Providing Solutions to Energy and Environmental Problems

Quarterly Report January 1 - March 31, 1998

Work Performed Under Contract No.: DE-FC21-93MC30127

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

By
Western Research Institute
Laramie, Wyoming

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Providing Solutions
to
Energy and Environmental
Problems

Quarterly
Technical Progress
Report

for
January 1, 1998 through March 31, 1998

on

Cooperative Agreement DE-FC21-93MC30127-37
Jointly Sponsored Research Program

for the

U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
Morgantown, West Virginia

by

Western Research Institute
Laramie, Wyoming

April 1998

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Cumulative JSRP Funding Summarized by Technology Area

More than \$18 million for energy programs emphasizing enhanced oil recovery, coal beneficiation and upgrading, coalbed methane recovery and renewable energy resources

\$4.1 million for technology enhancement activities encompassing resource characterization studies, improved environmental monitors and sensors, and improved dispersion modeling techniques

\$8.9 million for technology to clean underground oily wastes, mitigate acid mine drainage, and demonstrate uses for CCT and PFBC waste solids

Cooperative Agreement DE-FC21-93MC30127
Status of Total Approved Projects on July 1, 1997

***WRI's JSR Program is Focused on Technology Development
to Meet National and Regional Needs***

Goals of WRI's Jointly Sponsored Research Program

Increase the production of U.S. and western energy resources: low-sulfur coal, natural gas, oil, and renewable energy resources

Enhance the competitiveness of U.S. and western energy technologies in international markets and assist in technology transfer

Reduce the nation's dependence upon foreign energy supplies and strengthen the U.S. and regional economies

Minimize the impact of energy production and utilization on the environment

Summary
of
Appropriations,
Obligations
&
Expenditures
by
Task

Executive Summary

Jointly Sponsored Research Program

The Jointly Sponsored Research Program emphasizes technology commercialization and continues to be highly successful and supported strongly and enthusiastically by WRI's industrial clientele. All of the available Department of Energy (USDOE) funding for each of the first seven years has been committed to projects. All available FY 97 funding was obligated in June 1997. The demand for funds continues to outstrip available monies and an additional \$3 million per year in USDOE funding could easily be accommodated. As summarized in Table 1, since the program's inception in 1990, \$19,140,754 in USDOE funds have been obligated and committed against an industrial match of \$25,446,281.

Table 1
Summary of JSRP Funding for FY 1990-97

Fiscal Year	Funds Available	Funds Committed	No. of Projects	New Starts
1997	2,050,754	2,096,213	22	2
1996	2,220,000	2,174,541	20	2
1995	2,800,000	2,800,000	18	1
1994	2,411,000	2,411,000	17	3
1993	2,437,000	2,437,000	14	9
1992	2,442,000	2,442,000	17	10
1991	2,489,000	2,489,000	11	5
1990	2,291,000	2,291,000	14	14
Total	\$19,140,754	\$19,140,754		

Since entering into a new JSRP cooperative agreement with the Department of Energy on March 26, 1993 (Cooperative Agreement DE-FC21-93MC30127), WRI has put into place projects utilizing a total of \$13,082,477 in USDOE funds. These funds have been matched against \$18,342,205 in industrial funds to produce a program valued at \$31,424,682. Letters of commitment have already been obtained which envision utilizing more than \$5 million in FY 98 funds. As a result of this strong demand for program participation, unless additional funding is available, WRI may not be able to work in a significant fashion with any new JSRP participants until FY 98 or beyond. In fact, we estimate that \$6.5 million would be needed in FY 98 to adequately meet present demand. As Table 1 clearly indicates, new program participants can only be added in those instances where existing money can be reobligated.

Table 2
Tasks Approved for Funding Through Fiscal Year 1997

		Previous Commitments			FY 97 Commitment			Total Commitment		
Task	Project	USDOE	Sponsor	Total	USDOE	Sponsor	Total	USDOE	Sponsor	Total
Energy Programs										
1	Electric Downhole Steam Generator	1,282,785	1,315,200	2,745,985				1,282,785	1,315,200	2,745,985
2	Wetting Behavior of Crude Oil/Brine/Rock Systems	1,132,356	1,220,793	2,353,149				1,132,356	1,220,793	2,353,149
3	Kerr Coal Product Market Study	57,039	60,000	117,039				57,039	60,000	117,039
7	Optimization of FMC Carbonizer	48,418	45,000	93,418				48,418	45,000	93,418
9	Demonstration of the "Series C" Process	2,456,205	2,588,800	5,045,005	548,527	932,500	1,481,027	3,004,732	3,521,300	6,526,032
14	"Series B" Pilot Plant Tests	8,668	10,092	18,760				8,668	10,092	18,760
6	Enhanced Recovery of Coalbed Methane	1,135,900	1,716,270	2,852,170				1,135,900	1,716,270	2,852,170
16	Demonstration of a Wood-Fired Gas Turbine System	1,416,234	2,303,984	3,720,218				1,416,234	2,303,984	3,720,218
Subtotal Energy Programs		7,537,605	9,260,139	16,797,744	548,527	932,500	1,481,027	8,086,132	10,192,639	18,278,771

Table 2 (Continued)
Tasks Approved for Funding Through Fiscal Year 1997

		Previous Commitments			FY 97 Commitment			Total Commitment		
Task	Project	USDOE	Sponsor	Total	USDOE	Sponsor	Total	USDOE	Sponsor	Total
Technology Enhancement Programs										
8	Chemical Sensor and Field Screening Technology	749,900	749,900	1,499,800				749,900	749,900	1,499,800
10	Remote Chemical Sensor Development	355,000	232,081	587,081				355,000	232,081	587,081
12	NMR Analysis of Matured Kerogens	30,192	15,000	45,192				30,192	15,000	45,192
17	NMR Analysis of Mowry Formation Shales	60,064	60,000	120,064	20,000	20,000	40,000	80,064	80,000	160,064
19	PERF Phase II Demonstration	502,124	945,330	1,447,454				502,124	945,330	1,447,454
21	Validation of a New VOC Sampler	50,541	62,500	113,041	149,762	187,500	337,262	200,303	250,000	450,303
Subtotal Technology Enhancement		1,747,821	2,064,811	3,812,632	169,762	207,500	377,262	1,917,583	2,272,311	4,189,894

Table 2 (Continued)
Tasks Approved for Funding Through Fiscal Year 1997

		Previous Commitments			FY 97 Commitment			Total Commitment		
Task	Project	USDOE	Sponsor	Total	USDOE	Sponsor	Total	USDOE	Sponsor	Total
Environmental Programs										
4	Impact of CCT Waste Leachate on the Stability of Clay Liners	231,043	259,580	490,623				231,043	259,580	490,623
11	Market Assessment Study of PFBC Ash Use	447,638	603,500	1,051,138				447,638	603,500	1,051,138
13	CROW Field Demonstration Bell Lumber and Pole	120,800	541,396	662,196	23,000	36,000	59,000	143,800	577,396	721,196
15	In Situ Treatment of MPG Contaminated Soils	405,289	1,360,523	1,765,812				405,289	1,360,523	1,765,812
18	Acid-Mine Drainage Prevention and Control	211,068	210,845	421,913				211,068	210,845	421,913
20	Field Testing of the TaBoRR Process	285,000	285,415	570,415	1,282,287	2,500,000	3,782,287	1,567,287	2,785,415	4,352,702
22	Market Assessment Study of PFBC Ash Use from Lignite				72,637	79,996	152,633	72,637	79,996	152,633
Subtotal, Environ. Programs		1,700,838	3,261,259	4,962,097	1,377,924	2,615,996	3,993,920	3,078,762	5,877,255	8,956,017
Total, All Programs		10,986,264	14,586,209	25,572,473	2,096,213	3,755,996	5,852,209	13,082,477	18,342,205	31,424,682

C u r r e n t E x p e n d i t u r e s

Table 3
Expenditures on Contract DE-FC21-93MC30127

<i>Task</i>	<i>Budget</i>	<i>Expended Prior Periods</i>	<i>January 1998</i>	<i>February 1998</i>	<i>March 1998</i>	<i>Total</i>
1	\$1,282,785	\$1,304,835		Completed		\$1,304,835
2	1,132,356	1,161,421		Completed		1,161,421
3	57,039	56,989		Completed		56,989
4	231,043	232,574		Completed		232,574
5				Withdrawn		
6	1,135,900	1,027,017	5,894	8,818	6,982	1,048,712
7	48,418	36,974		Completed		36,974
8	749,900	745,899		Completed		745,899
9	3,004,732	2,555,884	208,520	90,962	133,858	2,989,224
10	355,000	354,182		Completed		354,182
11	447,638	441,394	-0-	-0-	44	441,437
12	30,192	30,780		Completed		30,780
13	143,800	132,499	5,135	2,236	2,438	142,308
14	8,668	8,668		Completed		8,668
15	405,289	398,058		Completed		398,058
16	1,416,234	1,288,391		Completed		1,323,472
17	80,064	69,651		Completed		78,018
18	211,068	203,383	4,726	-0-	-0-	208,109
19	502,124	433,099		Completed		512,965
20	1,567,287	1,476,997	17,241	23,732	22,641	1,540,611
21	200,303	114,739	12,320	23,071	22,581	172,712
22	72,637	34,534	4,279	5,144	6,432	50,390
Total	\$13,082,477	\$12,107,923	\$297,037	\$180,260	\$253,116	\$12,838,337

Technical Highlights

Contract work has been completed and final reports are in preparation.

Summary
of
Objectives
&
Accomplishments
by
Task

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Task 2	Wetting Behavior of Selected Crude Oil/Brine/Rock Systems	Status Completed
<p align="center">Sponsors</p> <p><i>ARCO, British Petroleum, Chevron, Conoco, Dagang (China), ELF (France), Exxon, Marathon, Mobil, NorskHydro (Norway), Phillips, Shell (The Netherlands), Statoil (Norway), and the University of Wyoming</i></p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>Fluid distribution and the displacement of oil by water or other fluids in an oil reservoir are governed by the fluid-solid interactions (wettability) of that system. Wettability governs interface shapes, which determine the mechanisms and efficiency of oil displacement from reservoir rocks. Because water flooding accounts for more than half of the oil production in the United States, understanding the effect of wettability on oil recovery is of great importance. To this end, WRI has undertaken a study of crude oil/brine/rock interactions for several selected crude oils, including oil from Prudhoe Bay. Special attention is being given to the possibility of increasing the efficiency of waterfloods through selection or adjustment of the composition of the injected brine.</i></p> <p align="center">Status</p> <p align="center"><i>The project has been completed.</i></p>		

Task 3	Coal Gasification, Power Generation, and Product Market Study	Status Completed
<p align="center">Sponsor Kerr Coal Company</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>The primary use of western low-sulfur coal is for power generation. Other potential uses of this coal need to be evaluated. This study is to perform a market survey of potential products and alternate technologies that may produce high-value products from coal obtained from the Kerr Company coal mine in Walden, Colorado.</i></p> <p align="center">Status</p> <p align="center"><i>The project has been completed.</i></p>		

Task 4	<i>The Impact of Leachate from Clean Coal Technology Waste on the Stability of Clay Liners</i>	<i>Status Completed</i>
<p align="center">Sponsor <i>Public Service Company of Colorado</i></p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>Wastes generated from clean coal technologies have much different physical and chemical characteristics than the wastes generated from conventional power plants. These wastes can have significantly different impacts on the permeability of a clay liner, which can affect the active lifetime of the liner. This study is evaluating the influence that clean coal technology waste materials will have on the stability of clay liners. Specifically, an understanding of the chemical and physical interactions will be determined between clay liners and waste leachates. The findings of the study will provide industry with valuable information for the management of wastes generated by the implementation of clean coal technology programs.</i></p> <p align="center">Status</p> <p align="center"><i>The project has been completed.</i></p>		

Task 5	Investigation of Coprocessing Heavy Oil, Automobile Shredder Residue, and Coal	Status Withdrawn
<p align="center">Sponsor Environmental Recovery Systems, Inc.</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>A major environmental problem today is the disposal of automobile shredder residue (ASR). This residue is composed of plastic, rubber, foam rubber, wood, glass, dirt, oil, and other fluids. WRI is developing a low-temperature coprocessing concept for conversion of ASR, heavy oils, and coal into gasoline and diesel fuel distillates. This concept is being explored to alleviate the problems associated with ASR disposal and to generate useful product streams.</i></p> <p align="center">Status</p> <p><i>This project was withdrawn due to the sponsor's inability to provide matching funds.</i></p>		

Task 6	<i>Injection into Coal Seams for Simultaneous CO₂ Mitigation and Enhanced Recovery of Coalbed Methane</i>	<i>Status Ongoing</i>
<p align="center">Sponsors <i>Amoco, Conoco, Resource Enterprises Inc., and New Mexico Petroleum Recovery Research Center</i></p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>This study is evaluating the technical feasibility of injecting CO₂, a byproduct of methane recovery from some coalbeds, into the coalbeds as both a technique of mitigating the level of CO₂ emissions from the production of methane from the coalbeds and as a technique for enhancing the recovery of methane from the coalbeds. The evaluation will be based on the operation and results of a two-well field pilot test in northwestern New Mexico.</i></p>		

Task Objectives

The overall objective of this task is to test the technical viability of injecting CO₂ into the Fruitland Coal to displace methane from the coal and to mitigate CO₂ emissions which are a consequence of primary coalbed methane production from surrounding wells in the area. To evaluate this technical viability, a field test was conducted and the test is being interpreted using data measured in WRI's laboratory, as well as using Amoco's state-of-the art coalbed methane simulator. Also, a second pilot of the process is being evaluated using the simulator. Ultimately, the technology developed will be applied to a Wyoming coal. The task is divided into five subtasks:

- Subtask 6.1: Two-Well Pilot Test of CO₂ Injection
- Subtask 6.2: CO₂/N₂ Laboratory Tests in the Fruitland Coal
- Subtask 6.3: Modeling of Two-Well Pilot Test
- Subtask 6.4: Allison Unit CO₂ Pilot Study and
- Subtask 6.5: CO₂/N₂ Laboratory Tests in Wyoming Coals.

Quarter Objectives

The objectives for the quarter were:

- Make final the report for Subtask 1.
- Complete the review process on the modeling study for Subtask 4.
- Contact Wyoming coalbed methane operators, obtain coal samples from these operators and begin laboratory testing of the samples.

Accomplishments

Subtask 6.1-Two-Well Pilot Test of CO₂ Injection

The revisions suggested by Amoco were incorporated into the Subtask 1 report. WRI's peer review process has been completed. WRI's Publication Coordinator is currently formatting the report for publication and the document should be submitted to the DOE by May 30, 1998.

Subtask 6.2-CO₂/N₂ Laboratory Tests in the Fruitland Coal

This Subtask has been completed.

Subtask 6.3-Modeling of Two-Well Pilot Test

This Subtask has been completed. No further work is anticipated.

Subtask 6.4-Design of Phase II CO₂ Injection

The pilot data were updated and the actual pilot performance and simulations were redone. Predicted and actual pilot performance were compared. A draft final report that analyzed the most recent performance of the pilot was written and sent to Amoco for their review in October. Amoco is still reviewing the document.

Subtask 6.5 CO₂/N₂ Laboratory Tests in Wyoming Coals

WRI has obtained a sample of Powder River Basin coal. Laboratory-scale displacement tests will be conducted on the coal with a sweep gas consisting of a N₂-CO₂ mixture. This mixture is intended to represent a flue gas such as would be discharged

from a power plant. The tests will demonstrate the ability of the sweep gas to desorb and displace methane from the coal. The tests will also determine the coal's ability to adsorb the CO₂. CO₂'s sorption by the coal would potentially reduce the power plant's emission of a greenhouse gas.

Activities for Next Quarter

- Complete the Subtask 1 reports and submit bound copies to the DOE and Amoco.
- Send the final document on Subtask 4 to WRI's Publication Coordinator when Amoco completes its review.
- Perform displacement tests on Powder River Basin Coal.

Program/Project Identification No. DE-FC21-93MC30127	Program/Project Title Task 006 Injection into Coal Seams for Simultaneous CO ₂ Mitigation and Enhanced Recovery of Coalbed Methane	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING	812,639	1,701,789
FY 1994 FUNDING		
FY 1995 FUNDING	323,261	14,481
FY 1996 FUNDING		
FY 1997 FUNDING		
PROJECT FUNDING TO DATE	1,135,900	1,716,270
TOTAL PROJECT VALUE \$2,852,170

Cosponsor funding in FY 95 consisted of \$14,481 cash
 Cosponsor funding in FY 93 consisted of \$41,389 cash and \$1,660,400 In-Kind

Signature of Recipient and Date 	Signature of USDOE Reviewing Representative and Date
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Task 7	Optimization of Carbonizer Operations in the FMC Coke Process	Status Completed
<p align="center">Sponsor University of Wyoming Western Coal Consortium</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p>Operation of the FMC coking process to date has resulted in insufficient production of heavy tar materials that serve as the binder in the coke production. Laboratory tests were conducted by WRI, in conjunction with the University of Wyoming, to develop the optimum operating conditions for the carbonizer to maximize the amount of tar produced for binder and to investigate the applicability of the process to other western coals.</p> <p align="center">Status</p> <p align="center">The project has been completed.</p>		

Task 8	Chemical Sensor and Field Screening Technology Development	Status Completed
<p align="center">Sponsor <i>In-Situ Incorporated</i></p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>The determination or screening of environmental contaminants in the field using portable analytical methodologies or down-hole real time in-situ measurements is an area of great interest in the environmental industry. WRI is expanding its efforts into new technology areas for the development and commercialization of these technologies.</i></p> <p align="center">Status</p> <p align="center"><i>The project has been completed.</i></p>		

Task 9	<i>Demonstration of the Koppelman "Series C" Process Using a Batch Test Unit with Powder River Basin Coal as Feed</i>	<i>Status Ongoing</i>
<i>Sponsor K-Fuel Incorporated</i>		
<i>Reporting Period: January 1 through March 31, 1998</i>		
<p align="center"><i>Background</i></p> <p><i>Although having the desirable characteristic of being low in sulfur, most western coals are comparatively low in heating value. Bench-scale tests have been successfully conducted using the Koppelman "Series C" process in which subbituminous Powder River Basin coal has been converted to a higher value product having the characteristics of a low-sulfur bituminous coal. WRI is working with K-Fuel Inc. to construct and operate a large-scale batch unit that will provide the design basis for a commercial plant and to evaluate the product samples and process emissions from the unit.</i></p>		

Task Objectives

- (Phase I) Demonstrate the feasibility of the Koppelman Series C process by constructing a 1,000 lb. batch test unit; conducting tests to further develop the design basis for a commercial plant; and producing samples of the product for testing and evaluation.
- (Phase II) Improve the process economics by designing, constructing and testing a low-cost, high-efficiency version of the processor.
- Characterize the gaseous and water emissions from the process by determining the quantity and composition of those respective emissions.
- (Phase III) Support the design and operation of the 500,000 ton per year commercial plant now being constructed by KFx and Thermo Ecotek.
- Expand the market for the products by testing high sulfur U.S. coals and foreign coals.
- Increase the product density by developing an extrusion system, and

Reduce the costs of future plants using the Koppelman Series C process by developing a feed-coal preheater along with an inverted processor.

Quarter Objectives

Continue to support the startup activities of the commercial plant and conducting bench-scale tests and tests using the Series C pilot plant. Prepare an annual technical report describing activities during the first year of Phase III.

Accomplishments

During this quarter we conducted extensive activities to help diagnose and correct problems in the commercial plant. We also continued bench-scale testing of foreign and domestic coal and participated in several tests using the Series C pilot plant. We completed preparation of a technical report describing WRI activities during Phase III of the project.

Activities for Next Quarter

Continue pelletization and bench-scale testing.

Program/Project Identification No. DE-FC21-93MC30127	Program/Project Title Task 009 Demonstration of the Koppelman "Series C" Process Using a Batch Test Unit with Powder River Basin Coal as Feed	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING	604,999	634,200
FY 1994 FUNDING	851,206	954,600
FY 1995 FUNDING		
FY 1996 FUNDING	1,000,000	1,000,000
FY 1997 FUNDING	548,527	932,500
PROJECT FUNDING TO DATE	3,004,732	3,521,300
TOTAL PROJECT VALUE \$6,526,032

Cosponsor funding in FY 97 consisted of \$932,500 In-Kind
 Cosponsor funding in FY 96 consisted of \$250,000 cash and \$750,000 In-Kind
 Cosponsor funding in FY 94 consisted of \$175,000 cash and \$779,600 In-Kind
 Cosponsor funding in FY 93 consisted of \$634,200 In-Kind

Signature of Recipient and Date 	Signature of USDOE Reviewing Representative and Date
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**Task
10
(Old
5.25)**

Remote Chemical Sensor Development

***Status
Completed***

***Sponsor
In-Situ Incorporated***

Reporting Period: January 1 through March 31, 1998

Background

The detection and monitoring of groundwater and soil contaminants is essential to environmental mitigation efforts. WRI is continuing work begun under the earlier cooperative agreement on the development of needed instruments for accurate measurements of chemical materials with easy-to-use, portable equipment and for in-situ, real-time monitoring. This includes development of a new field test kit for measurement of diesel and other fuels in soils and a downhole monitoring device for volatile organic compounds. The work involves optimizing soil extraction chemistry, exploring optimal design and configuration of the fuel test kit photometer, and constructing prototype instruments for downhole VOC monitoring.

Status

The project has been completed.

Footnote

This task completed work begun as Task 5.25 under the previous cooperative agreement. Total USDOE and cosponsor funding was \$575,000 each for a project total of \$1,150,000.

Task 11	Market Assessment and Technical Feasibility Study of PFBC Ash Use	Status Ongoing
<p align="center">Sponsor Electric Power Research Institute</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>The chemical characteristics of pressurized fluidized bed combustion (PFBC) ash are quite different from other Clean Coal Technology (CCT) ashes. These characteristics may make the PFBC ash more amenable to options for its use than other CCT ashes. This study is to make a market assessment of potential uses of PFBC ash, evaluate the technical feasibility of these uses, and develop plans for full-scale demonstrations of the most promising options.</i></p>		

Task Objective

The objective of this task is to determine the market and technical use options for PFBC ash.

Quarter Objectives

- Continue preparation of the final report.

Accomplishments

- Hydration phase analysis composition changes as a function of curing conditions were completed and the data are being analyzed. Germination studies were completed and plant production studies were completed. The soil amendment greenhouse study used each of the PFBC ashes and both Meadow Foxtail Grass and Common Bermuda Grass and an acid soil. Each of the PFBC ashes showed potential for amending an acid soil supporting the

establishment of both grass species. Second cutting production was lower than expected, but third cutting production showed recovery for all species. The cause for this behavior is presented being evaluated.

- The project was selected by DOE for inclusion in a poster session at the '98 Advanced Power and Environmental Controls Systems Conference and an abstract is being submitted to CFB-6 Conference in Germany.
- Preparation of the final report continued. The topical report was modified to include the results of the Karhula high sulfur coal tests.

Activities for Next Quarter

- Complete preparation of the final report.

Program/Project Identification No. DE-FC21-93MC30127	Program/Project Title Task 011 Market Assessment and Technical Feasibility Study of PFBC Ash Use	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING	99,998	100,000
FY 1994 FUNDING		
FY 1995 FUNDING	147,640	303,500
FY 1996 FUNDING	200,000	200,000
FY 1997 FUNDING		
PROJECT FUNDING TO DATE	447,638	603,500
TOTAL PROJECT VALUE \$1,051,138

Cosponsor funding in FY 96 consisted of \$200,000 In-Kind
 Cosponsor funding in FY 95 consisted of \$303,500 In-Kind
 Cosponsor funding in FY 93 consisted of \$100,000 In-Kind

Signature of Recipient and Date	Signature of USDOE Reviewing Representative and Date
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Task 12	<i>Solid State Nuclear Magnetic Resonance (NMR) Analysis of Naturally and Artificially Matured Kerogens</i>	<i>Status Completed</i>
<p align="center">Sponsor <i>University of Wyoming--EPSCoR</i></p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>As part of the University of Wyoming research project to develop new approaches and supporting technology for oil and gas exploration in the United States, pressure compartmentalization is being modeled. To do so, fundamental data are required on the natural and artificial maturation of petroleum source rocks. WRI is performing solid-state NMR measurements to provide a significant part of the required data.</i></p> <p align="center">Status</p> <p align="center"><i>The project has been completed.</i></p>		

Task 13 (Old 5.6)	Contained Recovery of Oily Wastes (CROW™) Field Demonstration with Bell Lumber and Pole	Status Ongoing
Sponsor Bell Lumber and Pole		
Reporting Period: January 1 through March 31, 1998		
<p align="center">Background</p> <p><i>Operation of a pole and tie treatment plant in New Brighton, Minnesota for a number of years resulted in contamination of soils at the site with organic materials. WRI is using the CROW process to demonstrate remediation of the site. The process displaces and recovers part of the contaminating materials. This is followed by in-situ bioremediation of the residual oily substances.</i></p> <p align="center">Footnote</p> <p><i>This task completes work begun as Task 5.6 under the previous cooperative agreement. Total USDOE funding is \$587,644 and total cosponsor funding is \$2,024,955 for a project total of \$2,612,599.</i></p>		

Task Objectives

The objective of this task is to design, construct, and operate a field demonstration of the CROW™ process technology to treat a site contaminated with organic wastes from the wood treatment process.

Quarter Objective

Continue the full-scale field demonstration.

Accomplishments

As of October 1997, the CROW system has been operating continuously for 194 days. At that time the CROW system was shutdown for maintenance, installation of some new equipment and to treat an oil/water emulsion that had again developed in the process tank. WRI conducted maintenance on the data acquisition system while the system was down. The emulsion was transferred to the oil storage tank and the system was restarted in December 1997.

The development of an oil/water emulsion in the 10,000 gal process tank after six to nine months of operation continues to be a problem. It appears

that the main source of the emulsion is the oil and water returned to the process tank from the air flotation unit. This fluid accumulates and is slow to separate. However, when the emulsion is transferred to the oil storage tank, it will break and the water is then pumped to the top of the process tank. The top to the organic layer in the tank is then skimmed and sent to the oil storage tank. Previously, this upper organic layer has been allowed to collect and only occasionally has it been removed.

At the end of March 1998, approximately 10.2 million gal of water have been injected and over 47,000 gallons of oil recovered. During 1997, about 16,00 gal of the 43,000 gal of produced oil were reused in the pole treatment operation. Assuming the current injection and extraction rates are maintained, another 16 to 20 months of operation will be needed to achieve 20 PV of injection.

The phase-one modeling with the WRI thermal simulator has produced an acceptable match with the cumulative oil production and the aquifer temperatures achieved in the field. As new data are generated, the model match is being reevaluated or modified to enhance the match.

Activities for Next Quarter

Operation of the phase-one, full-scale remediation will continue next quarter.

Program/Project Identification No. DE-FC21-93MC30127	Program/Project Title Task 013 Contained Recovery of Oily wastes CROW™ Field Demonstration with Bell Lumber and Pole	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING	90,800	
FY 1994 FUNDING		207,396
FY 1995 FUNDING		250,000
FY 1996 FUNDING	30,000	84,000
FY 1997 FUNDING	23,000	36,000
PROJECT FUNDING TO DATE	143,800	577,396
TOTAL PROJECT VALUE \$721,196

The project cosponsor has added an additional \$541,396 cash to the project raising their total contribution from \$1,940,955 to \$2,482,351
 Cosponsor funding in FY 97 consisted of \$36,000 cash

Signature of Recipient and Date	Signature of USDOE Reviewing Representative and Date

Task 14	"B Series" Pilot Plant Tests	Status Completed
<p align="center">Sponsor Heartland Fuels Corporation</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>In a previous JSRP task, WRI participated with Heartland Fuels Corporation in conducting pilot-scale tests of the "B" series process using three different coals. The present study determined the characteristics of the process condensate when operated at lower temperatures than previously tested. Seven tests were conducted in the pilot plant and samples of the condensate were collected and analyzed.</i></p> <p align="center">Status</p> <p align="center"><i>The project has been completed.</i></p>		

Task 15 (Old 5.26)	<i>In Situ Treatment of Manufactured Gas Plant Contaminated Soils Demonstration Program</i>	<i>Status Complete</i>
<i>Sponsors</i> <i>Pennsylvania Power and Light, US Environmental Protection Agency, Gas Research Institute, and Electric Power Research Institute</i>		
<i>Reporting Period: January 1 through March 31, 1998</i>		
<p data-bbox="740 569 894 596"><i>Background</i></p> <p data-bbox="251 619 1382 800"><i>The process of manufacturing gas from coal years ago resulted in the contamination of soils with carcinogenic materials. One such site that is presently being cleaned is the Brodhead Creek Site in Stroudsburg, Pennsylvania. WRI is using its CROW process in conjunction with in-situ biotreatment to demonstrate remediation of the site. The overall steps in the study are to design the application of the CROW process to the site, obtain permits, construct and operate the field demonstration test and evaluate the results.</i></p> <p data-bbox="760 823 875 850"><i>Footnote</i></p> <p data-bbox="251 873 1382 961"><i>This task completes work begun as Task 5.26 under the previous cooperative agreement. Total USDOE funding is \$518,689 and total cosponsor funding is \$1,360,523 for a project total of \$1,879,212.</i></p> <p data-bbox="776 993 859 1020"><i>Status</i></p> <p data-bbox="389 1052 1243 1079"><i>The project has been completed and awaits EPA approval for site closure.</i></p>		

Task 16	<i>Development and Demonstration of a Wood-Fired Gas Turbine System</i>	<i>Status Completed</i>
<i>Sponsors</i> <i>Power Generating Inc. and Office of Conservation and Renewable Energy, US Department of Energy</i>		
<i>Reporting Period: January 1 through March 31, 1998</i>		
<i>Background</i> <i>Development of a means to use inexpensive solid fuels for electrical power generation and thermal energy has the double benefit of providing low-cost energy and utilization of an otherwise possibly unused resource. Power Generating Inc. has patented a unique, direct-fired gas turbine power system that could be operated on such fuels. The system is expected to operate at thermal efficiencies in excess of 70% through full utilization of the electrical and thermal energy generated. Problems generally inherent in such systems are overcome by the unique design of this system and by close control of fuel specifications and operating procedures. WRI is working on the detailed design of a demonstration unit. When designed, a 425 kilowatt power system will be constructed and tested on a clean wood fuel. Immediately following the wood testing, the system will be reconfigured and operated on a low-ash coal.</i>		
<i>Status</i> <i>The project has been completed.</i>		

Task 17	<i>Solid State NMR Analysis of Mowry Formation Shale from Different Sedimentary Basins</i>	<i>Status Completed</i>
<p align="center">Sponsors <i>University of Wyoming and Gas Research Institute</i></p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>New approaches and supporting technology are needed to reverse the diminishing returns from oil and gas exploration in the United States. The discovery of subsurface fluid or pressure chambers has the potential to delineate a new class of hydrocarbon traps, thereby revitalizing interest in domestic exploration. The University of Wyoming has a research project to develop a conceptual model of the formation, distribution, and destruction of pressure chambers and seals in sedimentary basins. A key to understanding the diagenetic and maturational behavior is knowledge of the organic carbon structure of the kerogen in petroleum source rocks and how the kerogen structure changed during petroleum generation. As a part of this project, WRI is performing solid-state NMR measurements to provide information on the diagenesis and maturation of petroleum source rocks. The material being studied in this task is Mowry Formation shale from sedimentary basins.</i></p> <p align="center">Status</p> <p align="center"><i>The project has been completed.</i></p>		

Task 18	Acid-Mine Drainage Prevention, Control, and Treatment Development for the Stockett/Sand Coulee Area	Status Ongoing
<p align="center">Sponsor Montana Bureau of Mines and Geology</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>Extremely acidic water is continually discharging from abandoned coal mines in the Stockett/Sand Coulee area in Montana. The water is unusable and contaminates other waters in the area. Considerable money has been spent trying to remediate the acid-mine drainage that is occurring and in replacing other water supplies that have been contaminated by the drainage water. Techniques applied to the problem so far have focused on managing and containing the mine waters, with little success. This study is identifying the geologic, hydrologic, and chemical factors that control the production of the acid-mine drainage. Once the mechanisms are identified, potential treatment techniques will be evaluated. The most promising techniques will be modeled using a series of laboratory studies. Results of the study will be used to design a field demonstration project for the amelioration of drainage water at a specific site in the problem area.</i></p>		

Task Objective

The task objective is to evaluate the methods available and to develop methods to control or eliminate the production of acid in the Stockett/Sand Coulee mine area.

Quarter Objectives

Core samples will continue to be analyzed to determine the extent of the acid-forming reaction zone in the Number 6 mine. A set of columns evaluating a combination of acid neutralizing materials in various sequences on acid mine

drainage has been initiated. The monitoring program will continue at the mine site.

Accomplishments

On-site water monitoring is on-going. A column study showing the impact of underground placement of acid-neutralizing materials on acid mine drainage is complete. Analysis of overburden and coal samples has been completed.

Activities for Next Quarter

The final report will be completed.

Program/Project Identification No. DEFC21-93MC30127	Program/Project Title Task 018 Acid Mine Drainage Prevention, Control, and Treatment Development for the Stockett/Sand Coulee Area	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING		
FY 1994 FUNDING	119,665	120,000
FY 1995 FUNDING	91,403	90,845
FY 1996 FUNDING		
FY 1997 FUNDING		
PROJECT FUNDING TO DATE	211,068	210,845
TOTAL PROJECT VALUE \$421,913

Cosponsor funding in FY 95 consisted of \$90,845 In-Kind
 Cosponsor funding in FY 94 consisted of \$120,000 In-Kind

Signature of Recipient and Date 	Signature of USDOE Reviewing Representative and Date
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Task 19	PERF Dispersion Modeling Project Phase 2 Major Field Demonstration	Status Completed
<p align="center">Sponsor Petroleum Environmental Research Forum (Allied Signal Corporation, Amoco Corporation, Chevron Research and Technology Co., CITGO Petroleum Corporation, Clark Oil and Refining Co., Exxon Research and Engineering Co., Marathon Corporation, Mobil Research and Development Co., Phillips Petroleum Co., and Shell Research and Development Company)</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>WRI and Petroleum Environmental Research Forum (93-16) are assessing the application of newly developed mathematical models for predicting dense gas dispersion by testing the models against the experimental results of large scale field simulations of chemical spills. The PERF and WRI are conducting field scale tests of dense gas dispersion in order to validate the models and to provide the hydrocarbon and chemical industries with information needed to conduct risk management assessments. Major components of the tests are; source emissions release system, meteorology data analyses and meteorology instrumentation, and the array configuration. The WRI 1993 HAZMAT spill test results, wind tunnel tests, and model results were used to aid in the design of the dispersion grid dimensions, sensor location, and test operation.</i></p> <p align="center">Status</p> <p align="center"><i>The project is completed.</i></p>		

Task 20	Field Testing of the TaBoRR Process Using the Asphalt and Dry Bottoms Configurations	Status Ongoing
<p align="center">Sponsors Naval Petroleum Reserve -3, Pease Oil Field Equipment, Wallace Energy, Inc., the Rocky Mountain Oilfield Testing Center and Canadian Earth and Environmental Engineering, Inc.</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>Tank bottom wastes are emulsions composed of crude oil, water and solids that are produced from various depths. The crude oil composition is dependent on the source rock and reservoir maturation and consists of a wide range of hydrocarbons that include alkanes, naphthenes and aromatic compounds. These compounds have a wide range of emulsion characteristics that prevent the effective use of any current technology. Although the TaBoRR process was conceptually designed to handle this wide range of emulsified material, further testing is required to verify this experimentally. This project addresses the issues of processing a variety of different feed materials from many sources as well as modifying the process to handle a wider range of oil, water and solid concentrations.</i></p>		

Task Objectives

The task objectives are to:

- Perform modifications to the process to allow for handling larger water concentrations and larger solid sizes present in the feed material;
- Test and operate the unit using a variety of feed materials;
- Determine the feasibility of using the bottoms material as a road material;
- Perform modifications to the process to convert the bottoms into solid material and use the gaseous hydrocarbons as a fuel source for the process; and
- Test and operate the unit to ensure environmental compliance and verify process economics

Quarter Objectives

Finish processing the NPR-3 material and determine product quality. Complete the pyrolyzer modifications and determine the processing capacity of the pyrolyzer by processing stripper bottoms currently being stored in tanks at the WRI/ATC.

Accomplishments

Pyrolyzer modifications were completed. Shakedown tests of the pyrolyzer subsystems were also completed using the feed material obtained from Wallace Energy.

The completely integrated plant (all three subsystems viz., flash, strip, and pyrolysis, operating simultaneously at steady state) was operated to process materials received from NPR-3 and Wallace Energy. Test data are being evaluated and the samples collected have been submitted for analysis.

Preliminary indications are that the pyolyzer can process up to 125 bbls of stripper bottoms, a value in excess of its design capacity.

Activities for Next Quarter

Complete data analysis and prepare a final report.

Program/Project Identification No. DEFC21-93MC30127	Program/Project Title Task 020 Field Testing of the TaBoRR Process Using the Asphalt and Dry Bottoms Configurations	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING		
FY 1994 FUNDING		
FY 1995 FUNDING		
FY 1996 FUNDING	285,000	285,415
FY 1997 FUNDING	1,282,287	2,500,000
PROJECT FUNDING TO DATE	1,567,287	2,785,287
TOTAL PROJECT VALUE \$4,352,702

Cosponsor funding in FY 97 consisted of \$750,000 cash and \$1,750,000 In-Kind
 Cosponsor funding in FY 96 consisted of \$285,415 In-Kind

Signature of Recipient and Date	Signature of USDOE Reviewing Representative and Date
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Task 21	Validation of a New Soil VOC Sampler	Status Ongoing
Sponsor En Chem Incorporated		
Reporting Period: January 1 through March 31, 1998		
<p align="center">Background</p> <p><i>WRI is providing technical support directed at achieving national acceptance for the EnCore sampling device to enhance its market acceptance by both the regulatory community and environmental contract firms that are responsible for the evaluation of VOC contamination at sites throughout the country. One version of the EnCore sampler is accepted for use by the state of Wisconsin. It is a stainless steel device that requires cleaning after use. En Chem is developing a disposable version of the sampler which will lower the cost of use and enhance its acceptance. WRI is evaluating the operation of the stainless steel device. Following successful evaluation, WRI will approach the American Society for Testing and Materials (ASTM) to initiate a process for method preparation and approval in ASTM format. The ASTM approval process will be initiated with the goal of providing national acceptance of the EnCore samplers. WRI will also provide technical support to En Chem in the development of a disposable plastic version of the EnCore sampler.</i></p>		

Task Objective

Western Research Institute is facilitating national acceptance of the EnCore™ soil volatile organic compound (VOC) sampling device by conducting product tests, method development, and method validation activities.

Quarter Objectives

- Prepare a topical and final report.
- Send the main committee ballot with comments on the draft revision of ASTM D-4547, Standard Guide for Sampling Wastes and Soils for Volatile Organic Compounds, to ASTM.
- Attend the accelerated task group meetings of ASTM Committee D-34 on Waste Management in Las Vegas in February and discuss the new draft practice for using the sampling device and revisions of ASTM D-4547.

- Work with the corporate co-sponsor to verify the performance of the disposable En Core prototype sampling devices.

Accomplishments

- The ASTM main committee ballot, which included the revised draft of D-4547 was received in December. Comments were prepared on the draft D-4547, and the ballot and comments were sent to ASTM in January. Following the ASTM accelerated task group meetings in February, a new draft of D-4547 was received and reviewed. Comments and a ballot were sent to ASTM in March.
- Susan Sorini attended the accelerated task group meetings of ASTM Committee D-34 on Waste Management in Las Vegas in February. At the meeting, an update on the status of the draft practice for using the En Core device for sampling and storing soil for volatile organic analysis was given, as well as the concurrent subcommittee and main committee balloting results of

the draft revision of ASTM D-4547.

- At the ASTM meeting in February, it was announced that brand names can now be used in the titles of ASTM methods and practices. The new draft practice was subsequently revised to mention the En Core sampling device by name in the title and the text.
- We participated in an evaluation of both the 25-g and 5-g prototype En Core samplers with Alan Hewitt of the U.S. Army Cold Regions Research Lab. The 25 g devices worked well. Preliminary tests indicated that minor modifications in the manufacturing process were required for the 5 g sampler, which were implemented

by En Chem, Inc. by late March. The devices are now ready for systematic testing to be conducted to generate performance data for the new ASTM draft practice.

- A draft experimental plan for tests required for the development of the new ASTM practice was prepared and sent to En Chem, Inc. Four different soil types were collected for the tests and these were submitted for characterization.

Activities for Next Quarter

- The task will end. Activities with En Chem, Inc. will continue under Task 5 of the new cooperative agreement.

Program/Project Identification No. DEF C21-93MC30127	Program/Project Title Task 021 Validation of a New Soil VOC Sampler	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING		
FY 1994 FUNDING		
FY 1995 FUNDING		
FY 1996 FUNDING	50,541	62,500
FY 1997 FUNDING	149,762	187,500
PROJECT FUNDING TO DATE	200,303	250,000
TOTAL PROJECT VALUE \$450,303

Cosponsor funding in FY 97 consisted of \$37,500 cash and \$150,000 In-Kind
 Cosponsor funding in FY 96 consisted of \$12,500 cash and \$50,000 In-Kind

Signature of Recipient and Date	Signature of USDOE Reviewing Representative and Date
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Task 22	Market Assessment and Demonstration of Lignite FBC Ash Flowable Fill Applications	Status Ongoing
<p align="center">Sponsor North Dakota Industrial Commission and Montana-Dakota Utilities</p>		
<p align="center">Reporting Period: January 1 through March 31, 1998</p>		
<p align="center">Background</p> <p><i>Controlled low strength flowable fill materials have found acceptance in the construction industry as a viable low cost option for excavatable and structural fill applications. Use of the FBC ash derived from the burning of North Dakota lignite at the Montana-Dakota Utilities (MDU) Heskett plant in flowable fill construction materials represents a potential new market for the ash providing revenue and avoiding the costs and environmental consequences associated with its disposal. This study is to (1) establish the engineering and environmental properties of MDU ash based flowable fill materials; (2) make an assessment of the market for MDU flowable fill; and (3) demonstrate the viability of MDU flowable fill materials through full scale demonstrations.</i></p>		

Task Objective

Determine through laboratory testing and field demonstration the technical and environmental potential of using FBC ash from the Montana-Dakota Utilities (MDU) Heskett fluidized bed combustion (FBC) plant in the production of 'excavatable' and structural' grade flowable fill materials for construction applications.

Quarter Objectives

- Complete the laboratory scale MDU CLSFFM testing, and
- Initiate market assessments and potential field demonstration sites

Accomplishments

MDU CLSFFM Market Assessment

The market assessment of the Bismarck-Mandan region for the MDU flowable fill material has been initiated. Several potential demonstration sites and activities have been identified for the Fall '97 construction period that could be used for the demonstration portion of this project. A number of

project delays including delays in environmental assessment tests has in turn delayed NDDH approval. The demonstration activities have been postponed until Spring of '98.

As part of the market assessment, MDU and WRI personnel have participated in workshops, meetings and discussions with various engineering departments and contractors, and the ND Department of Health. The objectives of these activities were to: (1) inform these parties about the engineering and environmental properties of the MDU CLSFFM; (2) ascertain their concerns so that they can be addressed through further testing; and (3) ultimately receive their endorsement or permission to pursue a demonstration of the MDU CLSFFM.

The results of these discussions have been incorporated into the scope of testing. At the present time, NDDH still has concerns about the impact of the fill materials on the adjacent soils. As such, NDDH has requested further testing to verify at a laboratory scale the potential impact of the MDU flowable fill on local soils. These tests are being conducted and are described later in this discussion.

Although the TCLP extracts do appear to meet the Drinking Water Standards for the RCRA metals, the North Dakota Department of Health (NDDH) has continuing concerns with the levels of sodium, sulfates, chlorides, and radionuclides. NDDH believes that an alternate leaching procedure (e.g., ASTM 3987) may be more appropriate in assessing the impact on water resources and the impact on local soils. These concerns are addressed in our proposed permeability and permeate testing as part of Task II.

MDU CLSFFM Additional Testing

Although the results of the preliminary testing appear to be promising, there are a number of technical issues that need further clarification relating to geotechnical and environmental performance. The geotechnical properties that remain undefined include: (1) better definition of the pressures of expansion-shrinkage associated with wet-dry cycling; (2) better definition of the settlement characteristics of the CLSFFM; (3) determination of the benefit of AEA on freeze/thaw durability; (4) assessment of the permeability and permeate quality of CLSFFM and its impact on soils; and (5) assessment of longer term embed materials compatibility (particularly with galvanized conduit) with MDU CLSFFM.

Expansion-Shrinkage Pressures - Wet/dry cycle durability testing by WRI of the MDU CLSFFM indicated that there was a expansion-shrinkage cycling of the material coincident with the wet/dry cycles. Although small in magnitude, this swelling and contraction of the material on wet/dry cycling could be detrimental to embed materials. However, previous testing was conducted under zero load pressures. It is unclear whether under loads equivalent to several feet of fill material if the expansion/shrinkage would still exist. As a result, testing was conducted to determine the pressures exerted by the CLSFFM during wet/dry cycles. ASTM D-2435 and 3877 will be modified to determine these values. In these tests, the load is changed to present a non-expanding situation. The pressure associated with this load represents the amount of load (depth of fill) necessary to stop the expansion/shrinkage.

Standard consolidation tests were performed according to ASTM D-2435. The complete results

of the testing are presently being evaluated. However, preliminary analysis suggests that the MDU 'structural grade' flowable fill material shows very little consolidation with loads up to 18.6 tsf. Testing was also conducted to ascertain the pressures associated with the swelling and shrinkage observed during wet/dry cycle durability testing. The preliminary results indicate no swelling with loads as low as 0.3 tsf. This suggests that swelling is not a problem if overburden loads of 0.5 feet are present.

Freeze/Thaw Cycle Performance - Preliminary testing by WRI confirmed that commercially available air-entraining agents (AEA) are compatible with MDU CLSFFM, in that they do entrain air. The entrained air is important in developing a resistance to deterioration when the material is subjected to freeze/thaw conditions. Freeze/thaw durability is important for structural-grade CLSFFM applications more so than for the excavatable trench grade CLSFFM applications.

The benefit of AEA dosages on the freeze/thaw cycle resistance of the structural grade CLSFFM has been quantified according to ASTM D-560 testing. Both freeze/thaw and wet/dry cycle durability testing has been completed. The testing used the MDU 'structural' grade flowable fill with and without air entrainment. The results of the testing indicate that AEA are not needed for freeze/thaw durability. However, AEA can be used to reduce the strength for excavatable fill materials.

Environmental Testing - The North Dakota Department of Health had suggested that WRI conduct environmental testing to include more detailed characterization of the raw ash and leaching according to the ASTM D-3987. Samples of both the MDU raw fly ash and MDU flowable fill mix have been subjected to ASTM leachate D-3987 testing and bulk chemical analysis. The characterization of these materials is extensive, including trace metals and radionuclides. The list covers the relevant chemical species included in the Primary and Secondary Drinking Water Standards. The results have been tabulated and were reviewed by ND Department of Health. In summary, with the exception of the pH the D-3987 extract meets the specifications of both the domestic and agriculture water standards. However, the ND Department of Health analysis

concluded that the data were inconclusive for pH, sodium and sulfates. They wish to reserve their opinion of the environmental character of the flowable fill materials until they could review the results of all of the permeate analyses described below.

Permeate Characteristics - The permeate characteristics are being tested according to the experimental plan and methodology developed in conjunction with the North Dakota Department of Health. Based on the results of the ASTM D-3987 leachate and bulk analysis tests, WRI has developed a list of chemical parameters to be analyzed for on the permeates from the 'field simulator'.

Environmental "field simulator" testing is underway using a series of flex-wall permeameters at WRI.

To date, WRI has set up or is initiating tests using the following materials.

- Test 1 - MDU 'S' grade flowable fill core surrounded by a local ND soil;
- Test 2 - MDU 'S' grade fill only;
- Test 4a - 50:50 Mix of Rubblized MDU 'S' grade fill with soil;
- Test 4b - 50:50 Mix of Rubblized NDRM excavatable fill with soil;
- Test 4c - 50:50 Mix of Rubblized MDU 'E' grade fill with soil;
- Test 4d - 50:50 Mix of Rubblized MDU 'E2' grade fill (anti-SAR) with soil;
- Test 5 - Local ND soil;
- Test 6 - MDU 'E' grade fill core surrounded by local ND soil;
- Test 7 - NDRM excavatable fill core surrounded by a local ND soil (comparative test);
- Test 8 - NDRM excavatable fill only (comparative test);
- Test 9 - MDU 'E' grade fill core surrounded by a local ND soil;
- Test 10 - MDU 'E' grade fill only;

Permeates are being collected for analysis from all tests. The permeate sampling intervals are at approximate water/solids contacting ratios from 0.5 to 5. The Test 1 results indicate an elevated SAR level in the initial waters permeating through the field simulator. However, the concentrations of key components appear to decrease with successive

permeate samples. The Mix 6 rubblized MDU flowable fill and ND soil mixture, designed to simulate the impact of excavated fill on the soil, also shows elevated levels of sodium and sulfates and even nitrates/nitrites in the initial permeate samples. It is expected that these constituents will decrease in concentration in later permeate samples. The presence and origin of the nitrates/nitrites is curious since neither the ash nor the soil showed any significant concentrations. Additional testing (Tests 7, 8, 9, and 10) of the MDU excavatable grade MDU flowable fill and the excavatable flowable fill using the Leland Olds ash as being commercially applied in the Bismarck-Mandan area.

The hydraulic conductivity of the soil and the flowable fill materials is very low, in the range of 10^{-8} to 10^{-9} cm./sec. As a result the testing is taking a long time in generating permeates for analysis. Tests were conducted in order to generate permeate samples from the flowable fill materials using a high pressure permeameter. This apparatus improved the permeate generation rate by a factor of approximately 50 times. The results of these tests are being compiled and evaluated.

Embed Compatibility - The embed testing continues. Test coupons of copper, rebar, galvanized conduit, Portland cement and Portland cement with fly ash have been implanted in MDU flowable fill mix and are being cycled under wet/dry conditions for up to 1 year. Multiple sets of mixes and coupons have been fabricated to allow the coupons to be examined after varying ages. The first set of coupons were evaluated at the end of July '97 (6 months). There was no evidence of corrosion with any of the materials examined to date. At the request of MDU, WRI fabricated a set of black pipe coupons and initiated testing of these coupons during this quarter as well. The first set of coupons was evaluated in December '97 and the data showed no evidence of corrosion. The black pipe testing was in support of a possible natural gas pipeline trench filling demonstration application.

Activities for Next Quarter

- Continue the laboratory scale MDU CLSFFM testing with emphasis on the results of the permeate analyses, and
- Continue market assessments and assess potential field demonstration sites for the Spring construction period.

Program/Project Identification No. DE-FC21-93MC30127	Program/Project Title Task 022 Market Assessment and Demonstration of Lignite FBC Ash Flowable Fill Applications	Reporting Period 1/1/98 through 3/31/98
Name and Address Western Research Institute 365 North Ninth Street Laramie, Wyoming 82070		Program/Project Start Date March 26, 1993
		Completion Date June 30, 1998

PROJECT FUNDING HISTORY		
	USDOE	SPONSOR(S)
FY 1993 FUNDING		
FY 1994 FUNDING		
FY 1995 FUNDING		
FY 1996 FUNDING		
FY 1997 FUNDING	72,637	79,996
PROJECT FUNDING TO DATE	72,637	79,996
TOTAL PROJECT VALUE \$152,633

Cosponsor funding in FY 97 consisted of \$50,996 cash and \$29,000 In-Kind

Signature of Recipient and Date	Signature of USDOE Reviewing Representative and Date
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