Base Program on Energy Related Research

Quarterly Report

August 1 - October 31, 1996

Work Performed Under Contract No.: DE-FC21-93MC30126

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
Western Research Institute
365 North Ninth Street
Laramie, Wyoming, 82070

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Um

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ACKNOWLEDGMENT AND DISCLAIMER

This report was prepared with the support of the U.S. Department of Energy (DOE), Morgantown Energy Technology Center, under Cooperative Agreement Number DE-FC21-93MC30126. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the DOE.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agencies thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe on privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES AND FIGURES	iv
EXECUTIVE SUMMARY	v
TASK 1.0 OIL AND GAS	1
Subtask 1.2 Miscible/Immiscible Gas Injection Processes	2
Subtask 1.3 Development of a Portable Data Acquisition System and Coalbed Methane Simulator	5
Subtask 1.4 Tank Bottom Waste Processing Using the TaBoRR™ Process	7
TASK 2.0 ADVANCED SYSTEMS APPLICATIONS	9
TASK 3.0 ENVIRONMENTAL TECHNOLOGIES	10
Subtask 3.1 Conditioning and Hydration Reactions Associated With Clean Coal Technology Ash Disposal/Utilization	11
Subtask 3.2 Remediation of Contaminated Soils (Haz-Flote™)	14
Subtask 3.3 The Syn-Ag™ Process: Coal Combustion Ash Management Option ...	16
Subtask 3.4 The Maxi-Acid™ Process: In-Situ Amelioration of Acid Mine Drainage	17
Subtask 3.7 Evaluation of Dense Gas Dispersion	18
TASK 4.0 ENVIRONMENTAL TECHNOLOGIES	21
Subtask 4.2 Fossil Fuel and Hydrocarbon Conversion Using Hydrogen-Rich Plasmas	22
TASK 6.0 REMEDIATION	27
Subtask 6.1 North Site Remediation	27
FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORTS (Active Subtasks Only)	29
CONTRACT STATUS REPORT (Current Year Subtasks Only)	42
CONTRACT STATUS REPORT (Contract to Date)	43

LIST OF TABLES AND FIGURES

<u>Table</u>	<u>Page</u>
1. Summary of Base Funding for FY 1993–1996	vi
2. Subtasks Approved for Funding Through FY 96	ix
3. Contract Status Report (Contract to Date)	x

<u>Figure</u>	<u>Page</u>
1. Schematic Diagram of Continuous-Flow Plasma/Liquid Reactor System	23
2. Schematic Diagram of Stirred Batch Reactor System	25

EXECUTIVE SUMMARY

Introduction

The Base Research Program at Western Research Institute (WRI) is planned to develop technologies to a level that will attract industrial sponsors for continued development under the Jointly Sponsored Research (JSR) Program. In many instances, a potential JSR cosponsor has been identified but additional laboratory or bench-scale data are necessary to assess the utility of the technology prior to cosponsor investment. Both peer and management review are employed prior to proposing Base projects to the U.S. Department of Energy (DOE).

The goals of the Base Research Program are in support of those of the JSR Program, which are designed to:

- Increase the production of United States and western energy resources, particularly low-sulfur coal, natural gas, oil, and renewable energy resources
- Enhance the competitiveness of United States and western energy technologies in international markets and assist in technology transfer
- Reduce the nation's dependence on foreign energy supplies and strengthen both the United States and regional economies
- Minimize environmental impacts of energy production and utilization.

The goals of the JSR and Base Programs are accomplished by focusing research, development, demonstration, and commercialization in three major technology areas:

- ENERGY PROGRAMS emphasize the increased production and utilization of domestic energy resources and include enhanced oil recovery, coal bonification and upgrading, coalbed methane recovery, and renewable energy resources.
- ENVIRONMENTAL PROGRAMS minimize the impact of energy production and utilization by providing technology to clean underground oily wastes, mitigate acid mine drainage, and demonstrate uses for Clean Coal Technology (CCT) and pressurized fluidized bed combustion (PFBC) waste solids.
- TECHNOLOGY ENHANCEMENT activities encompass resource characterization studies, the development of improved environmental monitors and sensors, and improved techniques and models for predicting the dispersion of hazardous gas releases.

Interactions between the Base and the JSR Programs are dynamic and continuous, as commercialization of promising new technologies is the driving force for both. The Base Program explores innovative concepts that will attract industrial sponsors for continued development under the JSR Program. In many instances, a potential JSR cosponsor has been identified, but additional laboratory or bench-scale data are necessary to verify the process or product concept. Once done, the project moves to the JSR stage where the objective is to develop and demonstrate the technology sufficiently for sound and prudent commercialization decisions to be made.

Not infrequently the reverse occurs. A project will demonstrate considerable promise at the JSR stage but require a supplemental Base Program activity to complete the applied research required for process optimization and a thorough technical understanding of the phenomena being exploited. As a result, the two programs are tightly integrated and complementary components of the overall development process.

In a high-technology global economy, technology development is crucial to the preservation and growth of the American economy and standard of living. Much of this technology and growth will come from companies that were small or nonexistent just a decade ago. Unlike the large multinational companies with captive research and development facilities, these companies must rely upon creative and innovative contractors such as Western Research Institute to assist with their process and product development activities. It is a tribute to the wisdom and the foresight of the United States Department of Energy and the Morgantown Energy Technology Center that activities such as the Cooperative Agreement Programs exist to meet this crucial national need.

The Base Cooperative Agreement (DE-FC21-93MC30126) was initiated on February 2, 1993. Since that time, total funding of \$6,990,884 has been authorized both through the original agreement and subsequent modifications.

A summary of funding and the number of projects is shown in Table 1.

Table 1. Summary of Base Funding for FY 1993–1996

Fiscal Year	Funding	Number of Projects	New Starts
1996	780,000	21	2
1995	1,077,976	19	4
1994	3,132,908	15	5
1993	1,950,000	10	10
TOTAL	6,990,884		

Significant Accomplishments Under the Base Research Program

Subtask 1.2 Miscible-Immiscible Gas Injection Processes

WRI is currently developing a predictive model for miscible-immiscible gas injection processes with emphasis on use of CO₂. Physical simulations are in progress using the GEM 96.00 simulator developed by the Computer Modeling Group. Personnel at METC have made this simulator available for use by WRI researchers. Initial efforts with the simulator are encouraging. The GEM simulator has been leased by WRI, and the project leader was trained in its use. Physical simulations indicate that a 5 to 12% increase in recovered oil can be accomplished using a gas-trapping mechanism with proper immiscible injection of CO₂.

Subtask 1.4 Tank Bottom Waste Processing Using the TaBoRR® Process

WRI developed the Tank Bottom Recovery and Remediation (TaBoRR®) process to address the problem of tank bottom wastes. The method results in separation of water, a light hydrocarbon stream, a heavy hydrocarbon stream, and an inert, nonleaching, liquid-free solid. For this invention, WRI was granted U.S. Patent No. 5,259,945. Filings are proceeding under the Patent Cooperation Treaty in countries throughout the world. A process development unit (PDU) has been constructed to provide data for economic evaluation, numerical modeling of the process, and environmental analyses. The PDU is capable of processing 1 to 2 barrels per day of tank bottom wastes. This PDU is being used to support field mitigation work.

Subtask 2.1 Development and Optimization of a Process for the Production of a Premium Solid Fuel from Western U.S. Coals

WRI has developed technology that results in a dried coal with a decreased tendency to spontaneously combust. This technology, called COMPCOAL™ (Compliance Coal), is the subject of a patent, U.S. Patent No. 5,322,530. Recent evaluations under the Base Program have reaffirmed that the low-temperature ignition characteristics of the COMPCOAL products are similar to those of the raw coals. Work is continuing to obtain cosponsorship for a pilot-scale demonstration of the technology.

Subtasks 3.1-3.4 Other Environmental Technologies

WRI is working on four environmental technologies, each of which appears to have significant potential for application. WRI is currently assessing the patent position of these technologies, so this is a sensitive time for detailed discussion of results. Invention disclosures have been written on all four.

One subtask (3.1) evaluates fundamental properties of solid wastes (conventional and clean coal technology ashes) from coal combustion to determine the economic and technical viability of their productive use in cement or other materials. A related subtask (3.3) determines the economic and technical feasibility of using power plant ashes to produce synthetic aggregate in the Syn-Ag™ process. Work on the Haz-Flote™ process (under subtask 3.2) is designed for ex-situ decontamination of materials with hydrocarbon content. It will be a valuable complement to CROW™. A patent attorney is currently evaluating whether to seek patent protection for inventions from the prior three subtasks. WRI's Maxi-Acid™ process (under subtask 3.4) addresses in-situ treatment of precursors to acid mine drainage to quickly mitigate and treat acid formation. A JSR application is planned for a project in Montana with the Montana Bureau of Mines and Geology.

Subtask 4.1 Heavy Oil/Plastics Co-Processing

WRI has developed a method to co-process plastic mixtures with a variety of heavy oils. This method not only reduces the volume of landfill material but also produces low yields of char plus gas and high yields of liquids that show potential for use as fuels. Based on this invention, WRI has applied for patents in the United States, Canada, and Mexico, and has also filed under the Patent Cooperation Treaty (PCT) process. Work was recently completed to define scale-up parameters at bench scale for economic evaluation and improvement of process efficiency. These data are being used to seek industrial sponsorship.

The authorized subtasks and the corresponding funding is provided in Table 2. A summary of budgets, expenses prior to the quarter, expenses by month for this quarter, and remaining balances is provided in Table 3.

Overview of Accomplishments During August Through October 1996

Task 1.0

A physical simulation apparatus was used for three full-scale simulations to evaluate Miscible/Immiscible Gas Injection Processes for oil production (Subtask 1.2).

An evaluation of SIMED, a numerical model for coalbed methane recovery has shown it to be inconvenient to use (Subtask 1.3).

Several new and several continued industrial contacts were made relative to the TaBoRR® process (Subtask 1.4). More samples of tank bottoms were analyzed for chemical and physical properties. A pyrolyzer unit is under construction. A modeling effort has successfully determined the operational parameters of the flash operation.

Table 2. Subtasks Approved for Funding Through FY 96

Subtask	Project	Years 1-3 Funding	FY 96 Funding	Total Funding
1.1	CROW™ Process Modeling	471,163	0	471,163
1.2	Miscible/Immiscible Gas Injection	254,500	200,000	454,500
1.3	Coalbed Methane Simulator	316,841	0	316,841
1.4	Development of TaBoRR® Process	588,275	160,000	748,275
2.1	Premium Solid Fuel from Western U.S. Coals	127,835	0	127,835
2.2	On-line Alkali Monitoring Probe	107,250	0	107,250
2.3	Recycle Oil Process for Eastern Oil Shale	119,350	0	119,350
2.4	Support for COMPCOAL™	146,250	0	146,250
2.5	Eastern Oil Shale as an Asphalt Additive	66,145	0	66,145
2.6	Support for Koppelman Series C	108,405	0	108,405
2.7	Coal-Fired Gas Turbine	0	195,000	195,000
3.1	Solid Waste Management	691,998	0	691,998
3.2	Haz-Flote™ Remediation of Contaminated Soils	442,074	0	442,074
3.3	Syn-Ag™ Use of Coal Combustion Wastes	183,521	0	183,521
3.4	Maxi-Acid™ Treatment of Acid Mine Drainage	221,057	0	221,057
3.5	Spill Test Facility Data Base	186,539	0	186,539
3.6	Attenuation of Ammonium in Aquifer	16,400	0	16,400
3.7	Dense Gas Dispersion	0	175,000	175,000
4.1	Heavy Oil/Plastics Co-Processing	278,282	0	278,282
4.2	Fossil Fuel Conversion With Hydrogen Plasmas	81,447	50,000	131,447
6.1	North Site Cleanup	1,534,884	0	1,534,884
TOTALS		6,210,884	780,000	6,990,884

Task 3.0

Work on a final topical report on Subtask 3.1 (Solid Waste Management) continued. Evaluation of potential patent applications shows promise.

Mercury removal from contaminated soils was continued at high efficiency using the Haz-Flote™ (Subtask 3.2) process. A patent search was completed this quarter. Patentability is being evaluated with a patent attorney.

Under Subtask 3.3 (Syn-Ag™: Coal Combustion Ash Management), invention disclosures have been written, and patent applications are being prepared. Disclosures were sent to the DOE patent attorney.

Under Subtask 3.4 (Amelioration of Acid Mine Drainage), research was initiated to determine the impact of CO₂ on acid formation in low CO₂ environments. Vendors have been contacted to obtain acid-resistant materials for use in constructing a leaching pad.

The data base being developed under Subtask 3.7 (Evaluation of Dense Gas Dispersion) helps to establish a scientific and engineering basis for spill mitigation and to test regulations that will affect more than 100,000 sites. Data have also been verified under this subtask.

Task 4.0

A stirred batch reactor is being used to evaluate operations under Subtask 4.2 (Fossil Fuel and Hydrocarbon Conversion Using Hydrogen-Rich Plasmas). This replaced a recirculating flow system that was unreliable.

Federal Assistance Management Summary Reports (Substitute DOE Form F 4600.5) are included for active subtasks on pages 32–46.

TASK 1.0 OIL AND GAS

BACKGROUND

Conventional petroleum resources in the United States continue to diminish, resulting in our continued dependence on foreign sources. The development and application of methods to increase and support production from domestic resources is important to the nation's independence and well-being. A related area of environmental concern is the cleanup of oil waste materials. Numerous sites exist throughout the country where oily materials have been deposited and pose the threat of contamination to the environment. Effective methods for cleanup of these materials need to be developed for remediation of such sites.

LONG-TERM OBJECTIVES

The long-term objective of this task is to develop efficient processes that can be economically applied by independent, as well as major, oil producers. The present market for WRI-developed technologies appears to be with the independent operators.

Areas currently being targeted are:

1. Development of a predictive model for miscible/immiscible gas injection and verification of the model through physical simulations (Subtask 1.2)
2. Development of a portable data acquisition system and coalbed methane generator (Subtask 1.3)
3. Technology support, development of a lab process unit, numerical modeling, and economic analysis for the TaBoRR® process (Subtask 1.4).

Funding was approved for continuations of Subtasks 1.2 and 1.4 in the fourth year of Cooperative Agreement DE-FC21-93MC30126.

SUBTASK 1.2

MISCIBLE\IMMISCIBLE GAS INJECTION PROCESSES

Lyle A. Johnson
Francis M. Carlson

August–October 1996

OBJECTIVE

The objective of this subtask is to demonstrate a predictive model for the miscible\immiscible gas injection process with emphasis on the use of CO₂ as the injected gas. Data for the verification of the model will be obtained through the conduct of physical simulations designed with the use of the numerical simulator.

QUARTER OBJECTIVES

- Finalize the design for the physical simulation testing program.
- Complete evaluation of the reactor tube packing protocol and begin physical simulation testing.
- Begin use of physical simulation data in the CMG miscible\immiscible gas injection simulator.

ACCOMPLISHMENTS

The numerical simulator to be used in the subtask was selected based on availability and on the presence of the various capabilities desirable for the simulations. The simulator selected is the GEM 96.00 simulator offered by the Computer Modeling Group (CMG). A copy of this simulator resides at METC, and METC personnel are familiar with it.

Agreements have been finalized with CMG to secure the executables of the GEM 96.00 simulator for use at WRI. The agreement includes a training session at CMG facilities for WRI personnel and access to CMG personnel for troubleshooting and modification of the computer code.

A literature survey has been conducted to assist in the design of the physical simulations. The emphasis of the survey was on nonintrusive capillary pressure and three-phase saturation measurements during conduct of the physical simulations, methods to seal the core samples, and type of core to use.

A preliminary design for the physical simulation system has been developed, and the equipment specifications are being developed. Material for testing has been identified from information available in the literature, and the availability of the material is being investigated. The method to seal the solid material, core, or sand in the reactor tubes is being evaluated. It appears that a bismuth alloy can be used with core material because of its low melting point and its expansion characteristic when cooled. Methods to prevent slippage around sand packs are also being evaluated.

The physical simulation apparatus has been constructed, and shakedown testing (10+ tests) has been completed. Methods for packing the reactor tubes with sand to produce various permeabilities have been evaluated for eight tube packings. Three full-scale physical simulations have been completed. Results from the initial simulations indicate that a 5 to 12% increase in the recovered oil is created by the gas-trapping mechanism when immiscible injection is properly conducted. Additional simulations are under way.

ACTIVITIES FOR NEXT QUARTER

- Complete the physical simulation testing protocol.
- Continue matching the physical simulation results with those of the CMG miscible\ immiscible gas injection simulator.

PROCEDURES

This subtask is composed of four parts. The first part will be the selection of a numerical simulator followed by the acquisition or arrangements for use of the simulator. The second part will be the conduct of physical simulations to provide detailed data for the validation of the simulator. The numerical simulator will be used to develop the experimental plan and operational procedures for the physical simulations. Next will be the validation of the numerical simulator using history matching of the physical simulations. The model will be modified, if possible, to provide the necessary history matches. The final part will be the documentation of the numerical and physical simulations in a final topical report.

In a parallel effort, work is being conducted to evaluate the ability of the UTCOMP simulator to perform the required simulations for this project. A copy of this simulator is available for WRI use. The use of both the GEM and UTCOMP simulators is being considered for a comparative purpose.

RESULTS

The numerical simulator selected for use in this subtask is GEM 96.00 developed by CMG. The simulator was selected because of its capability to take into consideration the solubility of CO₂

in the aqueous phase and to allow for relative permeability hysteresis. Following discussions with personnel at the Morgantown Energy Technology Center (METC), the initial simulations using the CMG simulator were conducted by WRI personnel at the METC facilities, since the simulator is available there. Initial response to the use of the simulator was positive. An experimental plan for the physical simulations is being developed using initial simulations conducted with GEM.

Agreements have been finalized with CMG for the use of the GEM 96.00 simulator at WRI's facilities during this subtask. The agreement also includes training for WRI personnel on the simulator at CMG facilities. This training has been conducted.

Literature surveys identified methods for the use of non-intrusive measurements of capillary pressure and three-phase saturations, but these methods appear to be cost prohibitive. A preliminary design for the physical simulator has been completed, as has the construction and shakedown of the apparatus. An outline for the testing procedure has been developed.

Methods to pack the reactor tubes with unconsolidated sand have been developed and tested for reproducibility. Shakedown testing of the reactor system has been completed. Three full-scale physical simulations have been completed with an increase in recovered oil of 5 to 12% of the initial oil in place. It appears that the mechanism causing the increase is gas trapping. Further testing is underway to verify these results and evaluate other operating conditions.

CONCLUSIONS

From preliminary runs it appears that the GEM 96.00 numerical simulator is capable of performing the necessary simulations. However, the simulator has some problems handling an oil-wet system such as the one WRI is looking at. GEM 96.00 does not allow for the appropriate treatment of rock properties for oil-wet systems but does allow for hysteresis in capillary pressure and gas-oil permeability for water-wet systems. Consequently, the physical simulations will involve reversing the phases so that the wetting phase (water) will be displaced by the nonwetting phase (oil). In this manner, GEM 96.00 can be used to make predictions of the physical simulations which are consistent with its capabilities. CMG personnel have indicated that GEM 96.00 may be updated during the course of our work to permit more flexibility with rock properties.

Sand-packed reactor tubes have been evaluated to provide the desired range of contrasting permeabilities desired for the physical simulations. Preliminary testing has indicated that an increase in oil recovery can be expected from the immiscible gas injection method being used.

SUBTASK 1.3

DEVELOPMENT OF A PORTABLE DATA ACQUISITION SYSTEM AND COALBED METHANE SIMULATOR

Charles G. Mones

August–October 1996

OBJECTIVES

WRI is currently participating in a Jointly Sponsored Research (JSR) program with Amoco Production Company (Amoco) regarding the enhanced recovery of methane from coalbeds by the injection of CO₂. Enhanced coalbed methane (ECBM) processes use an injected gas to stimulate the production of methane from coalbeds and potentially reduce the production of water. Part of WRI's responsibility in this program was to use Amoco's Generalized Compositional Simulator (GCOMP) to model the performance of a CO₂/ECBM pilot. Involvement with Amoco's leading edge, enhanced recovery technologies and GCOMP simulator have given WRI direct experience in the area of coalbed methane recovery.

WRI intends to market its expertise in coalbed methane recovery to commercial developers. Our marketability as reservoir engineers depends on having access to a coalbed methane simulator. Based on our experience with Amoco, a simulator is needed to perform proof-of-concept studies, evaluate reservoir design options, predict recovery, and determine process economics. WRI initially intended to develop its own coalbed methane simulator which would be capable of simulating both ECBM and primary (gas depletion) scenarios. However as an alternative, WRI is evaluating the performance of a commercially available model, SIMED, offered by the Australian Petroleum Cooperative Research Centre (APCRC).

QUARTER OBJECTIVES

The objectives for the quarter were:

- Determine if an alternative GCOMP evaluation study is available for comparison with SIMED that requires three (or fewer) coal regions.
- Perform simulations with SIMED and compare results with those from GCOMP.

- If no GCOMP simulation is available, search the literature to find an alternative simulation problem. This alternative is less attractive since it does not allow a precise evaluation of model capabilities.

ACCOMPLISHMENTS

WRI performed a preliminary evaluation of SIMED. SIMED has several potentially valuable characteristics, including multicomponent sorption physics, a dual-porosity reservoir description, an ability to describe diffusion, and an implicit formulation for numerical solution. Unfortunately, SIMED uses an inconvenient and cumbersome input sequence for specifying reservoir properties. In addition, the users manual is limited and does not completely describe the use of SIMED's features. The most serious deficiency is the lack of technical information pertaining to the theoretical and numerical formulation of the model.

Our experience in numerically simulating the CO₂/ECBM pilot has suggested that improved predictions may be possible by accounting for gas diffusion. This diffusion occurs between the gas sorbed in the coal matrix and the free gas flowing in the cleat fracture system. A correct implementation of diffusion requires a dual-porosity formulation that individually describes gas storage in the relatively impermeable coal matrix and the flow of gas in the permeable fracture system.

WRI will evaluate the effects of diffusion by performing simulations of ECBM recovery using SIMED. Specifically, the modeling will compare methane recovery as a function of gas diffusion time constants in a dual-porosity coalbed reservoir. We will use as a basis a published study that evaluated the economics of recovering methane from coalbeds by using N₂ as an injectant (Stevenson, 1993). Results from the modeling study are expected to demonstrate the effects of diffusion and will determine the formulation method to be used by WRI's coalbed methane simulator. In addition, WRI will evaluate the performance of SIMED and determine the viability of its purchase as an alternative to an in-house model development.

ACTIVITIES FOR NEXT QUARTER

Activities for next quarter are to perform N₂/ECBM modeling studies to evaluate the effects of diffusion on predicted recovery.

REFERENCE

Stevenson, M.D., W.V. Pinczewski, and R.A. Downey, 1993, Economic Evaluation of Nitrogen Injection for Coalseam Gas Recovery. S.P.E. Paper 26199, 1993 Gas Technology Symposium, Calgary 1993.

SUBTASK 1.4

TANK BOTTOM WASTE PROCESSING USING THE TABORR™ PROCESS

Robert M. Satchwell

August–October 1996

OBJECTIVE

The objective of this project is to develop information for use in the successful deployment of WRI's patented TaBoRR® technology. To accomplish this objective, work is being conducted in areas of technology support, design and operation of a laboratory process unit, numerical modeling of the process, and economic analysis.

QUARTER OBJECTIVES

The objectives for the quarter were to:

- Locate and secure more samples of tank bottom wastes
- Characterize the sampled tank bottom wastes
- Supervise the construction of the pyrolyzing unit
- Continue numerical modeling related to the operation of the demonstration unit

ACCOMPLISHMENTS

- To date, approximately fifteen samples have been obtained and analyzed for various physical and chemical properties. The basic sediment and water (BS&W) analyses have shown that water concentrations can vary widely. This variation in BS&W concentrations appears to be caused by the many treatment methods employed by oil producers. The water concentrations for the samples collected range from 2 to 65%, with the solids concentration ranging from 1 to 95%. The oil concentration of these samples is between 1 and 98%.
- As they were received, samples were analyzed to determine their chemical and physical properties.
- Construction of the pyrolyzer is under way and will be completed in early December.

- The modeling effort has been successful in determining the operational parameters of the flash operation.

OBJECTIVES FOR NEXT QUARTER

The following activities are planned for next quarter:

- Sample other sources of tank bottom wastes to add to the database
- Characterize sampled tank bottom wastes
- Compare the results of numerical modeling to the operations of the demonstration unit.

TASK 2.0 ADVANCED SYSTEMS APPLICATIONS

BACKGROUND

Western U.S. coals and oil shale are quite different from their eastern counterparts. Eastern coals are typically higher in rank, heating value, and sulfur content than western coals. Conversely, western coals contain more moisture, higher volatile matter, and higher alkali and alkaline earth elements as ash. Therefore, combustion and conversion processes developed for eastern coals are often neither compatible with nor appropriate for the western coals.

Coal production is one of the most significant sources of revenue in the West. Over the last decade, the consumption of coal by electric utilities has grown at a faster rate than the consumption of either petroleum or natural gas. Energy development processes using coal are of interest to the state of Wyoming and the Rocky Mountain region.

Previous coal research at WRI has concentrated on the development and testing of coal drying and mild gasification technologies, as well as the tailoring and adaptation of advanced coal utilization concepts for low-rank western coals. These coals have several advantages over eastern coals. For example, because of their low sulfur content, they can be utilized in conventional PC boilers with relatively little emissions control equipment. Similarly, because of their low sulfur content, their use in advanced combustion systems requires less capital investment.

Current work at WRI is concentrating on design, assembly, and testing of a bench-scale fuel preparation and delivery system for pressurized application using coal fines. The results from this study will be used to design a fuel preparation and delivery system to be interfaced with WRI's solid fuel-fired gas turbine pilot unit.

LONG-TERM OBJECTIVES

The long-term objectives of this activity are to optimize and adapt the emerging coal-based technologies to Powder River Basin coals by exploiting some of the coals' unique properties while removing technical barriers.

A new subtask, Subtask 2.7 (Development and Testing of a Coal-Fired Gas Turbine) will be initiated later in the year under fourth-year funding.

TASK 3.0 ENVIRONMENTAL TECHNOLOGIES

BACKGROUND

Environmental issues in the United States have focused on ensuring clean air and water. The implementation of the Clean Air Act (CAA) and its amendments has indirectly resulted in an additional emphasis on solid waste management. The volume of solid waste is increasing from the fossil fuel production and consumption sectors, and the character of these wastes is also changing. The remediation of contaminated sites in the United States still remains a high priority. However, efforts to speed the cleanup of these sites are being hampered by the lack of effective high-volume treatment processes. Effective means of mitigating the environmental consequences related to energy development and utilization and the remediation of contaminated sites are needed today.

LONG-TERM OBJECTIVES

The Environmental Technologies task is designed to provide a range of environmental waste management services and research and development activities. The scope of the program includes developing waste management options for fossil fuel related industries and regulatory agencies. The long-term objectives of this task are to develop technologies that improve solid waste management practices, remediate hazardous waste and contaminated soils, and provide predictive models for environmental technologies.

Current areas of work include:

1. Solid waste management to evaluate conditioning and hydration reactions associated with clean coal technology ash disposal/utilization (Subtask 3.1)
2. Remediation of contaminated soils using the Haz-Flote™ process (Subtask 3.2)
3. Development and evaluation of the Syn-Ag™ process for coal combustion ash utilization (Subtask 3.3)
4. In-situ amelioration of acid mine drainage using the Maxi-Acid™ process (Subtask 3.4)
5. Attenuation of ammonium contaminate in an aquifer (Subtask 3.6) There was no appreciable activity on Subtask 3.6.
6. Evaluation of a series of dense gas dispersion tests (Subtask 3.7). Subtask 3.7 is a new project initiated under fourth-year funding.

SUBTASK 3.1

CONDITIONING AND HYDRATION REACTIONS ASSOCIATED WITH CLEAN COAL TECHNOLOGY ASH DISPOSAL/UTILIZATION

Alan E. Bland
Terry H. Brown

August–October 1996

OBJECTIVES

Project objectives are to generate the required fundamental data and to develop technologies that can be used by industry to assess and implement economical and technically viable ash management strategies and plans for CCT ashes.

QUARTER OBJECTIVES

The objectives for the quarter were:

- Prepare patent applications
- Prepare a final report for U.S. DOE METC

ACCOMPLISHMENTS

WRI has initiated patent applications related to the results of the project. Preparation of a public version of the final report that does not compromise the patent applications has been initiated.

ACTIVITIES FOR NEXT QUARTER

- Finish final report for U.S. DOE METC
- Continue with patent applications.

PROCEDURES

Standard ASTM procedures for the geotechnical testing were used, including ASTM D-698 and 1557 for moisture-density relationship, ASTM C-109 (modified) for unconfined compressive strength, and ASTM C-157 for dimensional stability (expansion/shrinkage) testing. Chemical characterization used ASTM wet chemical methods, as well as standard ICAP, XRF, TGA, DSC, SEM and XRD techniques.

RESULTS

The results to date on the project are summarized below by project activity.

Activity 3.1.1 - Evaluation of the Chemical, Physical and Geotechnical Properties of Various CCT Ashes.

Four FBC ashes and two PFBC ashes were evaluated as part of the project. Geotechnical testing included moisture-density relationships (Proctors), unconfined compressive strength, and dimensional stability. Hydration reaction chemistry for the ashes has been completed. The geotechnical properties, such as strength and expansion, can be correlated with hydration reaction products in the ash.

Activity 3.1.2 - General Nature of Hydration Reactions

The reaction products from CCT ashes were examined, and they appear to be sensitive to a number of geochemical conditions. Evaluation of methods for the identification and/or quantification of the appropriate hydration phases was also conducted. Ettringite synthesized in the laboratory has been analyzed by a number of analytical techniques, of which advanced high-resolution TGA appears to be the most promising for quantification purposes.

Activity 3.1.3 - Development of Process for Stable Ash Disposal or Use

Several methods for the stabilization of CCT ashes have been developed and appropriate invention disclosures written. Copies of the disclosures have been filed with the US DOE Patent Office. **The nature of these processes and their disclosures are therefore confidential and restricted to US DOE and WRI only.**

Activities are also under way to write and file the appropriate patent applications.

Activity 3.1.4 - Effect of Conditioning Media on Properties of Ashes.

The use of alternate water sources for conditioning CFBC ashes could provide relief to often scarce fresh water supplies. Testing was conducted on two ashes using two different water sources.

Activity 3.1.5 - Production of CLSFFM from CCT Ash.

Tests were completed using conventional and FBC ash-based controlled density flowable fill material (CLSFFM) designed at WRI. The FBC ash generator has asked WRI for assistance in the demonstration and marketing of the flowable fill under the JSR program.

SUBTASK 3.2

REMEDIATION OF CONTAMINATED SOILS (Haz-Flote™)

Terry H. Brown

August–October 1996

OBJECTIVES

The primary objective of this subtask is to develop physical and chemical treatments to remove inorganic and organic compounds from contaminated materials. The project is divided into four areas of work:

- The acquisition of equipment and materials for the construction of the soil washing systems to be used in the remediation tests
- The preliminary evaluation of washing and remediation techniques for materials contaminated with metals and hydrocarbons
- The determination of physical and chemical treatment options for remediating mercury-contaminated soils associated with oil and gas pipelines
- Technical project management and reporting.

QUARTER OBJECTIVES

The objectives for this quarter were:

- Complete a patent and literature search to determine if a patent application should be filed
- Dispose of the mercury-contaminated waste using a contract waste disposal operation

ACCOMPLISHMENTS

- Discussions of the patentability of the Haz-flote technology are continuing with Luke Santangelo. A decision to pursue a patent application has not been made.

- Arrangements are being made by Craig Brommer for a licensed disposal operation to ship and landfill the mercury waste.

ACTIVITIES FOR NEXT QUARTER

- Make a final decision on the patentability of the Haz-Flote technology
- Dispose of the mercury wastes
- Begin preparing the final report to DOE

SUBTASK 3.3

THE SYN-AG™ PROCESS: COAL COMBUSTION ASH MANAGEMENT OPTION

Alan E. Bland

August–October 1996

OBJECTIVES

Project objectives are to develop and demonstrate the technical process feasibility and economic viability of the Syn-Ag process for aggregate production using power plant ashes. The specific objectives are:

- Develop and document the Syn-Ag process
- Verify the properties of the aggregate produced from the Syn-Ag process
- Determine the process costs, including capital and operating costs, for the Syn-Ag process.

QUARTER OBJECTIVES

The objectives for the quarter were:

- Continue testing the production of the lightweight Syn-Ag product
- Continue with patent applications for Syn-Ag process configurations.

ACCOMPLISHMENTS

Disclosures have been written and copies of the disclosures have been supplied to the U.S. DOE Patent Office. Patent applications are in preparation. As a result, all information about the Syn-Ag process remains confidential to WRI, and therefore not available to the public and protected therein.

SUBTASK 3.4

THE MAXI-ACID™ PROCESS: IN-SITU AMELIORATION OF ACID MINE DRAINAGE

Terry H. Brown

August–October 1996

OBJECTIVE

The objective of this subtask is to develop a method for the in-situ amelioration of acid mine drainage problems. The subtask includes the following work:

- Laboratory simulation and method development
- Design and modeling of the processes, including a containment system
- Application of the technology in a field trial.

QUARTER OBJECTIVES

The objectives for the quarter were:

- Continue evaluations of the influence of environmental conditions on acid and alkalinity production
- Design and construct the leaching pad.

ACCOMPLISHMENTS

- Research on the impact of CO₂ on the formation of acid in a low O₂ environment was initiated.
- Several vendors were contacted in an effort to find materials resistant to H₂SO₄ for the construction of the leaching pad.

OBJECTIVES FOR NEXT QUARTER

- Construct the leaching pad
- Continue depletion studies

SUBTASK 3.7

EVALUATION OF DENSE GAS DISPERSION

David Sheesley

August–October 1996

OBJECTIVES

The objectives of this subtask are to:

- Archive spill test facility results from the U.S. Department of Energy Liquefied Gaseous Fuels Spill Test Facility (LGFSTF), at the Nevada National Test Site, hereinafter called Spill Test Facility (STF)
- Update the data base on chemical spill technology documents and data
- Make these data available to the public and industry.

BACKGROUND

Congress has passed legislation to develop technology to protect the health and welfare of the public in the event of fuel and chemical spills. The public stakeholders' concern is whether available dispersion models accurately predict air toxic dispersion at the facility fenceline and whether chemical spill source term expressions can be used with some degree of confidence. PL 99-499, the Superfund Amendments and Reauthorization Act (SARA), and PL 101-549, the Clean Air Act Amendments, (sect. 103 (f)) mandate that the Secretary of Energy make the STF near Mercury, Nevada, available to industry, federal agencies, and others to deliberately spill chemicals in an effort to validate and improve model technology and evaluate emergency response technology.

PL 99-499 directs the U.S. Department of Energy (DOE) to test and evaluate technologies for responding to liquefied gaseous and or hazardous substance spills that threaten public health or the environment. Under this public law, funding was authorized for Western Research Institute (WRI) to develop technology with chemical spill tests to be carried out at the STF consistent with Section 103 (f) of the Clean Air Act amendments (CAAA). An additional \$1,600,000 per year has been provided to the DOE Office of Emergency Management (NN-60) to support tests and manage the site. These public funds were matched with private funds, in kind, and Department of Defense (DOD) equipment for the Kit Fox tests of 1995, which WRI conducted in conjunction with the DOE, EPA and commercial sponsors. As the U.S. Environmental Protection Agency (EPA) also provides some

funding for this program, a quality assurance plan with common calibration standards was developed to ensure that data and other information collected is consistent with Clean Air Act objectives.

ACCOMPLISHMENTS

The data processing this quarter related to DOE data files from past tests, data files to be generated in future tests, and preparation for the limited analyses of the Kit Fox collaborative R&D program. The work for all the SARA-directed data management in this project has been to capture the spill or gas release data together with meteorological conditions for all the tests performed at the STF. Combining the two data sets ensures that the data can and will be used. Included is the companion objective to ensure that the government's STF data are also made available to the public and fuel and chemical industries.

An example of the data that should be archived in this STF data base is the data from the jointly sponsored research (JSR) project, Kit Fox, conducted by WRI with the petroleum industry's Petroleum Environmental Research Forum (PERF) project 93-16 (WRI/DOE/PERF CAAA-STF). As designed by WRI and the test cosponsors, the field tests at the STF simulated a typical industrial site at one-tenth scale, as designed using wind tunnel tests. The STF data base of previous tests and meteorological data supported the WRI design of the Kit Fox project. The new data collected through the Kit Fox project is significant for developing a scientific and engineering basis for developing regulations that will affect more than 100,000 facilities. Cosponsor funding has not developed to complete data analyses for archive in this National Spill Test Facility data base.

Some discrepancies have been identified between atmospheric stability determined from vertical heat flux data from the eight-level tower and that based on the less rigorous weather observations typically practiced at the STF before the dense gas dispersion tests designed by WRI were initiated in 1993. Given confidence in these data, WRI's objective is to compare the eight-level tower data to Kit Fox data to determine values of the surface-roughness length, which is a major consideration in the prediction of dense cloud dispersion in time and space.

In a related effort, chemical and physical properties data have been entered into an interim-use data archive of STF results. The information is being processed to convert values into a uniform set of units. Verification to assure data quality for about 1200 chemicals has been accomplished. The chemical property data base for material safety data sheets was manipulated using data from Department of Defense CD-ROMS. The CRC press reportedly will have a more consistent set of chemical properties available in late 1996 for comparison with the STF data base results.

ACTIVITIES FOR NEXT QUARTER

WRI will archive Kit Fox data when \$500,000 funding for analysis has been allocated. WRI continues to seek funding to complete analysis in the related DOE NN-60 technology transfer project. WRI has also sought funding to complete the 1995 jointly sponsored Kit Fox research data processing and analysis as mandated by PL 101-549.

TASK 4.0 APPLIED ENERGY SCIENCE

BACKGROUND

In general, the reason alternative fossil fuels such as coal and oil shale have not found their way into the marketplace as sources for the production of transportation fuels is the high cost of recovery and conversion of these resources to useful products. In addition, the refining of crude oils to transportation fuels is becoming more costly because the amounts of heavy crude oils in the feedstock that must be refined is gradually increasing. Work on a different type of resource has recently been conducted that demonstrates that a light distillate can be produced that contains very little heteroatomic species. In addition, it is estimated that the cost of recovering this resource is not as great as producing a syncrude from oil or oil shale. The feedstocks for this process are waste motor oil and waste plastics that are normally discarded into landfills.

Preliminary results have also been obtained using hydrogen-rich plasmas to convert solid or high boiling fossil fuels to liquid products with low heteroatomic content.

Resources that can potentially be investigated under these subtasks include not only the more conventional resources, such as heavy crude oils, coal and coal-derived liquids, but also waste plastics and other streams that may potentially be converted into useful products. The successful conversion of the latter resources to useful products also has the potential of making a significant impact on our demand for foreign oil. In addition, the utilization of waste streams also helps resolve an impending problem with landfills in the United States. Legislation is being enacted in many states that will severely limit the types of wastes that can be disposed of in a landfill.

LONG-TERM OBJECTIVE

The long-term objective of this task is to conduct basic science research to better understand and evaluate various applied energy technologies as they pertain to different feedstocks. This can be accomplished either through a better understanding of the nature and impact of the composition of different fossil fuels during the application of current processes or through the development of new processes.

Work resumed on Subtask 4.2 (Fossil Fuel and Hydrocarbon Conversion Using Hydrogen-Rich Plasmas).

SUBTASK 4.2

PRELIMINARY EVALUATION OF A PROCESS USING PLASMA REACTIONS TO DESULFURIZE HEAVY OILS

Francis P. Miknis and Will Grimes

August–October 1996

OBJECTIVE

The objective of this subtask is to provide data needed to assess the viability of a process to desulfurize heavy oils through the use of plasma reactions.

QUARTER OBJECTIVES

The objectives for this quarter were to:

- Modify an available recirculating-flow plasma/liquid reactor system to work with very heavy oils and asphalts
- Conduct shakedown tests to verify the suitability of the reactor
- Begin conducting experiments outlined in the test matrix.

ACCOMPLISHMENTS

An available recirculating-flow plasma/liquid reactor system was modified to work with very heavy oils and asphalts. Shakedown testing showed this system to be unreliable for attaining steady-state operation and for acquiring mass balance data. A stirred batch reactor system was devised and assembled, and experimental work has begun using this system.

PROCEDURES

The continuous flow plasma/liquid reactor system shown schematically in Figure 1 was assembled. A heated syringe pump was used to provide a continuous steady flow of heavy oil into the reaction chamber, where it was exposed to various plasmas as it flowed into the sump at the bottom of the plasma tube. Shakedown testing of this system revealed problems caused by gas bubbles bursting at

Figure 1. Schematic Diagram of Continuous-Flow Plasma/Liquid Reactor System

the surface where the liquid exits the supply tube and is exposed to the plasma. Bursting bubbles caused oil to splash, coating the interior surface of the plasma tube, and making steady-state operation impossible. Obtaining mass data from the system also proved to be very difficult. Therefore, the continuous-flow reactor was replaced with the simple stirred batch reactor shown in Figure 2. In this system, the oil surface exposed to the plasma is renewed by continuously stirring the liquid pool.

Using the batch reactor system and a high-sulfur asphalt obtained from the Strategic Highway Research Program (SHRP) Materials Reference Library (MRL) [1], experimental work was begun following the test matrix shown in Table 1. For each of the first five tests, approximately 4.5 g of asphalt was placed in the reactor and heated to 120° C. Gas flow was established at 36 sccm, pressure in the reactor was pumped down to 6 mm Hg (0.8 kPa), and microwave power was set at ~ 200 watts. Individual samples were exposed to plasmas generated from the gases shown in the test matrix. Exposure to the plasma was 165 min for all samples. Identical conditions were used for the sixth test, except that the reactor pressure was set at 15 mm Hg (2.0 kPa).

During each test, gas samples were withdrawn downstream of the reaction chamber and analyzed by chromatography for sulfur and hydrocarbon species. Initial and final weights for the asphalt, and the weight of any light liquid collected in the cold trap were recorded. After the test, the cold trap and reactor were cleaned with methylene chloride. The rinsings were combined and the solvent was evaporated. These samples were submitted for C,H,N,S elemental analysis.

Table 1. Test Matrix of Plasma Desulfurization Experiments

Test #	Gas	Flow, sccm	Plasma	Pressure, Pa	Oil
1	H ₂	36	no	800	AAD-2
2	He	36	yes	800	AAD-2
3	H ₂	36	yes	800	AAD-2
4	CH ₄	36	yes	800	AAD-2
5	CH ₄ /H ₂ O	36	yes	800	AAD-2
6	H ₂	36	yes	2000	AAD-2
7	H ₂	36	yes	800	TBD
8	H ₂	36	yes	800	TBD

Figure 2. Schematic Diagram of Stirred Batch Reactor System

RESULTS

Various sulfur-containing species were present in the reactor effluent gas in all the tests in which there was a plasma. Also, the sample lost weight in all tests in which there was a plasma. Hydrocarbons in the effluent gas were typically methane and C_2 's, except when liquid splashed onto the walls of the reactor. Hydrocarbons as heavy as C_7 's were seen in shakedown tests with the circulating reactor in which oil splashed onto the reactor walls.

Measureable quantities of light oils were produced in tests with H_2 , CH_4 , and CH_4/H_2O plasmas at 6 mm Hg. The test with hydrogen plasma at 15 mm Hg did not produce significant light oils. Table 2 shows the relative weights of the residual asphalt, light oil, and gas produced in the various tests. Results from elemental analysis of the oils were not available this reporting period.

Table 2. Relative Weights of Resid, Light Oil, and Gas for the Various Tests with AAD-2 Asphalt

Test #	Gas	Resid, %	Light Oil, %	Gas, %	Oil
1	H_2	99.78	0.00	0.22	AAD-2
2	He	95.68	0.23	4.09	AAD-2
3	H_2	83.04	2.42	14.54	AAD-2
4	CH_4	88.17	5.13	6.70	AAD-2
5	CH_4/H_2O	88.40	4.38	7.22	AAD-2
6	H_2	89.34	0.23	10.43	AAD-2

ACTIVITIES FOR NEXT QUARTER

In the next quarter we will complete the experimental program outlined in the test matrix, analyze the results, and begin preparation of a final report.

REFERENCES

Cominsky R.J., J.S. Moulthorp, W.E. Elmoreand, T.W. Kennedy, SHRP Materials Reference Library Asphalt Selection Process: Rept. No. SHRP-IR-A-89-002, Strategic Highway Research Program, Washington, DC, 1989, 31pp.

TASK 6.0 REMEDIATION

Task 6.0 has Subtask 6.1 as the only activity. This subtask was not anticipated in the original work plan for Cooperative Agreement DE-FC21-93MC30126 but was included for convenience.

SUBTASK 6.1 NORTH SITE REMEDIATION

Norm Merriam

August–October 1996

OBJECTIVES

The overall objectives of this subtask are to clean up the WRI north site in a cost-effective and environmentally sound manner. The objectives for the individual phases are:

Phase I–Definition of waste streams

Phase II–Disposal of hazardous wastes

Phase III–Disposal of nonhazardous wastes

Phase IV–Sampling of soil and removal of buried wastes

Phase V–Decontamination and removal of equipment

Phase Va–Groundwater monitoring

Phase VI–Preparation of a materials inventory data base

QUARTER OBJECTIVES

Objectives for this quarter were to:

- Prepare an overall final report
- Submit the final report to DOE in September
- Arrange for an organization to transfer low-level radioactive materials

ACCOMPLISHMENTS

- Phase I is complete.
- Phase II is complete. Low-level radioactive materials need to be removed.
- Phase III is complete.
- Phase IV is complete.
- Phase V is complete. A draft of the final report was submitted to DOE during the quarter.
- Site revegetation and surface water control are complete.
- Phase VI, materials inventory database, is complete.
- Monthly reports were submitted.
- Topical reports have been prepared as phases were completed.

OBJECTIVES FOR NEXT QUARTER

- Revise the final report as necessary
- Arrange for removal of low-level radioactive materials

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Johnson, L.
 Project Title: Subtask 1.2 - Miscible-Immiscible Gas Injection Processes
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Year - 254,500)	264,500	334,500	404,500	454,500
Expenditures (Prior Year - 93,907)	71,047	40,975	65,888	-
Remaining Budget	289,549	244,571	178,683	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Doneme 11/26/96

Signature of USDOE Reviewing Representative and Date

Substitute DOE Form F 4600.5 replacing Form EIA-459E

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Carlson, F.
 Project Title: Subtask 1.3 - Development of a Portable Data Acquisition System and Coalbed Methane Simulator
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address
Western Research Institute
365 North Ninth Street
Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	316,841	316,841	316,841	316,841
Expenditures (Prior Years - 157,522)	1,417	471	9,675	-
Remaining Budget	157,902	157,431	147,756	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Dorence 11/26/96

Signature of USDOE Reviewing Representative and Date

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Satchwell, R.
 Project Title: Subtask 1.4 - Tank Bottom Remediation
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address
Western Research Institute
365 North Ninth Street
Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years - 588,275)	593,275	668,275	713,275	748,275
Expenditures (Prior Years - 486,719)	30,903	99,127	30,138	-
Remaining Budget	230,453	131,526	100,588	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Dorence 11/26/96

Signature of USDOE Reviewing Representative and Date

Substitute DOE Form F 4600.5 replacing Form EIA-459E

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Sethi, V.

Name and Address
Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

Project Title: Subtask 2.7 - Development and Testing of a Coal-Fired Gas Turbine System
 Reporting Period: August 2, 1996 - October 1, 1996

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget	67,000	112,000	157,000	195,000
Expenditures	0	67	18	-
Remaining Budget	195,000	194,933	194,915	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

SM Donence 11/26/96

Signature of USDOE Reviewing Representative and Date

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Bland, A.
 Project Title: Subtask 3.1 - Solid Waste Management
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	691,998	691,998	691,998	691,998
Expenditures (Prior Years - 636,017)	49,107	(4,321)	6,691	-
Remaining Budget	6,874	11,195	4,504	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Donance

11/26/96

Signature of USDOE Reviewing Representative and Date

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Brown, T.
 Project Title: Subtask 3.2 - Remediation of Contaminated Soils (Haz-Flote)
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	442,074	442,074	442,074	442,074
Expenditures (Prior Years - 341,301)	37,657	36,881	13,595	-
Remaining Budget	63,116	26,235	12,640	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Donenue

11/26/96

Signature of USDOE Reviewing Representative and Date

Substitute DOE Form F 4600.5 replacing Form EIA-459E

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Bland, A.
 Project Title: Subtask 3.3 - Syn-Ag Process: Coal Combustion Ash Management Option
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	183,521	183,521	183,521	183,521
Expenditures (Prior Years - 63,992)	11,037	5,832	24,124	-
Remaining Budget	108,492	102,660	78,536	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Donenue

11/26/96

Signature of USDOE Reviewing Representative and Date

Substitute DOE Form F 4600.5 replacing Form EIA-459E

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
Client: U.S. Department of Energy

Contract Start: February 2, 1993

Contract Complete: February 1, 1998

Subtask Manager: Brown, T.

Project Title: Subtask 3.4 - Maxi-Acid Process: In-Situ Amelioration of Acid Mine Drainage Problems

Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
365 North Ninth Street
Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	231,057	231,057	231,057	231,057
Expenditures (Prior Years - 85,116)	8,155	3,956	14,882	-
Remaining Budget	137,796	133,840	118,958	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Am Donenice

11/26/96

Signature of USDOE Reviewing Representative and Date

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Sheesley, D.
 Project Title: Subtask 3.5 - Spill Test Facility Data Base
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	186,539	186,539	186,539	186,539
Expenditures (Prior Years - 149,101)	35,132	1,074	797	-
Remaining Budget	2,306	1,232	435	-

EXPENDITURES VERSUS APPROVED BUDGET

Milestones	Planned	Actual	Progress	Scheduled	Delivered
96-3.5 Spill Test Facility Data Base					
96-3.5A Final Topical Report					
96-3.5B Quarterly Report					

Signature of Recipient and Date <i>Sm Doreme</i> 11/26/96	Signature of USDOE Reviewing Representative and Date
--	--

Substitute DOE Form F 4600.5 replacing Form EIA-459E

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Brown, T.
 Project Title: Subtask 3.6 - Attenuation of Ammonium Concentrate in an Aquifer
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	16,400	16,400	16,400	16,400
Expenditures (Prior Years - 0)	1,259	0	693	-
Remaining Budget	15,141	15,141	14,448	-

EXPENDITURES VERSUS APPROVED BUDGET

Milestones	Planned	Actual	Progress	Scheduled	Delivered
96-3.6 Attenuation of Ammonium Concentrate					
96-3.6A Final Topical Report					
96-3.6B Quarterly Report					

Feb 1 May 1 Aug 1 Nov 1 1996 Feb 1 1997

Signature of Recipient and Date

Sm Donenue 11/26/96

Signature of USDOE Reviewing Representative and Date

Substitute DOE Form F 4600.5 replacing Form EIA-459E

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Sheesley, D.
 Project Title: Subtask 3.7 - Evaluation of Dense Gas Dispersion
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget	40,000	85,000	130,000	175,000
Expenditures	2,839	140,249	23,442	-
Remaining Budget	172,161	31,912	8,470	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Donenue

11/26/96

Signature of USDOE Reviewing Representative and Date

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Miknis, F.
 Project Title: Subtask 4.2 - Fossil Fuel and Hydrocarbon Conversion Using Hydrogen-Rich Plasmas
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years - 81,447)	96,447	111,447	126,447	131,447
Expenditures (Prior Years - 78,231)	2,190	348	11,789	-
Remaining Budget	51,026	50,678	38,889	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Jim Donahue

11/26/96

Signature of USDOE Reviewing Representative and Date

Substitute DOE Form F 4600.5 replacing Form EIA-459E

FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Subtask Manager: Merriam, N.
 Project Title: Subtask 6.1 - North Site Remediation
 Reporting Period: August 2, 1996 - October 1, 1996

Name and Address

Western Research Institute
 365 North Ninth Street
 Laramie, Wyoming 82070

EXPENDITURES (\$)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Approved Budget (Prior Years)	1,534,884	1,534,884	1,534,884	1,534,884
Expenditures (Prior Years - 1,142,253)	95,898	160,705	65,356	-
Remaining Budget	296,733	136,028	70,672	-

EXPENDITURES VERSUS APPROVED BUDGET

Signature of Recipient and Date

Sm Donenue

11/26/96

Signature of USDOE Reviewing Representative and Date

CONTRACT STATUS REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Reporting Period: 3rd Quarter, Year 4

CUMULATIVE ACCRUED EXPENDITURES, YEAR 4 (\$)

	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>
Approved Budget	137,000	387,000	607,000	780,000
Expenditures (Cumulative)	2,839	171,629	258,455	—
Remaining Budget	777,161	608,371	521,545	—

EXPENDITURES VERSUS APPROVED BUDGET

CONTRACT STATUS REPORT

Contract No: DE-FC21-93MC30126
 Client: U.S. Department of Energy
 Contract Start: February 2, 1993
 Contract Complete: February 1, 1998
 Reporting Period: Cumulative Through 3rd Quarter, 4th Year

APPROVED BUDGET

Year 1 (3/93)	Year 1 (12/93) Cleanup	Year 2 (4/94)	Year 2 (9/94) Cleanup	Year 3 (2/95)	Year 3 (9/95) Cleanup	Year 4 (4 - 9/96)
\$1,950,000	\$828,000	\$1,750,000	\$604,908	\$976,000	\$101,976	\$780,000

Total Approved Budget: \$6,990,884

Total Expenditures Through 10/96: \$6,018,384

Remaining Budget: \$972,500

EXPENDITURES VERSUS APPROVED BUDGET