling the fate and transport of contaminants in the subsurface, and supports field research designed to provide critical understanding in support of decision making across the DOE complex. Goals of this research are 1) to understand fate and transport of contaminants to predict and control environmental remediation and facilitate stewardship, 2) to explore new options for remediation of subsurface systems, and 3) to develop new measurement and monitoring tools to better understand and manage contaminant transport (DOE 2006). Continuation of the ORFRC for long-term research on the scientific foundations underpinning subsurface processes controlling fate, transport, and remediation of metals and radionuclides will assist ERSP in meeting its long-term measure (DOE 2006): "by 2015, provide sufficient scientific understanding to allow a significant fraction of DOE sites to incorporate coupled biological, chemical and physical processes into decision making for environmental remediation." The ORFRC supports interdisciplinary field-scale studies and sample acquisition in both radiologically contaminated and uncontaminated environments. This research should increase the development of scientific understanding that could reduce remediation risks, costs, and schedules, and help solve currently intractable problems.

1.2. THE OAK RIDGE FIELD RESEARCH CENTER (ORFRC)

The ORFRC lies within the Y-12 National Security Complex area of responsibility on the Oak Ridge Reservation. The Y-12 Complex is located in Bear Creek Valley adjacent to the city of Oak Ridge. The ORFRC provides a site for investigators in the ERSP and potentially other DOE programs to conduct field-scale research and obtain samples related to subsurface processes governing fate and transport of contaminants. The ORFRC is the focus of the IFC project field and laboratory research and provides a means of examining the biogeochemical processes that influence remediation and stewardship under realistic field conditions.

The Oak Ridge Reservation is the site of three major DOE facilities administered by DOE's Oak Ridge Operations Office—Oak Ridge National Laboratory, Y-12 National Security Complex, and East Tennessee Technology Park, formerly known as the K-25 Site. Figure 1.1 shows the general location of the ORFRC, surrounding counties, and the three DOE facilities within the Oak Ridge and Knoxville region.

The Oak Ridge Reservation was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List in 1989. Remediation efforts on the Oak Ridge Reservation, including individual sites in Bear Creek Valley, are governed by the Federal Facility Agreement among DOE, Region IV of the U.S. Environmental Protection Agency (EPA), and the Tennessee Department of Environment and Conservation (TDEC). Subsequently, the Remedial Investigation/Feasibility Study for the Bear Creek Watershed was performed to address contamination associated with former waste disposal activities in Bear Creek Valley. The CERCLA Record of Decision was signed in May of 2000. Various sites within the Oak Ridge Reservation are also regulated under the Resource Conservation and Recovery Act (RCRA) through permits administered by TDEC. The Y-12 National Security Complex is administered through the DOE Headquarters Defense Programs Office. It is operated by BWXT Y-12, the Management and Operations contractor. Bechtel Jacobs Company is the Management and Integration contractor responsible for environmental management activities (administered through DOE Headquarters Office of Environmental Management) conducted on the Oak Ridge Reservation. UT-Battelle is the Management and Operations contractor for Oak Ridge National Laboratory (ORNL), which is administered through DOE Headquarters Office of Science.

The ORFRC includes a 243-acre (98-ha), previously disturbed contaminated area used for conducting experiments on a plume of contaminated groundwater. It also includes a 404-acre (163-ha) background area (Fig. 1.1) that provides for comparison studies in an uncontaminated area, and ancillary structures located within a 3.2-mile (5.2-km) radius of each other on the Oak Ridge Reservation. The contaminated site includes the commingled groundwater plume found in the shallow unconsolidated sediments (<10 m depth) in the Nolichucky Shale, and in the Maynardville Limestone that originated from a combination of Y-12's S-3 Waste Disposal Ponds, Bear Creek Burial Ground and Bone Yard/Burn Yard. The initial focus of ERSP investigations, however, has been on the easily accessible shallow unconsolidated sediments that overlie the Nolichucky Shale. Contaminants in this plume and in the shallow saturated and unsaturated soils include uranium, Tc-99, strontium metal, nitrate, barium, cadmium, volatile organic contaminants and other inorganics and radionuclides of interest to ERSP investigators. Initially, test plots situated in proximity to the S-3 Ponds Site parking lot have been used. As the course of ERSP and IFC project investigations has proceeded, other test plots have been used farther down Bear Creek Valley, thus looking at the entire plume.

The contaminated and background areas are located in Bear Creek Valley (Fig. 1.1). Bear Creek Valley is approximately 10 miles (16 kilometers [km]) long and extends from the eastern end of the Y-12 National Security Complex to the Clinch River on the west. Bear Creek is a tributary to East Fork Poplar Creek, which drains into the Clinch River at the East Tennessee Technology Park.

No new permanent structures were required to establish and maintain the ORFRC; field trailers were relocated to both the contaminated and background areas, and a large tent has been placed in the contaminated area near the S-3 Ponds location to house experimental equipment in use at the site. Existing ancillary facilities (e.g., equipment sheds) are also used to support the ORFRC and IFC activities. Researchers use existing facilities at ORNL, including offices and research laboratories. The ORFRC is of sufficient size to accommodate multi-investigator IFC and other studies over the lifespan of the ERSP studies.

1.3. THE INTEGRATED FIELD CHALLENGE (IFC) PROJECT

Initiated in 2007, the Integrated Field Challenge (IFC) project entitled *Multi-scale Investigations on the Rates and Mechanisms of Targeted Immobilization and Natural Attenuation of Metal, Radionuclide, and Co-Contaminants in the Subsurface* will elucidate the mechanisms and rates of removal for important DOE contaminants in plumes that emanate from contaminated source zones, and the effects of source zone remediation measures on those plumes.

The long-term goal of the IFC project is to provide a mechanistic understanding of the linkages among ground water flow, lithology, biogeochemical processes, and the metabolic activity of microorganisms that limit the fate and transport of metal and radionuclide contaminants in the subsurface of DOE sites. IFC research is motivated by the need to (a) understand the limits of natural processes in attenuating contaminant plumes, (b) delineate uncertainties in how recharge events affect subsurface transport of contaminants, and (c) define the level of source zone mitigation that is required to protect human health and the environment. Because the results of this research will improve our ability to predict the feasibility of natural attenuation of contaminant plumes and the impact of source zone remediation at multiple scales, the research will provide information to aid decision-making about remediation measures that may be required for effective long-term stewardship at DOE sites.

The primary objective of the project is to advance the understanding and predictive capability of coupled hydrological, geochemical, and microbiological processes that control the *in situ* transport,

remediation and natural attenuation of metals, radionuclides, and co-contaminants at multiple scales ranging from the molecular to the watershed. IFC research focuses on determining the key coupled hydrobiogeochemical factors such as pH, electron donor utilization, and redox conditions along contaminant pathways and within specific transition zones that control the fate and transport of uranium, technetium, and co-contaminant nitrate within spatially distributed source zones and ground water plumes at the ORFRC. Because remedial decisions are made at the watershed scale, investigating and understanding these processes at this scale are necessary for making informed remedial decisions. The specific objectives of IFC research are to:

- quantify recharge pathways and other hydraulic drivers for ground water flow and dilution of contaminants along flow pathways and determine how they change temporally and spatially during episodic events, seasonally, and long term;
- determine the rates and mechanisms of coupled hydrological, geochemical, and microbiological processes that control the natural attenuation of contaminants in highly diverse subsurface environments and over scales ranging from molecular to watersheds;
- explore novel strategies for enhancing the subsurface stability of immobilized metals and radionuclides;
- understand the long-term impacts of geochemical and hydrologic heterogeneity on the remobilization of immobilized radionuclides;
- improve our ability to predict the long-term effectiveness of remedial activities and natural attenuation processes that control subsurface contaminant behavior across a variety of scales.

A list of tasks and schedule to accomplish these objectives is provided in Figure 1.2.

Anticipated research products include:

- predictive monitoring and modeling tools that can be used at sites throughout the DOE complex to inform and improve the technical basis for decision making, and to assess which sites are amenable to natural attenuation and which would benefit from source zone remedial intervention;
- recommendations and strategies, conveyed via technical reports and stakeholder workshops, that will assist local decision makers in making scientifically informed choices on ground water remediation actions; and
- scientific publications that convey our improved understanding of *in situ* contaminant attenuation rates and mechanisms and the long-term effectiveness of remedial activities relevant to *in situ* remediation and stewardship at DOE sites.

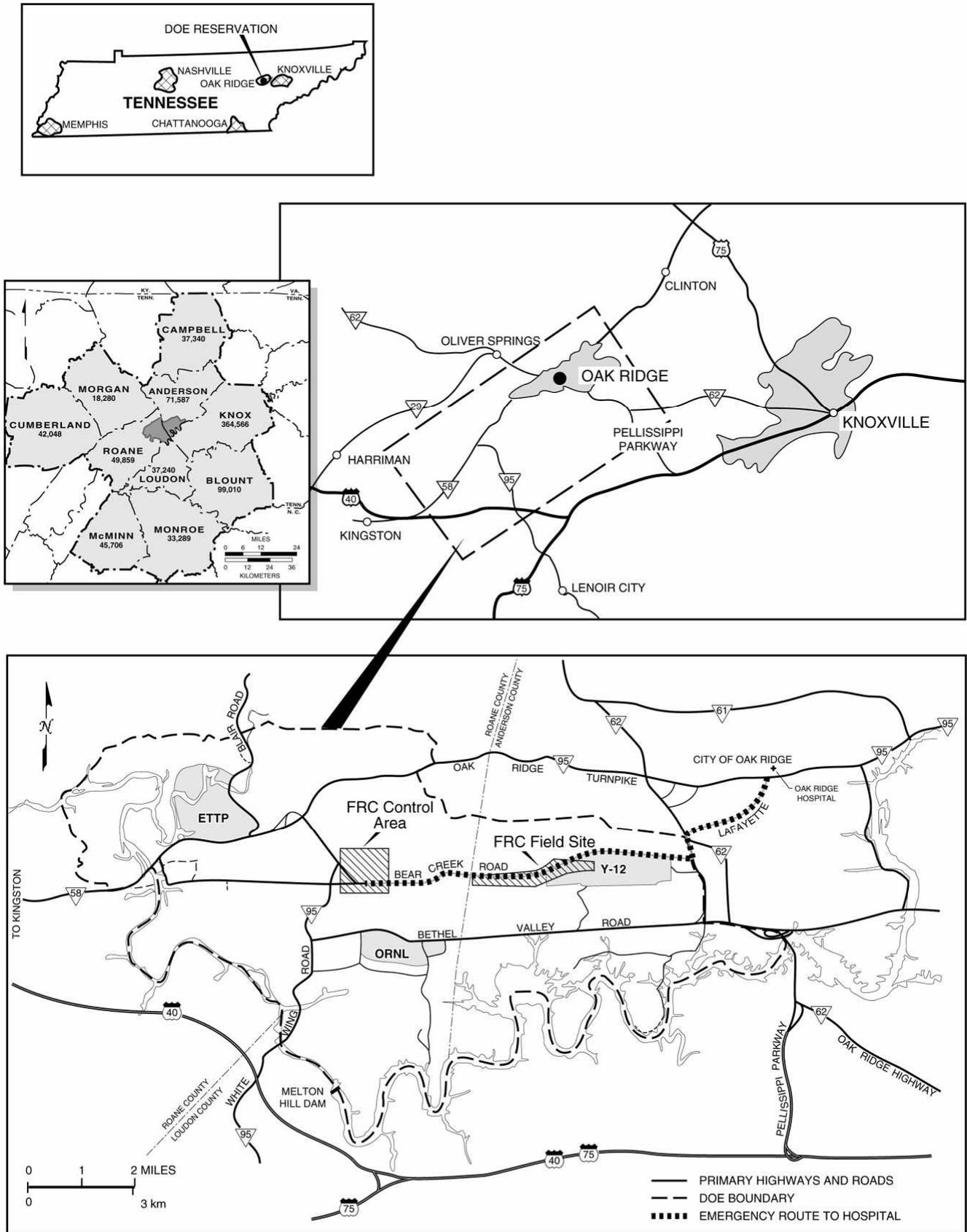


Fig. 1.1. Location of the Oak Ridge Field Research Center (ORFRC), in Tennessee.

| Task | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|--|--|----|----|----|--|----|----|----|--|----|----|----|--------|----|----|----|--------|----|----|--|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| A. GEOPHYSICAL DEFINITION OF SUBSURFACE HETEROGENEITY WITHIN PATHWAYS | | | | | | | | | | | | | | | | | | | | |
| A.1 Link Geophysics Response to Media | Install borings/arrays | | | | Assessments | | | | | | | | | | | | | | | |
| A.2 Define Heterogeneity and Pathways | Install arrays | | | | Assessments | | | | | | | | | | | | | | | |
| B. QUANTIFYING RATES AND MECHANISMS OF NATURAL ATTENUATION | | | | | | | | | | | | | | | | | | | | |
| B.1 Shale and Carbonate Pathways | | | | | | | | | | | | | | | | | | | | |
| B.1.1 Coring and well installation | Share borings from Task A | | | | Install additional borings | | | | | | | | | | | | | | | |
| B.1.2 Rates and mechanisms - nitrate | Assessments with Task A and existing wells | | | | Assessments with new well transects and consideration of geophysical data | | | | | | | | | | | | | | | |
| B.1.3 Rates and mechanisms - U and Tc | Assessments with Task A and existing wells | | | | Assessments with new well transects and consideration of geophysical data | | | | | | | | | | | | | | | |
| B.2 U/Tc Immobil. by pH Adjustment | | | | | | | | | | | | | | | | | | | | |
| B.2.1 Field column studies | Field columns | | | | | | | | | | | | | | | | | | | |
| B.2.2 Controlled field plot studies | | | | | Develop field plot | | | | Manipulations | | | | | | | | | | | Recovery |
| B.2.3 Microbial assessments | | | | | Premanipulation | | | | Manipulation and post manipulation phases | | | | | | | | | | | |
| B.3 Recharge Studies | | | | | | | | | | | | | | | | | | | | |
| B.3.1 Hydrobiogeochemical studies | | | | | | | | | | | | | | | | | | | | |
| B.3.2 Geophysics studies | | | | | | | | | | | | | | | | | | | | |
| B.3.2 Recharge reduction test | | | | | | | | | Perched zone continuous tracer injection | | | | | | | | | | | |
| | | | | | | | | | Install arrays----monitor recharge events----assess data | | | | | | | | | | | Drainage ditch diversion |
| C. ENHANCED CONTAMINANT STABILITY STRATEGIES FOR SOURCE CONTROL | | | | | | | | | | | | | | | | | | | | |
| C.1 Field Plot Expansion | | | | | | | | | | | | | | | | | | | | |
| C.1.1 Expand field plots - install wells | Coring and install wells | | | | | | | | | | | | | | | | | | | |
| C.1.2 Field plot biostimulation | | | | | Biostimulation of plots as needed | | | | | | | | | | | | | | | Remobilization studies |
| C.2 Microbial Reduction Assessment | | | | | | | | | | | | | | | | | | | | Gravel pathway: years 2-5 / Saprolite pathway: years 2-5 |
| C.3 Oleate Slow Release Assessment | | | | | | | | | Gravel pathway oleate additions | | | | | | | | | | | |
| C.4 Metal Sequest. by Organo-phosphate | | | | | | | | | Gravel pathway: years 2-5 / Saprolite pathway: years 3-5 | | | | | | | | | | | |
| C.5 Microbiology of Manipulated Zones | Premanipulation | | | | Manipulation and post manipulation phases | | | | | | | | | | | | | | | |
| C.6 Geophysical Studies | Premanipulation | | | | Manipulation and post manipulation phases | | | | | | | | | | | | | | | |
| D. MULTISCALE AND MULTIPROCESS NUMERICAL MODELLING AND DATA ANALYSIS | | | | | | | | | | | | | | | | | | | | |
| D.1 Multiscale Flow and Transport Model. | | | | | | | | | | | | | | | | | | | | |
| D.1.1 Site-wide modeling | Expand existing model and incorporate reactive transport | | | | Iterative feedback from data collected during implementation of Tasks A, B, and C | | | | | | | | | | | | | | | |
| D.1.2 Local scale modeling | | | | | Localized models for Plots 1, 2, and 3, recharge and transition zones, and batch and column test | | | | | | | | | | | | | | | |
| D.1.3 Upscaling and model accuracy | | | | | Iterative feedback from data collected during implementation of Tasks A, B, and C | | | | | | | | | | | | | | | |
| D.2 Advanced Pattern Recognition | | | | | Summarize data, classify results based on sites and manipulations, develop predictive capability | | | | | | | | | | | | | | | |

Fig.1.2. Schedule of tasks.

2. PURPOSE

The purpose of the IFC is to provide an understanding of interactions among ground water flow, lithology, biogeochemical processes, and microorganisms that limit the fate and transport of contaminants in the subsurface at DOE sites. This research will maximize the ability to use natural attenuation appropriately for effective long-term stewardship at DOE sites.

The purpose of the ORFRC is to support interdisciplinary field-scale studies and sample acquisition in radiologically contaminated and uncontaminated environments (DOE 2006). The ORFRC is operated in a manner that supports ERSP's mission and goals by providing a field site for investigators in the ERSP and other DOE programs to conduct basic research to advance our understanding of the fundamental biological, chemical and physical processes that control contaminant behavior in the environment. ORFRC operations are integrated with the IFC Project field and laboratory research to provide a means of examining new concepts for remediation and long-term stewardship of contaminants under field conditions. The ORFRC is operated by Oak Ridge National Laboratory's Environmental Sciences Division.

The purpose of this IFC and ORFRC Management Plan is to outline procedures to facilitate the scientific approach to research at the ORFRC, and the approach to ensuring Environment, Safety and Health compliance. This plan also provides a list of the roles and responsibilities of individuals and organizations involved with research activities at the ORFRC.

This IFC and ORFRC Management Plan tiers from the Office of Science Strategic Plan (DOE 2004b), ERSP Strategic Plan (DOE 2006) and ERSD Management Plan for the Integrated Field Challenge (IFC) Projects (DOE 2007) and is one of a set of high-level planning documents (available at <http://public.ornl.gov/nabirfrc/>) that govern the operation of the ORFRC and implementation of the IFC and other projects. These include the following plans:

- Environmental Assessment and FONSI (DOE 2000a,b)
- Quality Assurance Plan (Brandt et al., 2001, revised 2007)
- Health and Safety Plan [Site-Specific] (Watson and Quarles 2001, revised 2007) (tiered from the ORNL HAZWOPER Program Manual (ORNL 1993))
- Research Safety Summary (ORNL 2007b)
- ORFRC Researcher's Guide (ORNL 2005)
- Implementation Plan for the Integrated Field-Scale Challenge Project (ORNL 2007a)

Together, these plans form a "road map" for conduct of operations at the ORFRC for both the scientific research to be conducted, as well as the commitments to Environment, Safety and Health.

Specific Environment, Safety, Health, and Quality (ESH&Q) requirements for activities conducted at the ORFRC are determined on a project-by-project basis through individual Integrated Safety Management System (ISMS) project reviews conducted in accordance with, and as described in, this ORFRC Management Plan. The reviews include preparation of a Research Safety Summary (RSS) which addresses necessary and appropriate controls, requirements, and training specific to the hazards presented by each project.

3. GOALS AND OBJECTIVES

The ORFRC is providing access to the IFC project and all IFC team members. The long-term goal of the IFC project, which began in 2007, is to provide a mechanistic understanding of the linkages among ground water flow, lithology, biogeochemical processes, and the metabolic activity of microorganisms that limit the fate and transport of metal and radionuclide contaminants in the subsurface of DOE sites. The primary objective of the project is to advance the understanding and predictive capability of coupled hydrological, geochemical, and microbiological processes that control the *in situ* transport, remediation and natural attenuation of metals, radionuclides, and co-contaminants at multiple scales ranging from the molecular to the watershed. IFC research focuses on determining the key coupled hydrobiogeochemical factors such as pH, electron donor utilization, and redox conditions along contaminant pathways and within specific transition zones that control the fate and transport of uranium, technetium, and co-contaminant nitrate within spatially distributed source zones and ground water plumes at the ORFRC. Because remedial decisions are made at the watershed scale, investigating and understanding these processes at this scale are necessary for making informed remedial decisions. While natural processes at several uncontaminated watersheds (e.g., DOE Walker Branch Watershed in TN, Coweeta Watershed in NC, and Hubbard Brook Watershed and USGS Mirror Lake site both in NH) are being investigated, there are no comparable watershed-scale contaminated sites where contaminant fate and transport issues are being investigated.

The ORFRC provides access to contaminated and uncontaminated sites for scientists sponsored by the ERSP (and potentially other programs) to conduct field-scale remediation and fate and transport studies. The ORFRC and supporting infrastructure are designed to facilitate long-term, interdisciplinary research and, as needed, to provide samples to individual ERSP investigators to conduct laboratory and field studies. The ORFRC seeks to serve as a premier field research site at which ERSP and other investigators can obtain samples and conduct *in situ* studies that will lead to new insights into the subsurface fate and transport processes governing remediation and stewardship of metal and radionuclide contaminants and co-contaminants such as nitrate and organics.

The field research sites provided to ERSP investigators by the ORFRC contain a spectrum of waste types and subsurface environmental media (vadose zone and saturated zone) that are representative of both background and contaminated conditions within the DOE complex. The ORFRC also offers a source of relevant DOE subsurface samples for ERSP investigators, and field locations for *in situ* research. Field scale research at the ORFRC offers the investigator the opportunity to move laboratory-based research to the field, and observe and manipulate remediation processes involving heavy metals and radionuclides in a field setting at larger scales that are relevant to site cleanup decisions. Data collected from research conducted at the ORFRC is managed in accordance with the Quality Assurance Plan to ensure consistency, and is available to ERSP researchers through the ORFRC Data Management System maintained by ORNL.

Specifically, as described in the ERSP Strategic Plan (DOE 2006, http://www.sc.doe.gov/ober/ERSD_top.html), the three goals of the research program of which the ORFRC is a part is to:

- 1) Develop an improved understanding of the processes governing the fate and transport of contaminants to predict and control the long-term performance of environmental remediation and facilitate stewardship of DOE sites.
- 2) Explore new options and concepts for remediation and long-term stewardship of subsurface systems.

3) Provide the scientific foundation for new measurement and monitoring tools to better understand and manage contaminant transport.

Currently the primary focus of activities at the ORFRC is the Integrated Field Challenge (IFC) project. The long-term goal of this project is to provide a mechanistic understanding of the linkages among groundwater flow, lithology, biogeochemical processes, and the metabolic activity of microorganisms that control the fate and transport of metal and radionuclide contaminants in the subsurface of DOE sites.

4. ROLES AND RESPONSIBILITIES

The IFC Principal Investigator (PI), and the Field Site Manager of the ORFRC receive general direction from, and are accountable to, the DOE ERSP Manager. The ERSP Manager is responsible for coordinating, reviewing, and funding the IFC Project conducted at the ORFRC. ERSD Program Managers at DOE fund other individual ERSP investigator projects as appropriate, some of which may use ORFRC resources (e.g., samples). The IFC/ORFRC staff facilitates researchers' access to field locations at the DOE site, and ensures coordination of research activities and compliance with applicable state and federal law and DOE Environment, Safety, and Health requirements. Operation and management of the ORFRC and IFC project involves interaction among various DOE, contractor, and stakeholder organizations, as well as the Field Site Manager, IFC Principal Investigator (PI) and other ERSP investigators. The roles and responsibilities of the major entities are shown in Table 4.1; contact information for individuals and organizations important to the operation of the ORFRC and IFC Project is provided in Appendix I.

The Field Site Manager and IFC PI are supported as needed by staff members from a variety of disciplines; including:

- Administrative Assistant
- Data Management Quality Assurance / Quality Control Specialist
- Environment, Safety, Health and Quality Specialist
- Field Technicians
- Radiation Surveillance Specialist
- Regulatory Specialist
- Site Safety and Health Officer

The IFC PI and other PIs conducting field work at the ORFRC are responsible for preparing project plans and detailed task plans describing the scientific endeavors, methodologies, and resources needed to complete the research. Research will be conducted consistent with ERSD ORFRC Operations and Policies (Appendix II).

The IFC PI is the primary point of contact for external communications with the ERSP Manager and provides ERSP with updates on activities and events at the ORFRC through quarterly reports and conference calls. Additional information on roles and responsibilities of IFC Project personnel are provided in the IFC Project Implementation Plan (ORNL 2007a) and ERSD Management Plan for the Integrated Field Challenge (IFC) Projects (DOE 2007).

The Field Site Manager works closely with the IFC PI and other researchers working at the ORFRC to achieve research objectives in a safe and efficient manner. The Field Site Manager is responsible for the overall management of field operations, including maintaining infrastructure, coordination of users, interactions with regulators and other on-site contractors, coordinating and conducting field activities and waste management. Tasks include record keeping, coordination of meetings, distribution of information, managing any required subcontracts such as drilling, and permit tracking as needed to support the IFC Project and other ORFRC activities.

The Field Site Manager and staff communicate directly with regulatory compliance staff members at ORNL who have responsibility for obtaining or coordinating permits for various activities. In addition, the Field Site Manager meets with the CERCLA Federal Facilities Agreement Project Managers as necessary to avoid conflicts with CERCLA activities. The DOE Office of Biological and Environmental

Research, DOE Oak Ridge National Laboratory Site Office/DOE Environmental Management, and DOE Defense Programs staff, and their prime contractors UT-Battelle, Bechtel Jacobs Company (BJC), and BWXT Y-12 are updated as needed on IFC and ORFRC activities by the Field Site Manager and IFC PI.

IFC and ORFRC information is communicated to local environmental restoration regulators via DOE Environmental Management and Bechtel Jacobs Company, who have that role as part of their environmental restoration mission. As appropriate, IFC/ORFRC staff attend regulator meetings and brief regulators on ORFRC activities. The Field Site Manager and staff strive to link ORFRC activities with other research and development supported by Environmental Management or other agency offices. The IFC PI and Field Site Manager periodically update other stakeholders as appropriate (e.g., SSAB, EQUAB, LOC/CAP, ITRC). The Reservation Management Organization (RMO) is the primary organization for decision making with respect to use of Oak Ridge Reservation (ORR) land. The RMO has representatives from each of the major DOE contractors in Oak Ridge. The Field Site Manager, or his designee, briefs the RMO as needed on progress and issues related to the IFC and ORFRC.

A Local IFC Review Panel (LIRP) that includes local representatives from DOE ORR Environmental Management, the cleanup contractor (BJC), and State regulators has been formed to provide the Field Site Manager and IFC Principal Investigator with input on day-to-day operational issues, project relevance to site needs, and regulatory compliance issues. This Panel will also provide an avenue to communicate the results of research studies to some of the local stakeholders.

DOE ERSP has also established a Field Research Executive Committee (FREC) consisting of national scientific experts that will review ERSP IFC projects and provide broader technical comments and advice on IFC research initiatives. The primary role of the FREC is to provide ERSD with technical support and oversight for the management of the ERSD field research programs (DOE 2007).

Table 4.1 Roles and responsibilities of ORFRC entities

| | |
|--|-------------------------------|
| Position: | IFC Principal Investigator |
| Organization: | Oak Ridge National Laboratory |
| Designee: | Philip Jardine |
| <ul style="list-style-type: none"> • Overall responsibility for implementing IFC Project, coordination between Task Leaders and Field Site Manager and ensuring scientific quality and integrity • Develops IFC schedules and budgets and responsible for subcontracting • Works with Field Site Manager and IFC Task Managers preparing Project Implementation Plans, Detailed Task Plans and QAPP describing the scientific endeavors, methodologies, data quality and resources needed to complete the tasks • Implement health and safety plans • Provides briefings to the Local IFC Review Panel • Periodically analyzes the extent to which ERSP research, whether conducted in the field or in laboratories using site samples, is coordinated and linked, and recommends methods for improving that coordination • Provide reports and other information to DOE for FREC reviews • Submits quarterly and annual progress reports to ERSP Manager and participates in quarterly conference calls • Maintains a data management system that provides scientists with characterization data through a web-based data retrieval system | |
| Position: | Field Site Manager |
| Organization: | Oak Ridge National Laboratory |
| Designee: | David Watson |
| <ul style="list-style-type: none"> • Coordinates IFC and other ORFRC field activities, including obtaining applicable state permits, preparing and | |

| | |
|---|---|
| <p>implementing site safety plans, scheduling IFC and other ORFRC field activities and operations, and supervision of field staff and support personnel</p> <ul style="list-style-type: none"> • Interacts with the DOE Oak Ridge National Laboratory Site Office, DOE Environmental Management, DOE Defense Programs Staff and their prime contractors, UT-Battelle, Bechtel Jacobs Company, and BWXT Y-12 • Participates in evaluation of proposed field experiments at the ORFRC field sites • Reviews work plans for all field activities at the ORFRC field sites prior to initiation of such activities and works with IFC PI and Local IFC Review Panel • Distributes ground water, sediment/soil, core and other relevant environmental samples to investigators • Maintains/oversees collection, analysis, and tracking documentation of field samples • Participates in quarterly conference calls with the ERSD ERSP Manager • Establishes and maintains operational procedures and associated documentation for the IFC and other ORFRC projects • Disseminates data from characterization studies to scientists to support hypothesis-based research • Provides state-of-the-art equipment and knowledgeable support staff to quantify key field-scale hydrological, geochemical, and microbiological processes | |
| Position: | ERSP Manager for the IFC project |
| Organization: | DOE Office of Biological and Environmental Research |
| Designee: | Paul Bayer |
| <ul style="list-style-type: none"> • Works with the DOE Oak Ridge Operations Office staff, IFC PI and the Field Site Manager to coordinate IFC and other field research activities at the ORFRC • Oversees activities on the IFC and other projects at the ORFRC • Reviews and approves the IFC Management Plan, Health and Safety Plan, Site Characterization Plan, Communications/Community Interactions Plan, Closure Plan and Project Implementation Plans • Participates in evaluation of proposed and completed IFC field research activities at the ORFRC site • Reviews DOE Field Work Proposal for annual IFC funding and provides approximate budget for the IFC • Reviews quarterly IFC progress reports and participates in conference calls with IFC PI and Field Site Manager • Convenes FREC to review IFC activities • Ensures that field-scale activities are linked to the goals of the ERSP Strategic Plan • Encourages synergism of investigations and operational activities between the IFCs through quarterly conferences calls | |
| Position: | IFC Task Managers and other ERSP PIs |
| Organization: | Universities, National Laboratories, other scientific organizations |
| Designees: | Various |
| <ul style="list-style-type: none"> • Work with IFC Principal Investigator and Field Site Manager assuming responsibility for major field components of ORFRC research • Implement health and safety plans • Submit preliminary work plans and full work plans for both sampling and <i>in situ</i> research to the IFC PI • Provide periodic reports to the IFC and Field Site Manager on activities and necessary training certification • Provide data and results in a timely manner to the IFC PI and Field Site Manager for submittal to the ORFRC Data Management System • Current IFC Task Managers include: <ul style="list-style-type: none"> David Watson (ORNL), Hydraulic Studies Susan Hubbard (LBNL), Geophysics Studies of Manipulations Craig Criddle (Stanford University), Biological Manipulations Joel Kostka (Florida State University), Microbial Studies Jack Parker (University of Tennessee), Flow and Reactive Transport Modeling | |
| Position: | Oak Ridge Reservation Management & Operating Contractors |
| Organization: | UT-Battelle (Oak Ridge National Laboratory) BWXT Y-12 |

Bechtel Jacobs Company (Environmental Management)

- **UT-Battelle**
 - Operates the IFC and ORFRC
 - Provides Field Site Manager, IFC Principal Investigator, and staff
 - Assures compliance with National Environmental Policy Act
 - Ensures compliance with DOE orders, State of Tennessee and federal environmental laws, Occupational Safety and Health Act, Nuclear Regulatory Commission requirements, and Department of Transportation requirements

- **BWXT Y-12**
 - Coordinates Defense Programs (Y-12) activities
 - Provides general access to ORFRC sites
 - Provides Emergency response
 - Provides site services
 - Provides Penetration Permits

- **Bechtel Jacobs Company**
 - Coordinates Environmental Management activities
 - Provides waste disposal and treatment
 - Provides site access to contaminated areas

Position: DOE ORFRC Field Administration
Organization: DOE Oak Ridge Operations Office
Designees: Elizabeth C. Phillips (Environmental Management)
 David L. Buhaly (ORNL Operations Division)
 James P. Donnelly (Technical Support Division)

- Reviews ORFRC Plans to ensure there are no conflicts among Environmental Management, Defense Programs, and Office of Science activities

- Serves as interface with Environmental Protection Agency and Tennessee Department of Environment and Conservation

- Provides funding for the IFC project via UT-Battelle

- Ensures compliance with DOE orders, State of Tennessee and federal environmental laws, Occupational Safety and Health Act, Nuclear Regulatory Commission requirements, and Department of Transportation requirements

Position: Local IFC Review Panel
Organization: Various
Designees: Elizabeth C. Phillips (DOE Environmental Management)
 Richard Ketelle (EM Contractor BJC-LLC)
 Robert Benfield (Tennessee Department of Environment and Conservation)

- Reviews ORFRC Plans to ensure there are no regulatory or Environmental Management conflicts

- Provides input on day-to-day operational issues, project relevance to site needs, and regulatory compliance issues.

- Serves as an avenue to communicate the results of IFC research studies to some of the local stakeholders (i.e., EM and regulators)

5. PROCEDURES FOR NON-IFC ERSP-FUNDED INVESTIGATORS TO INITIATE PROJECTS

This section outlines the procedures for ERSP-funded investigators who are not part of the IFC project to guide them in using the ORFRC field sites for *in situ* research (i.e., criteria for making selection and/or prioritization on whether an ERSP-funded investigator(s) can undertake an *in situ* research investigation). Various reviews and approvals are necessary for a project to reach the stage where it can be initiated in the field.

The process begins when ERSD solicits proposals from the scientific community for projects that meet the goals and objectives of the ERSP. Submitted proposals are peer reviewed and successful proposals are identified. For proposals that review well and that have a component that involves obtaining samples from the ORFRC or conducting *in situ* research at the ORFRC, such proposals are submitted to the Field Site Manager. The Field Site Manager reviews each proposal to determine whether there is a high probability that the project can be successfully implemented at the ORFRC, including whether there are any potential conflicts or synergies to be achieved in relation to the IFC project. If there are potential conflicts, then the proposal is referred to ERSD for additional consideration and possible modification. If the proposed project is appropriate for the conditions at the ORFRC then the Field Site Manager recommends to the IFC PI and the ERSP Manager for the IFC that the project be approved for implementation.

If the ERSP Manager for the IFC project, the IFC PI and the Field Site Manager agree that the proposed project can be successfully implemented at the ORFRC, then the Field Site Manager is notified that the proposal is to be funded. The Field Site Manager then asks the PI for the proposed project to prepare a work plan that describes the project's location within the ORFRC, and the nature and duration of activities to be conducted. For most projects, the review process takes only a few days to complete. However, some projects take longer if there are special permitting requirements or other complicating factors.

The work plan is reviewed for implementability by the Field Site Manager, the IFC PI and Local IFC Review Panel for completeness; if additional information is required in order to properly evaluate the project, the Field Site Manager requests it from the ERSP-funded investigator.

For the project to proceed further it must be approved for specific implementation on the physical location of the ORFRC by the Oak Ridge Reservation contractors and various government entities. This process begins with the Field Site Manager providing the work plan for review, as needed, to Bechtel Jacobs Company, BWXT Y-12, and DOE Environmental Management at the Oak Ridge Operations. Their reviews will lead to a determination of whether the project can be conducted under the dual relevant regulatory authorities of CERCLA and RCRA, and whether it is within the scope of contractor responsibilities.

The project must not conflict with CERCLA cleanups being conducted on the Oak Ridge Reservation. If the project is to be conducted in a contaminated area of the Bear Creek Valley, then DOE Environmental Management determines if the proposed work presents any potential conflict with CERCLA remediation or monitoring. If not, then the CERCLA review is completed. If there is a potential conflict, then Environmental Management informs the Field Site Manager, and as needed the EPA, and TDEC. The Field Site Manager attempts to resolve the conflict by working with the ERSP investigator to change the project timing, location, and potentially the scope. If more information is

requested by the EPA or TDEC, it is provided. If these efforts do not resolve the conflict, then the Field Site Manager presents project details at a Federal Facility Agreement Project Managers meeting for evaluation by the parties. The Federal Facility Agreement Project Managers then determine if unresolved concerns remain. If so, the project is suspended until the conflict issues are resolved. If the resolution requires significant changes that could impact the technical aspects of the project, then the revised work plan may be resubmitted to the Lead Principal Investigator and Local IRP Review Panel for review.

If there are no CERCLA conflicts, or when any such potential conflicts are resolved, the proposed project is evaluated to determine whether it is within the scope of individually negotiated Memorandums of Understanding (MOUs) with BWXT Y-12 and Bechtel Jacobs Company. The MOUs specify, among other things, whose operating and waste certification procedures are used (where and when), and who maintains specific areas. The Field Site Manager and BWXT Y-12 determine if the project activities are within the scope of the MOU with BWXT Y-12. If the project is not within the scope of the MOU, the IFC Field Site Manager and BWXT Y-12 will modify the MOU and/or scope of work as necessary. Similarly, the Field Site Manager and Bechtel Jacobs Company determine if the project is within the scope of the MOU with Bechtel Jacobs Company. If not, the parties will modify the MOU and/or scope of work as necessary.

If the project is in the contaminated area of Bear Creek Valley, then a modification of the post-closure RCRA permit for the S-3 Ponds site must be obtained from TDEC if the work is significantly different from what has been done at the ORFRC in the past. Bechtel Jacobs Company is the co-operator to DOE on the RCRA permit. Under the MOU with Oak Ridge National Laboratory, Bechtel Jacobs Company agrees to submit to TDEC the necessary Class 1 permit modification. The permit modification is based on information in the work plan supplemented by the Field Site Manager as necessary.

After a potential project is determined to be free of CERCLA conflicts and handled within the scope of the MOUs with Bechtel Jacobs Company and BWXT Y-12, a review of the proposed project activities can begin to determine ESH&Q requirements as described in the following Sections. In some cases these processes are conducted concurrently.

Limited ad-hoc field activities such as limited collection of cores and groundwater samples can be approved by the Field Site Manager. All proposed field activities for this type of work are documented, evaluated, and approved prior to initiation of any on-site activity.

6. SITE-SPECIFIC PROJECT REQUIREMENTS REVIEW

The Field Site Manager, IFC PI and other ERSP investigators are responsible for ensuring ESH&Q compliance at all stages of each project and the sample handling life cycle. The Oak Ridge National Laboratory Integrated Safety Management System (ISMS) program is employed as the framework and overall approach to meeting all ESH&Q requirements. A major principle of ISMS is the identification of standards and requirements before work is performed. Oak Ridge National Laboratory has in place various compliance-related organizations that are responsible for identifying the entire spectrum of requirements that could apply to a particular project. These requirements arise from federal and state statutes and regulations, Executive orders, DOE Orders, work smart standards, and compliance and settlement agreements. For particular projects or classes of activities, Oak Ridge National Laboratory evaluates the associated hazards (to human health and the environment) and establishes an agreed-upon set of working standards and requirements, which, when properly implemented, provide adequate assurance that workers, the public, and the environment are protected from adverse consequences.

ORFRC staff, in consultation with ERSP investigators, prepare an Oak Ridge National Laboratory Environmental Sciences Division ESH&Q Research Safety Summary (RSS) which covers activities performed under all projects conducted at the ORFRC. The RSS is designed to assist in identifying the hazards, requirements, and controls associated with each of the activities associated with each project and in implementing the Safe Work Practices. The RSS is completed by answering various sets of questions in an interactive computer format about the planned project activities. Based on answers to the questions, the tool provides a listing of potentially applicable controls and requirements that will ensure safe work practices are implemented for each activity. The interactive format also returns to the preparer links to the applicable requirements and controls associated with the identified hazards, including potential training programs that may be required. The RSS questions are available to ORFRC staff in their interactive format at <https://sbms.ornl.gov/rhac/AuthUsers/Reports/rptJheQuesWithCtrl.cfm>.

RSS questions are keyed to Oak Ridge National Laboratory procedures and associated requirements. Hard copies of all procedures, requirements, and other documents and plans related to the ORFRC are kept in an on-site library at Oak Ridge National Laboratory. RSS questions are answered based on information contained in the ERSP investigator's work plan. The completed RSS is then reviewed by representatives within the following Oak Ridge National Laboratory compliance-related organizations: Environmental Protection (includes National Environmental Policy Act Compliance), Training, Radiation Control, Industrial Hygiene, Laboratory Waste Services, Quality Assurance, and the Resource Management Organization. These representatives request additional information from the Field Site Manager to the extent necessary to aid them in identifying all applicable regulatory and other requirements that would apply during the project and sample handling life cycle. These requirements, including the need for any new permits or modifications to existing permits, are then listed in the completed RSS document.

Operation of the ORFRC has been addressed in an Environmental Assessment (DOE 2000a) and subsequent Finding of No Significant Impact (DOE 2000b) [http://public.ornl.gov/nabirfrc/ea_fonsi.cfm] pursuant to the National Environmental Policy Act. Approval of projects is granted subject to agreement by ERSP investigators' who will work on the ORFRC site to meet all identified requirements as evidenced by electronically signing the RSS. The Field Site Manager, IFC PI and other ERSP investigators bear responsibility for assuring that all ERSP investigators comply with ESH&Q requirements. If project ERSP investigators do not follow ESH&Q procedures, they will not be allowed to

work on site. Worker safety is of the greatest concern to DOE, ORNL, the IFC PI, the Field Site Manager and FRC staff.

6.1. PERMITS

Following identification of the requirements for a particular ORFRC project, the process for obtaining any necessary permits or permit modifications that have not already been obtained can begin. In some cases, the processes can be conducted concurrently. Oak Ridge National Laboratory has a good record of working with regulators to gain rapid approval for activities conducted at the ORFRC. Dye trace registration covering addition to groundwater of all tracers, including electron donors and nutrients, is handled on an as needed basis by submission of information from ORNL and DOE to, and subsequent approval by, TDEC.

Any necessary authorizations from the EPA for Class V injection wells are handled by ORNL and DOE. To the extent feasible, permits are obtained for classes of similar activities to lessen the need for acquiring or modifying permits on a project-specific basis. Similarly, as internal and external requirements are identified (e.g., sample transportation shipping and safety requirements), methods are developed to rapidly process various classes of similar samples to assure their timely analysis while minimizing the procedural burden on ERSP-funded investigators.

As discussed in previous Sections, each unique project conducted at the ORFRC contaminated area requires a Class 1 permit modification to the Resource Conservation and Recovery Act (RCRA) post-closure permit for the S-3 Ponds site. Information necessary to obtain the permit modification is submitted to the Tennessee Department of Environment and Conservation (TDEC) by Bechtel Jacobs Company (as co-operator to DOE on the permit) based on information provided by the Field Site Manager.

6.2. TRAINING REQUIREMENTS

Work conducted at the contaminated area of the ORFRC may fall under the scope of 29 *CFR* 1910.120, *Hazardous Waste Operations and Emergency Response (HAZWOPER)*. Related requirements that are applicable to each ERSP investigator and staff member are those regulating access to the ORFRC site and associated buildings. All personnel requiring access to the ORFRC must successfully complete General Employee Training for ORR Site Access. This training is required by DOE Orders 5480.10 and 5480.40, and the Occupational Safety and Health Act of 29 *CFR* 1910.1200, and 1910.1450. The purpose of General Employee Training for ORR Site Access is to provide an overview of hazards present at the site; the means used to identify hazardous areas; site emergency procedures and alarms; site safety and quality assurance programs; and site policies, procedures, and instructions that apply to all employees. In addition, laboratory personnel are required to have Hazard Communication training and job-specific training (e.g., Fume Hood Training, Radiation Worker II). Both laboratory and field personnel are required to complete project-specific training that may include procedures for tracer injection, sampling, and analysis and for obtaining and recording field measurements. The Research Safety Summaries prepared covering ORFRC projects list the personnel who will perform the associated project activities. These personnel sign copies of the relevant Research Safety Summaries stating their familiarity with the project activities and controls. Personnel working at the contaminated site usually receive 40-hr HAZWOPER training (24-hr at a minimum is required), and all personnel receive a site-specific hazard communication and site-specific access briefing. Personnel involved with core extraction near the S-3 ponds or requiring entry to designated Radiological Areas also require Radiation Worker II training. Laboratory-specific training provided by the Laboratory Steward is required to work in the Environmental Sciences Division laboratories. Other training required of staff and guests working at the

ORFRC includes Storm Water Pollution Prevention training, and Environmental Management System Awareness training. All required training is available through Oak Ridge National Laboratory in addition to a variety of other institutions.

Project requirements must be consistent with the ORFRC Site-Specific Health and Safety Plan (HASP). The purpose of the ORFRC Site-Specific HASP is to establish health and safety guidelines to be followed by all personnel performing work at the ORFRC. Work is conducted in accordance with requirements identified in the Oak Ridge National Laboratory HAZWOPER Program Manual and applicable DOE and Oak Ridge National Laboratory policies and procedures. All personnel are required to read the HASP, and are specifically briefed on sections of the HASP covering the tasks they perform. The Site-Specific HASP serves as an extension of the Oak Ridge National Laboratory HAZWOPER Program Manual. The combined plans fulfill the requirements of 29 *CFR* 1910.120. The HASP is available at http://public.ornl.gov/nabirfrc/frcdoc_a.cfm

6.3. TRANSPORTATION REQUIREMENTS

Applicable Department of Transportation (DOT) requirements for the packaging and shipping of samples are identified by the Oak Ridge National Laboratory Transportation Specialist. When characteristics of samples fall outside of parameters specified in a MOU between ORNL's Environmental Sciences Division and the Transportation and Packaging Management Organization, a specific Sample Transportation Checklist is completed by ORFRC staff during the ISMS review for all projects involving transport of samples on public roads. The checklist includes questions about the specific activity of the material, its flashpoint, whether or not it is preserved, whether samples contain hazardous materials, if the sample is a Resource Conservation and Recovery Act waste, and whether there is any question about the hazardous nature or radioactivity of the shipment. Based on past experience with sample collection in the Bear Creek Valley, samples collected at the ORFRC are generally below both the DOT radioactivity limits, and the limits for transportation of corrosives/preservatives. However, the potential to exceed DOT regulations does exist. Therefore, special provisions for sample transportation are required if DOT regulations are exceeded. Off-site laboratories receiving samples are required to document that they have obtained the necessary approvals from the governing regulatory agency to handle anticipated radioactivity and other contaminant levels. Sample tracking documentation and sample receipt notification is maintained by the Field Site Manager as specified in the ORFRC Quality Assurance Plan (Brandt et al. 2001, revised 2007).

6.4. EMERGENCY RESPONSE

The Y-12 National Security Complex emergency response organization is located in close proximity to the ORFRC and would be contacted for response to all emergencies at the ORFRC. The Plant Shift Superintendent would coordinate all emergency response operations and can be reached by dialing 911 from any plant telephone or by calling (865) 574-7172 for emergency medical assistance and first aid. Medical assistance would be provided by the Y-12 Health Division doctor and/or nurse, or Y-12 Protective Services Organization Emergency Medical Technicians.

7. POLICY FOR NON-OAK RIDGE NATIONAL LABORATORY EMPLOYEES

Oak Ridge National Laboratory policy, for the ORFRC as well as all other laboratory operations, requires that use of laboratory resources (e.g., analytical facilities, etc.), DOE site equipment (e.g., drilling equipment, vehicles, etc.), and sample storage operations be conducted in accordance with the requirements of all federal and state statutes and regulations, Executive orders, DOE orders, work smart standards, compliance and settlement agreements, and ERSP work plans. Compliance with this policy is implemented primarily through the review process as explained in Sect. 6.0.

Because many ERSP investigators will not be employees of Oak Ridge National Laboratory, there are additional considerations and requirements associated with the use of Oak Ridge National Laboratory facilities by those who are not bound by the requirements and understandings specific to the employer-employee relationship. Although many such requirements are determined through the ISMS process, an additional check and specific review is conducted through the Personnel Access System procedure.

After tentatively approving projects that have completed the ISMS review, the Field Site Manager initiates the Personnel Access System procedure. During this review, information concerning the project, ERSP investigators, and all non-Oak Ridge National Laboratory employees including U.S. Citizens and foreign nationals, is reviewed by appropriate Environmental Sciences Division and Personnel Access System contacts, and any additional requirements for non-employees, including all ESH&Q training requirements, are identified. **Note: the processing procedure for foreign nationals can take up to several months, and plans should be made accordingly.**

ERSP investigators are notified of these requirements by the Field Site Manager and may then report to Oak Ridge National Laboratory for entry badging. If non-employees have not completed the required training at this time, they may complete it at Oak Ridge National Laboratory before work on the project begins.

Once project requirements are defined, the ERSP investigator and Field Site Manager will come to an agreement on how project task responsibilities will be divided (e.g., who will conduct specific sampling analysis and well installations).

8. SAMPLE STORAGE AND DATA MANAGEMENT

Samples to be stored and archived will be managed in compliance with 10 *CFR* Part 835 which establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities. Storage areas will be posted and monitored as necessary consistent with these requirements as identified in the ISMS. Archived samples are stored in a 4° C refrigerator, or a -80° C freezer as needed. Sample tracking documentation will be maintained by the ORFRC Data Manager.

As part of Oak Ridge National Laboratory's environmental restoration work, procedures for managing large volumes of electronic data in a centralized data repository were developed (North et al., 1997). This experience forms the foundation for the data management system, which is described in the ORFRC Quality Assurance Plan.

IFC investigators working at the ORFRC are expected to provide the ORFRC Data Manager with any data collected in a mutually agreeable format.

9. PROCEDURES FOR WASTE DISPOSAL

Project-related wastes generated at the contaminated field site which require disposal are treated and disposed of, as appropriate, by Bechtel Jacobs Company. BWXT Y-12 may be contacted by ORFRC staff to assist in the handling, storage, classification, and delivery of wastes to Bechtel Jacobs Company. For most projects, wastes are stored in drums or other suitable containers for ultimate disposal by Bechtel Jacobs Company. All associated requirements are determined through the ISMS review process. Existing UT-Battelle waste certification procedures are employed, and the required applicable Bechtel Jacobs waste stream profiles are met. Once project waste is placed in the custody of Bechtel Jacobs Company, no further costs associated with its handling and ultimate disposal are borne by the ORFRC. Satellite Accumulation Areas for Resource Conservation and Recovery Act waste generated from field analysis using Hach kits have been established in the contaminated field site near the old S-3 Ponds in Areas 1 and 3. Dumpsters for disposal of uncontaminated wastes and personal protective equipment wastes (e.g., disposable gloves and tyvek) are available at the ORFRC contaminated field site. Solid radioactively contaminated waste is stored at the contaminated field site in 4'X4'X6' metal boxes. Waste groundwater and rinse water generated at the contaminated field site is stored in tanker trucks and analyzed to assure that it meets Bechtel Jacobs Company waste criteria before being taken for treatment.

10. CONFLICT OF INTEREST AND INTELLECTUAL PROPERTY RIGHTS

The approach to handling conflict of interest issues as well as intellectual property rights of all parties, including ownership of both microorganisms and experimental data obtained from the ORFRC field sites, is determined through the Oak Ridge National Laboratory directives and guidance documents under the categories Legal, and Technology Transfer and Economic Development, maintained in the Standards Based Management System which is located at http://home.ornl.gov/directorates/human_resources/HR_Managers/SBMS_Subject_Areas.shtml.

DOE's Assistant General Counsel for Technology Transfer and Intellectual Property addressed some of these issues in a guidance letter entitled *Bailment of Biological Materials and Tangible Research Products*, that was sent to DOE Field Office Patent Counsels on September 3, 1998. The ERSP Program is assisting with development of further guidance documentation as needed.

11. SITE CLOSURE PLAN

At the cessation of ORFRC research activities all ORFRC supplies, equipment, field trailers, tents, wells and associated structures will be distributed among ORNL, Bechtel Jacobs Company, and BWXT Y-12 as appropriate. Supplies and equipment owned by UT-Battelle will be removed from ORFRC sites unless they are transferred to BWXT Y-12 and/or Bechtel Jacobs Company. Supplies and equipment owned by BWXT Y-12 and Bechtel Jacobs Company (if any) will be returned to them in substantially the same condition as when loaned to UT-Battelle, and will be decontaminated in accordance with UT-Battelle's Radiation Protection Program. ORFRC field trailers and tents will be removed, unless they are offered to and accepted by Bechtel Jacobs Company, BWXT Y-12, or some other responsible party. UT-Battelle will be responsible for terminating site services to these field trailers and tents in a safe and compliant manner. ORFRC wells and associated structures installed by the ORFRC at the ORFRC contaminated field site will be plugged and abandoned unless BWXT Y-12 or Bechtel Jacobs Company agrees to accept them, or the regulators agree upon another regulatory strategy. ORFRC wells and associated structures installed by the ORFRC at the ORFRC background area will be either left in place for future use, or turned over to BWXT Y-12 if requested.

Further details of site closure are given in the draft Closure Plan (Bogle and Watson 2006). This plan documents the actions to be taken for the disposition of all ORFRC supplies, equipment, field trailers / tents and structures and wells as part of final project closure of the ORFRC and provides a cost estimate for completion of these actions.

12. COMMUNICATIONS/COMMUNITY INTERACTIONS STRATEGY

The IFC communication strategy has a three-part structure: communication goals, target audiences, and methods or products that will achieve particular goals with intended audiences (Wolfe et al. 2001). The strategy is designed to be flexible, to respond to opportunities that may arise unexpectedly, and to shift to meet the needs of the IFC project as it evolves. It recognizes that effective communication may take place both formally and informally.

IFC project communication goals are to provide scientifically accurate information that (a) enhances scientific understandings and (b) may be used in remediation and long-term stewardship decision making. The primary audiences for IFC communication are the research community as well as regulators, site managers, and surrounding communities that may use IFC information in decision making. These groups include Bechtel Jacobs Company LLC, DOE ORR Closure Project Core Teams, the Tennessee Department of Environment and Conservation, and the Oak Ridge Site-Specific Advisory Board, to name just a few. Communication efforts that target the research community also target the multi-disciplinary, multi-institutional IFC project team. Thus, one aim of the IFC communication plan is to facilitate and enhance communication across the diverse IFC project team.

Despite some overlap across goals and target audiences, the IFC communication products are tailored to particular communication goals and audiences. So, for example, products suited to enhance scientific understanding among members of the IFC research community include data, presentations and posters, and peer-reviewed publications. Venues for these products include the IFC web site, journal publications, and professional meetings that include ERSP PI meeting. Products aimed at better informing remediation and long-term stewardship decision making include recommendations and strategies, conveyed via technical reports, and stakeholder workshops. Information useful to decision makers may include web- and hard-copy publications, periodic documents such as research highlights, presentations/posters, summary descriptions of research and findings that indicate the implications of those findings, site tours, and, potentially, access to more technical information.

While much of the IFC communication strategy consists of one-way communication—the provision of data, information, and findings, some elements of the strategy are interactive. These interactive elements are intended to improve the effectiveness of communication and the usefulness of the data, information, and findings that flow from IFC research in remediation and long-term stewardship decision making. As an example, the IFC communication strategy includes participation in such venues as the ORR Groundwater Core Team, thus providing opportunities for such two-way interaction.

13. REFERENCES

Bogle, M.A., and D.B. Watson. 2006. Closure Plan for Facilities and Installations at the Oak Ridge ERSP Field Research Center, Oak Ridge, Tennessee (draft). Oak Ridge National Laboratory. September.

Brandt, C.C., S.K. Holladay, and D.B. Watson. 2001. Quality Assurance Plan for Field Activities at the Natural and Accelerated Bioremediation Research (NABIR) Field Research Center (FRC), Oak Ridge, Tennessee. Oak Ridge National Laboratory. ORNL/TM-2000/268. September. Revised 2007.

DOE (Department of Energy) 2000a. Environmental Assessment for Selection and Operation of the Proposed Field Research Centers for the Natural and Accelerated Bioremediation Research (NABIR) Program. Office of Science, Office of Biological and Environmental Research. DOE/EA-1196. March 7.

DOE (Department of Energy) 2000b. Finding of No Significant Impact - Selection and Operation of the Proposed Field Research Centers for the Natural and Accelerated Bioremediation Research (NABIR) Program. Office of Science, Office of Biological and Environmental Research. DOE/EA-1196. April 8. URL: http://public.ornl.gov/nabirfrc/ea_fonsi.cfm Accessed 15 October 2007

DOE (Department of Energy) 2004b. Office of Science Strategic Plan. February 12. URL: http://www.sc.doe.gov/bes/strat_plan.htm

DOE (Department of Energy) 2006. Environmental Remediation Sciences Program (ERSP) Strategic Plan. Office of Biological and Environmental Research, Environmental Remediation Sciences Division. March. URL: http://www.sc.doe.gov/ober/ERSD/ERSD_2006_Strategic_Plan.pdf Accessed 15 October 2007.

DOE (Department of Energy) 2007. ERSD Management Plan for the Integrated Field Challenge (IFC) Project.

North, M.P., C.C. Brandt, S.W. Christensen, J.B. Atwater, and D.S. Tharpe. 1997. Technical specification for transferring biota data to the Oak Ridge Environmental Information System (OREIS). ES/ER/TM-195. Lockheed-Martin Energy Systems, Oak Ridge, TN.

ORNL (Oak Ridge National Laboratory) 1993. ORNL HAZWOPER Program Manual. ORNL/M-2716. March 17.

ORNL (Oak Ridge National Laboratory) 2005. A Researcher's Guide to Using the Oak Ridge Field Research.

ORNL (Oak Ridge National Laboratory) 2007a. Implementation Plan for the Integrated Field-Scale Challenge Project.

ORNL (Oak Ridge National Laboratory) 2007b. Research Safety Summary Report-Detailed, Number 824.4.

Watson, D.B. and H.D. Quarles. 2001. Site-Specific Health and Safety Plan for Work Activities at the Natural and Accelerated Bioremediation Research (NABIR) Field Research Center (FRC), Oak Ridge, Tennessee. Oak Ridge National Laboratory. ORNL/TM-2000/264. October 10. Revised 2007. Available at http://public.ornl.gov/nabirfrc/frcdoc_a.cfm Accessed 15 October 2007.

Wolfe, A.K., D.J. Bjornstad, and D.B. Watson. 2001. Communication Strategy for the U.S. Department of Energy Natural and Accelerated Bioremediation Research (NABIR) Field Research Center

(FRC). Oak Ridge National Laboratory. ORNL/TM-2001/96. Available at http://public.ornl.gov/nabirfrc/frcdoc_a.cfm Accessed 15 October 2007.

APPENDIX I

CONTACT LIST OF INDIVIDUALS AND ORGANIZATIONS IMPORTANT TO THE OPERATION OF THE IFC/FRC

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APPENDIX II

ERSD IFC/ORFRC Operations and Policies

(1) Research at the ORFRC will be conducted in a safe and environmentally responsible manner in accordance with the ORFRC Implementation Plan, Health and Safety Plan, Research Safety Summary, Management Plan, Quality Assurance Plan, and other ORFRC management documents. These documents can be found on the FRC website <http://public.ornl.gov/nabirfrc/frcdoc2.cfm>. Specific safety and training requirements are defined in these documents.

(2) Research associated with the ORFRC project will be conducted in accordance with standards of [scholarly conduct](#) and [ethical behavior](#) in [professional scientific research](#) (e.g. NAS, 1995 <http://books.nap.edu/readingroom/books/obas/>; ORNL, 2000; AAAS Scientific Freedom, Responsibility and Law Program, <http://www.aaas.org/spp/sftrl/>). The AAAS Scientific Freedom, Responsibility and Law Program (SFRL) focuses on the ethical, legal, and social issues associated with the conduct of research and with advances in science and technology.

(3) Any field or laboratory activities at the ORFRC should be discussed with and authorized in advance by the ORFRC Project PI, Phil Jardine. Once authorized, they must be planned, reviewed, and approved through the operating procedures in place with the Field Research Manager, Dave Watson.

(4) The DOE ERSD Program Manager, Paul Bayer, requests that all inquiries related to the ORFRC be directed exclusively to Phil Jardine, who is the designated the single point-of-contact.

(5) Dissemination of data, research results, etc. arising from the ORFRC Project, through peer-reviewed publications, technical reports, presentations, web-postings, etc. is strongly encouraged. Advanced approval by ORNL is NOT required except for press-releases which should be reviewed by all project personnel prior to release. A courtesy copy of peer-reviewed journal article should be provided to the ORFRC Project PI, Phil Jardine and the Field Manager David Watson, as soon as practical prior to submission so that a quick review of logistical details within the manuscript can be evaluated. The ORFRC will also maintain a database of publications and other products of the project. Any documents provided to the Project PI, which the authors wish to maintain confidential (e.g., in review papers), may be treated as such at the authors' request. ORNL prefers that manuscripts that are submitted to journals for review be shared immediately among the research team and that they be available on the web and sent to BER. Such information may be password protected if desired (e.g. sharepoint). It is recommended that appropriate credit be given to individuals who materially contribute to research through acknowledgements or co-authorship as deemed appropriate by the lead authors. Historically we have encouraged authorship to include anyone who has been directly involved with the research (PI's, collaborators, technicians) and indirectly with the research (programmatic, intellectual support).

(6) All publications must contain the following acknowledgement statement: "This publication is a product of the Oak Ridge Field Research Center and was partially funded by the U.S. Department of Energy's Office of Science Biological and Environmental Research, Environmental Remediation Sciences Program. Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725".

(7) Technical highlights of research, significant achievements, announcements of awards, etc. are strongly encouraged. These should be sent to Phil Jardine for review upon which they will be sent to Paul Bayer at DOE. An example technical highlight is provided and this format is preferred by DOE.

ERSD ORFRC OPERATIONS AND POLICIES

(8) Quarterly reports should be submitted to Phil Jardine by all sub-project PIs. The reports should briefly summarize research progress, difficulties encountered, and plans for the next quarter and products/publications completed. Reports should be submitted by January 15, April 15, July 15 and October 15 (or the following business day if on a weekend or holiday) for the preceding quarter. Electronic submissions are preferred and may be sent to jardinepm@ornl.gov. An example outline for a quarterly report will be sent. A conference call among all co-P's will be arranged a week after the quarterly report submittal in order to discuss research progress and other issues.

(9) ORFRC co-PI's will submit a revised statement of work each new fiscal year by September 30th that describes (1) research that will be conducted and the institutions involved, (2) anticipated budget, and (3) budget justification. Budgets are tied to proposal scope and productivity and may change as the overall research project evolves.

(10) If issues arise in the course of research projects that the individual investigators think may impact projects at the ORFRC, the investigators should advise Phil Jardine immediately. If Jardine is unavailable, Dave Watson should be contacted immediately.

(11) An ORFRC data management and implementation plan is forthcoming which will require input from co-PIs. All project participants must follow this data policy so that a comprehensive and organized database is readily available to project staff, project reviewers, external auditors, and DOE personnel. Until a formal data policy is in place, we will follow the data management procedures described in the ORFRC Quality Assurance Plan (<http://www.esd.ornl.gov/nabirfrc/>). Data shared externally will be placed on the existing ORFRC database accessible through the ORFRC website and data shared internally only will be placed on the password protected ORFRC sharepoint site.

References

National Academy of Sciences. 1995. On Being A Scientist: Responsible Conduct In Research. 2nd addition. National Academy of Engineering, Institute of Medicine. National Academy Press, Washington, D.C.

Oak Ridge National Laboratory Corporate Fellows Council. 2000. Oak Ridge National Laboratory's Values in the Conduct of Research and Development.