December 28, 1998

Ms Karlene Fine
Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue
Bismarck, ND 58505

Subject: Transmittal Letter, North Dakota Lignite Research Program Proposal
'COMMERCIAL DEMONSTRATION OF MDU CONTROLLED DENSITY FILL (CDF)'

Dear Ms. Fine,

Enclosed are 35 copies of the proposal, which we are submitting to the North Dakota Industrial Commission for consideration under the Lignite Research Program. This transmittal letter represents a commitment by Montana-Dakota Utilities and its' prime contractor Western Research Institute (WRI) for the completion of the project as described in the proposal.

Also enclosed is the $100 application fee.

Sincerely,

Duane O. Steen
Administration and Project Manager

Enclosures

cc Alan E. Bland - WRI
File

TECHNICAL AND COST PROPOSAL

COMMERCIAL DEMONSTRATION OF MDU CONTROLLED DENSITY FILL (CDF)

Total LRC Funds Requested $97,115

Submitted to:

Lignite Research Program
State of North Dakota
The Industrial Commission
State Capital
Bismarck, ND 58508

Submitted by:

Montana-Dakota Utilities
Bismarck, ND
and
Western Research Institute
Laramie, WY

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December 28, 1998

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COMMERCIAL DEMONSTRATION OF MDU CONTROLLED DENSITY FILL (CDF)

ABSTRACT

Western Research Institute (WRI) and Montana-Dakota Utilities proposes a 24-month project that will address market assessment and development for the lignite ash controlled density fill (CDF) materials. CDF materials can be formulated using ash from the Montana-Dakota Utilities R.M. Heskett Station in Mandan, North Dakota, and the MDU CDF appears to be a viable engineering material and environmentally safe. The results of an ongoing project sponsored by U.S. DOE, Montana-Dakota Utilities (MDU) and the North Dakota Industrial Commission (NDIC) have been so encouraging that MDU is pursuing the commercialization of the technology. However, there still remain a number of technical and economic issues that need to be determined and documented prior to putting the MDU CDF in commercial service with warrantees. These include: (1) the ability to produce a consistent product; (2) the ability to provide a product year round (cold weather retards strength development); and (3) the ability to evaluate and produce commercial quantities of MDU CDF using different and cheaper materials. The proposal herein provides the marketing, testing, demonstration and follow-up monitoring essential to the commercialization of this material. The project will address the following:

Task I. Product Variability and Product Service Environment Testing - Testing will examine the effect of MDU ash variability on the geotechnical properties of the resultant CDF. In addition, the effect of temperature and adjacent soil conditions on the geotechnical properties will also be examined.

Task II. Construction and Operation of CDF Plant - A CDF batch plant will be constructed in order to examine the economics and technical performance of MDU CDF formulated with alternative materials.

Task III. Demonstration and Monitoring of Commercial-Scale Application of MDU CDF - This task will monitor the performance of the MDU CDF materials in commercial scale demonstrations and applications for up to two years.

Upon completion of the project, a new market will be commercially available for the ashes from the burning of lignite in fluidized bed combustors, thereby transforming a present waste product into a salable commodity in the construction industry. The project will benefit not only MDU but also the State of North Dakota by establishing a commercial product for lignite-derived ash in CDF applications. The project will define to the construction industry both the engineering benefits and the environmental acceptability of lignite ash use.

The cost of the program is $358,375, to be shared by MDU, NDIC and WRI through its Cooperative Agreement with the U.S. DOE (Federal Energy Technology Center). MDU will contribute $82,100 in cash and in-kind services, personnel costs associated with the marketing and commercial demonstration activities, and project management. It is requested that the NDIC provide $97,115. WRI and U.S. DOE will match both the MDU and NDIC funding for the amount of $179,160.

1.0 PROJECT SUMMARY

Controlled density fill (CDF) is a construction material that has a number of applications, such as removable backfills, structural fills, isolation fills, and trench bedding. Conventional flowable fill mixtures consist of water, portland cement, Class F or C fly ash, and fine aggregate. CDF has a specified compressive strength ranging from 80 psi to 1200 psi at 28 days, depending on the application. In addition, CDF has a slump of 9 to 10 inches and can be readied for traffic in 2 to 6 hours. This material is not concrete although it is in a flowable state at the time of placement. The CDF is usually mixed in a ready-mix concrete truck, and kept mixing during transport to prevent segregation of the aggregate. The material can be discharged by chutes or pumped using standard concrete or grout equipment.

Western Research Institute (WRI) has been involved in development and demonstration of controlled density fill materials formulated using ash from the Montana-Dakota Utilities R.M. Heskett Station in Mandan, North Dakota. The initial development was sponsored solely by Montana-Dakota Utilities (MDU). The promising results of that effort resulted in a Jointly Sponsored research (JSR) project to evaluate the geotechnical properties and environmental compatibility and to construct demonstrations of the various grades of CDF in full-scale demonstrations. This program was co-sponsored by U.S. DOE, MDU and the North Dakota Industrial Commission (NDIC). The results of this program have been so encouraging that MDU is pursuing the commercialization of the technology. The results of this program proved the following:

- The geotechnical properties of the MDU ash-based CDF can be modified to meet the needs of a range of applications from structural fill applications to excavatable applications, such as utility trench fill.

- The environmental properties of the fill materials are compatible with numerous construction applications and do not pose a threat to either adjacent groundwater or soils. In fact, the North Dakota Department of Health has approved its use in North Dakota.

- The demonstration of the MDU CDF appears to be successful for structural, as well as excavatable applications.

However, there are a number of technical and economic issues that need to be determined and documented prior to putting the MDU CDF in commercial service with warrantees. The following are needed for commercial implementation: (1) the ability to produce a consistent product; (2) ability to provide a product year round (cold weather retards strength development); (3) and ability to evaluate and produce commercial quantities of MDU CDF using different and cheaper materials.

WRI is proposing, in conjunction with Montana-Dakota Utilities (MDU) and the U.S. DOE Federal Energy Technology Center (FETC), a two-year continuation of the current program to examine the issues that are critical to the commercialization of the MDU CDF in the Bismarck-Mandan area. The program would be funded by Montana Dakota Utilities, North Dakota Industrial Commission (NDIC), and the WRI-U.S. DOE Jointly Sponsored Research (JSR) Program. The following tasks are proposed:

Task I. Product Variability and Product Service Environment Testing - As mentioned, the MDU CDF produced under the laboratory-controlled conditions did not have the same performance as the MDU CDF made at a batch plant for the demonstrations. The success of the MDU CDF is clearly contingent upon the delivery of a consistent product that can be used year round in a range of weather conditions. Testing will examine the effect of MDU ash variability on the geotechnical properties of the resultant CDF. If the ash variability is found to be detrimental to CDF performance, an examination of the cause of the variability related to plant operations will be undertaken with the intent to isolate and control the variability. In addition, the effect of curing conditions, such as temperature and adjacent soil conditions, on the geotechnical properties will be examined.

Task II. Construction and Operation of CDF Plant - A CDF batch plant will be constructed to examine the economics and technical performance of MDU CDF formulated with alternative materials. Present facilities at the commercial ready-mixed plants in the Bismarck-Mandan area are not able to modify their facilities to produce sufficient CDF quantities using alternate materials As a result, it is proposed that a batch plant be constructed with the capability of using alternate materials and be capable of producing quantities sufficient for assessing its characteristics in commercial scale applications.

Task III. Demonstration and Monitoring of Commercial Scale Application of MDU CDF - This task will monitor the performance of the MDU CDF materials for up to two years. The small-scale demonstrations constructed in October-November 1998 will be monitored for an additional year. Commercial-scale applications of the CDF produced from the MDU batch plant will be documented and monitored for general CDF properties, such as long-term strength development and excavatability.

Task IV. Project Management and Reporting - Mr. Duane Steen of MDU will serve as the Project Manager with NDIC. Project Manager for WRI will be Dr. Alan E. Bland, who has been the project manager on the prior activities with MDU. The progress on the project will be reported to all participants on a quarterly basis and an Interim report on each of the technical tasks will also be provided. A final technical report will be written following the completion of the project.

The project is expected to establish a new market for lignite-based ash in the construction industry. This will give an advantage to the lignite industry, specifically the users of North Dakota lignite. The successful commercial development of markets for the ash is of environmental benefit as well as economic benefit to the lignite user. The creation of jobs will be another direct benefit to the local and North Dakota economy.

2.0 BACKGROUND

Montana Dakota Utilities is a generator of power for a major part of the northern Rocky Mountain area, and as such, ashes generated from MDU facilities must be disposed of or used in beneficial applications. Ash from MDU's R. M. Heskett Station in Mandan, North Dakota, represents one such ash management challenge. One potential use of the ash from this fluidized bed combustor (FBC) is in the formulation of a flowable fill for a variety of construction applications in the Bismarck area.

2.1 Flowable Fills and Applications - Conventional CDF mixtures consist of water, portland cement, Class F or C fly ash, and fine aggregate. CDF is a construction material that has a specified compressive strength ranging from 80 psi to 1200 psi at 28 days, depending on the application. The characteristics of the CDF also include a high slump of 9 to 10 inches and an ability to be readied for use in 2 to 6 hours. This material is not concrete but is in a flowable state at the time of placement. The CDF is usually mixed in a ready-mix concrete truck, with the material kept mixing during transport to prevent segregation of the aggregate. The material can be discharged by chutes or pumped using standard concrete or grout equipment.

A number of applications for CDF have been documented in the literature (see Related References Section 12.0). Conventional CDF is considered a commercial product in most regions of the country. A major consideration in the use of CDF is its economics relative to other construction materials and methods. CDF has been shown to be competitive with these other construction methods. These applications include:

- removable backfills
- structural fills
- isolation fills
- trench bedding
- road base
- floor base
- void fills
- caisson and pile fills and
- small bridge restorations.

Table 1.
Typical Mix Proportions and Characteristics of Controlled Density Fill Materials.

Construction Application	*Cement (1)*	*Type F Fly Ash (1)*	*Fine Sand Aggregate (1)*	*Water (1)*	*28 day UCS (psi)*
Backfill	50	250-300	2700-2800	400-500	80
Structural	200	250-300	2800	380	1000
Floor	100	250-300	3100	300	500
Backfill (No fly ash)	100	9 oz AEA(2)	2800-2900	500	80

(1) lbs/cu. yd.
(2) Air entraining agent (AEA) in ounces/cu. yd.

Backfills - Granular or site-excavated backfills, even if compacted properly in the required thickness, may not achieve the uniformity of CDF. CDF has been used as a backfill around structures, buried tanks, and various conduit materials, such as concrete, metal, fiberglass, reinforced plastic, and vitrified clay. The compressive strength of CDF backfill is usually 80 psi or less.

Structural Fill - CDF may be used for foundation support, in that it helps to distribute the structure's load over weak soil. In the case of uneven soil surfaces the CDF provides a uniform surface for foundation structure. Structural fill mixtures typically have compressive strengths in the range of 200 to 1,000 psi.

Isolation Fills - CDF mixtures may provide density and strength characteristics that may reduce the transfer of vibration and shock.

Road Base - CDF mixtures have been used for pavement bases and subbases in subdivision, arterial streets and parking lots. The mixtures can be placed directly from mixer onto the subgrade between curbs. According to American Association of State Highway Transportation Officials (AASHTO), the structural coefficients for this type of material are in the range of 0.25 and 0.35, depending on the compressive strength achieved in the field. CDF must have a wearing surface applied since it typically has poor wear resistance.

Trench Bedding - CDF mixtures can be placed around and under conduit as trench bedding to provide uniform support and density. Strengths are maintained low in order to facilitate excavation if needed.

Void Filling - Cavities under slabs, pavement and structures have been filled with CDF. For these applications erosion conditions should be considered. Abandoned mines, old sewers, and underground tanks have been filled with CDF.

Non-standard materials in the formulation of CDF have been used, and their selection is typically based on the flowability, strength, removability, and density characteristics of the resultant mix.

2.2 Initial WRI/MDU Testing - Western Research Institute under sponsorship by Montana-Dakota Utilities conducted a preliminary evaluation of the potential of using FBC ash from the Montana-Dakota Utilities R. M. Heskett Station and a local fine aggregate in the formulation of CDF for a number of construction applications. The results of the testing were encouraging, and it appeared feasible to produce a CDF that meets the geotechnical and environmental specifications for a range of construction activities. However the testing identified a number of geotechnical performance issues, and the North Dakota Department of Health (NDDH) requested a more rigorous evaluation of the environmental impact of the MDU CDF on water and soils. This initial testing defined the potential for this type of material and led to the current program sponsored by U.S. DOE, MDU and NDIC. This current testing addressed (1) market assessment, (2) laboratory-scale geotechnical and environmental testing, and (3) field-scale demonstration of a range of MDU CDF grades.

2.3. Results of MDU CDF Market Assessment - A market assessment of the Bismarck-Mandan region for the MDU flowable fill material was conducted. The market assessment addressed the acceptability of the MDU CDF by contacting a number of potential consumers, such as the City of Bismarck, local contractors, MDU gas resources personnel, and the ready-mixed concrete suppliers and by soliciting their evaluation of the CDF product and market. These groups were invited to review the performance data as well as to observe the construction of the demonstrations conducted in the Fall of 1998. The applications suggested for the CDF material ranged from structural applications, such as sub-bases for residential and commercial businesses, to excavatable fill applications, such as gas line and utility trench filling.

The market for the MDU CDF is presently limited by the high cost of the material compared to alternative fill materials. The cost of the product as produced by the ready-mixed concrete suppliers is in the range of $30-$35/cu.yd. The cost of the CDF must be lowered before this material can become a common construction material in the area. The formulations using MDU ash and lower cost sand alternatives offers that opportunity. An estimated market of 10,000 cubic yards of MDU CDF could be easily realized if prices could be made competitive.

The environmental acceptability of the MDU CDF was initially a concern of the North Dakota Department of Health. They insisted that before the material could be used, a more rigorous evaluation of its impact on the adjacent soils be conducted. WRI developed a method of assessing the environmental impact of the MDU CDF on the adjacent soils and conducted detailed chemical analyses and leachate testing. The results of this testing are described below.

2.4 Results of the Laboratory-Scale MDU CDF Testing - Although the results of the preliminary testing appeared promising, there were a number of technical issues relating to geotechnical and environmental performance that needed further clarification.

Geotechnical Engineering Testing - The geotechnical properties that remained undefined included: (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 air entraining agent (AEA) on freeze-thaw durability; and (4) assessment of longer term embed materials with MDU CDF.

The results of the laboratory testing indicated that MDU CDF could be formulated to exhibit a range of properties. Expansion-shrinkage with wet-dry cycling proved not to be an issue. The settlement characteristics of the MDU structural-grade CDF were excellent and the material behaved more like concrete than soils. The use of AEA was found not to be required for structural grade applications but may have benefit for reducing strength development and enhancing excavatability of excavatable-grade CDF. A year-long test with a range of embed materials showed no evidence of corrosion. In summary, the geotechnical properties of the MDU CDF are excellent.

Environmental Properties Testing - Environmental testing of the MDU flowable fill materials was based on discussions with the NDDH. NDDH had suggested that additional standardized tests, as well as specialized testing (Field Simulator Tests) related to the zone of impact of the fill materials on the adjacent soil environment, should be conducted.

ASTM D-3987 testing was conducted on both the MDU raw fly ash and MDU CDF mix. The characterization of these materials was extensive, including trace metals and radionuclides. The list covered the relevant chemical species included in the Primary and Secondary Drinking Water Standards. In summary, with the exception of the pH, the D-3987 extract meets the specifications of both the domestic and agriculture water standards.

WRI devised a methodology called a field simulator that employed the use of fexible-wall permeameters to generate a permeate to be assessed for chemical properties. The field simulator could be used to address the impact of the MDU fill materials on the adjacent soils and to address the magnitude of the zone of impact. A series of tests were conducted at a range of water-to-fill ratios, representing a range of rainfall events and annual precipitation quantities.

The results of the testing clearly established that the zone of impact for the fill materials is less than two inches. In fact, it is believed that the zone of impact is in the range of one to two centimeters. Based on these results, the NDDH issued a letter approving its use in construction applications.

2.5 Results of the Field-Scale Demonstrations - WRI conducted several demonstrations of the various grades of MDU CDF. The grades of CDF included structural grade, excavatable (200 psi) grade and excavatable (>50 psi) grade.

Structural Grade MDU CDF Demonstration - Approximately 48 cubic yards of MDU structural grade CDF were poured at the R.M. Heskett Station as a base for the existing rail car loadout for the plant. The CDF was batched and delivered by Atlas Ready Mix. Due to the logistics at the Atlas plant, it was not possible to use the alternate cheaper sand material. Instead, we were forced to use their standard concrete sand. The CDF was poured at a thickness of 1 foot, and it essentially self-levelized. A concrete slab was poured over part of the base, and the forming, including driving stakes, was easily accomplished. The CDF was designed to reach over 1000 psi. The CDF will see front end loader services and will be monitored in the spring to ascertain its performance over the winter.

Excavatable Grade MDU CDF Demonstration - Three different excavatable grade MDU CDF mixes were tested. Approximately 8 cu. yds. of two of the three mixes were poured into a trench to simulate trench filling applications. These mixes were designed to produce a strength of >200 psi. As mention earlier, the mix used the Atlas Ready Mix standard concrete sand instead of the finer alternate sand used in the laboratory tests. Typical embed materials, such as cast iron pipe, brass valves, and gas pipe, were embedded in the fill materials. These materials will be excavated in the spring and examined for corrosion. The third trench filling demonstration used approximately 16 cu. yds. of a low strength CDF. This material was designed to have a strength of > 50 psi. This material is designed to be able to be excavated with hand tools, such as shovels. The excavatability of this CDF will be tested in the spring. All of these CDF materials could support a person's weight after setting overnight.

2.6 Summary - In summary, the results of the previous testing and demonstration activities proved the following:

(1) The geotechnical properties of the MDU ash based CDF can be modified to meet the needs of a range of applications from structural fill applications to excavatable applications, such as utility trench fill;

(2) The environmental properties of the fill materials are compatible with their application and do not pose a threat to either adjacent groundwater or soils. In fact, the North Dakota Department of Health has approved its use in construction applications in North Dakota; and

(3) The demonstration of the MDU CDF appears to be successful for structural as well as excavatable applications.

However, there are a number of technical and economic issues that need to be determined and documented prior to putting the MDU CDF in commercial service with warrantees. The following are needed for commercial implementation: (1) the ability to produce a consistent product; (2) the ability to provide a product year round (cold weather retards strength development); and (3) the ability to evaluate and produce commercial quantities of MDU CDF using different and cheaper materials. These issues represent the scope of the proposed project described herein.

3.0 PROJECT DESCRIPTION

3.1 Introduction - Western Research Institute, through the U.S. DOE, NDIC and MDU have been conducting a Jointly Sponsored Research (JSR) project to evaluate the geotechnical properties and environmental compatibility of the CDF and to construct demonstrations of the various grades of CDF in full-scale demonstrations. This program was co-sponsored by U. S. DOE, MDU and the NDIC. The results of this program have been so encouraging that MDU is pursuing the commercialization of the technology.

As mentioned earlier, there are a number of technical and economic issues that need to determined and documented prior to putting the MDU CDF in commercial service with warrantees. The following are needed for commercial implementation: (1) the ability to produce a consistent product; (2) the ability to provide a product year round (cold weather retards strength development); and (3) the ability to evaluate and produce commercial quantities of MDU CDF using different and cheaper materials.

3.2 Goals and Objectives - The goal of the proposed project is to bring the MDU CDF technology to a commercial status, thereby providing a market for a present waste product and in doing so provide jobs and economic growth for the state of North Dakota and lignite-related industries. The specific objectives of the project include (1) the development of the information necessary to ensure the ability to deliver a consistent CDF material to the user and to do so under limited warrantees; (2) verify the economics and performance of MDU CDF produced in commercial quantities using alternate materials; and (3) document the performance of MDU CDF through commercial-scale demonstrations and the monitoring of those demonstrations. Through meeting these objectives, the commercial acceptance and deployment of the MDU CDF can be realized.

3.3 Methodology - WRI and MDU, in conjunction with the U.S. DOE FETC are proposing a program of testing and demonstration of the MDU CDF in commercial-scale applications. This testing and commercialization program incorporates the following tasks.

Task I.	Product Variability and Product Service Environment Testing
Task II.	Construction and Operation of CDF Plant
Task III.	Demonstration and Monitoring of Commercial-Scale Application of MDU CDF
Task IV.	Project Management and Reporting

The following represent a brief description of each of these tasks.

3.3.1 Task I. Product Variability and Product Service Environment Testing - It was observed that the MDU CDF produced under the laboratory-controlled conditions did not have the same geotechnical performance as the MDU CDF made at a batch plant for the demonstrations. This is potentially a major obstacle to the commercial acceptance of the MDU CDF, since the success of the MDU CDF is clearly contingent upon the delivery of a consistent product that can be used year round in a range of weather conditions. Unfortunately, due to the logistics of batching of the CDF at the Atlas Ready Mix plant, we were unable to use the exact materials for both the laboratory and the demonstrations. This leaves the cause for this difference in geotechnical performance unclear. There are a number of possible causes, including (1) difference in materials (cement, fly ash, sand or water), (2) difference in the bleeding of the mix as a result of adjacent soils; and (3) differences in the temperature regimes of the curing of the materials. Each of these parameters could be responsible, and it is therefore imperative to understand the effect of each on the geotechnical properties of the CDF.

Testing will examine the effect of MDU ash variability and curing environment on the geotechnical properties of the resultant CDF. Three different fly ash samples from the Heskett plant will be taken over a six-month period, including the the ash used in the demonstrations. Cement used in the laboratory tests and that used during the demonstration activities of 1998 will also be evaluated. Chemical analyses of the fly ash will be performed to ascertain what changes in composition occur with time. Strength and set time specimens will be prepared with these different materials and strength tested for up to one year.

If the ash from the Heskett Station is found to be variable and that this variability is found to be detrimental to its use in CDF, an assessment of the cause of the variability will be conducted. The objective of this investigation would be to isolate the cause at the plant and thereby either modify the cause or alert the ash management side of the plant operations that ash is being generated that should not be used in CDF, but instead disposed.

The curing environment, specifically the effect of temperature and adjacent soil conditions on the geotechnical properties will be examined. The strength and set time specimens will be cured at 73 °F (23 °C) and at 35 °F (2 °C). The CDF will be cured in plastic containers and with soil to simulate the effect of bleeding of the CDF into the adjacent soils.

3.3.2 Task II. Construction and Operation of CDF Plant - One the deficiencies in the demonstration activities of 1998 was the fact that the logistics at the Atlas Ready Mix plant prevented the incorporation of low-cost alternative materials such as sand in the demonstration mixes. Instead, we were forced to use the standard concrete sand available at the Atlas Ready Mix plant. It is known that alternate sand materials not only can influence the geotechnical properties of the CDF, but they also represent a major cost savings.

The present facilities at the commercial ready-mixed plants in the Bismarck-Mandan area are not able to modify their facilities to produce sufficient CDF quantities using alternate materials. It is therefore proposed that a batch plant be constructed with the capability of using alternate materials, which will also be capable of producing quantities sufficient for assessing its characteristics in commercial-scale applications. The CDF batch plant is also deemed necessary to examine the economics associated with the use of these alternative materials. A commercial-scale batch plant will be constructed on MDU property centrally located to each of the three ready-mixed concrete companies. The facility will be capable of batching CDF with a range of properties using a range of alternate materials. The facility will be operated by MDU personnel. Any and all three of the local ready-mix concrete companies will have access to the CDF batch plant, and we intend to use their trucks and drivers for hauling the CDF to potential commercial demonstration sites.

3.3.3 Task III. Demonstration and Monitoring of Commercial Scale Application of MDU CDF - The purpose of the project is to use different MDU CDF grades and formulations in commercial-scale demonstrations and to monitor the geotechnical performance and assess the costs of these CDF mixes.

A series of demonstrations will be conducted in addition to the demonstration activities conducted in 1998. Like the 1998 demonstrations, the proposed demonstrations will be of sufficient size to use conventional trucking and emplacement equipment. The demonstrations will be selected following extensive assessment of the types of markets that the MDU CDF could penetrate. MDU and WRI personnel will interact with potential users, such as the City of Bismarck and Mandan, the MDU gas distribution division, and local residential and commercial contractors. Based on these contacts, three to five commercial-scale demonstrations will be conducted.

This task will also monitor the performance of the MDU CDF materials for up to two years. The small scale demonstrations constructed in the October-November 1998 time frame will be monitored for an additional year. In addition, the commercial-scale applications of the MDU CDF produced from the MDU batch plant will be documented and monitored for general CDF properties, such as long-term strength development and excavatability.

3.3.4 Task IV. Project Management and Reporting - Mr. Duane Steen of MDU will serve as the Project Manager with NDIC. Project Manager for WRI will be Dr. Alan E. Bland, who has been the project manager on the prior activities with MDU. The progress on the project will be reported to all participants on a quarterly basis. A final technical report will be written following the completion of the project. At the discretion of the project sponsors, the results may also be disseminated to the academic community and power industry through presentations at international meetings, as well as articles in peer reviewed journals. A final report that will include the monitoring activities will be prepared for MDU, NDIC and U.S. DOE in December, 2000.

4.0 STANDARDS OF SUCCESS

The following milestones will be used to measure the success of the project. These milestones are incorporated in the Timetable for the project.

Milestone 1. ***Award Contracts*** by ND Industrial Commission and USDOE. Must be under contract with all potential funding sponsors (MDU, NDIC, and USDOE) by end of March 1999.

Milestone 2. ***Conduct Product Variability and Product Service Environment Testing*** - Finish short-term tests by June, 1999. Interim Report on testing will be provided. Long-term tests to continue until June, 2000.

Milestone 3. ***Acquire and Erect CDF Batch Plant*** - Complete construction by July, 1999.

Milestone 4. ***Identify and Conduct Commercial Demonstrations*** - Demonstrations to continue through 1999 and spring of 2000.

__Milestone 5.__ ***Monitor Commercial Demonstrations -*** Monitoring to continue up through October 2000.

__Milestone 6.__ ***Deliver Draft Final Report*** on project to funding sponsors by November 30, 2000 and complete final report with comments from cosponsors by the end of December, 2000.

Progress on the project will be reported through brief quarterly reports. These reports will be submitted to North Dakota Industrial Commission by MDU based on the reports by Western Research Institute. Reports to the U.S. Department of Energy after review by MDU personnel will be submitted by WRI. The first quarterly report will be made to coincide with the U.S. DOE reporting schedule in order to minimize the reporting requirements Teleconference calls and other progress reporting between MDU personnel, Western Research Institute, and NDIC will take place as the need arises. The first quarterly report will be delivered on or before the 10^{th} of the month on a quarterly basis. Interim reports covering the results of the laboratory testing program and demonstrations will be prepared in the summer of 1999 and the summer of 2000. A draft final report on the project will be delivered November, 2000 with the finalized version due December, 2000.

5.0 VALUE TO NORTH DAKOTA

The project will benefit not only MDU, but also the State of North Dakota by establishing the commercial market for lignite derived FBC ash in CDF applications. The project is expected to clearly establish this new market for lignite-based ash in the construction industry, providing value, income, and jobs based on the MDU CDF. This creation of jobs and value to the ash will have a direct benefit to the both the local and the North Dakota economy. Commercial deployment of the MDU CDF technology will also demonstrate a positive advantage to the lignite industry, specifically the users of North Dakota lignite, by showing that the ash from such lignite use can be used in a positive manner. As such, the successful commercial development of markets for the ash is an environmental benefit, as well as an economic benefit, to the lignite user.

6.0 QUALIFICATIONS

Montana-Dakota Utilities and Western Research Institute have assembled a team of professionals that bring together the combination of science, engineering, and commercialization experience necessary to successfully perform the scope of the project as outlined above. WRI is a nonprofit research and development organization. Western Research Institute maintains a 52,000-square-ft laboratory facility on 2.3 acres located adjacent to the University of Wyoming campus in Laramie, Wyoming. Four satellite buildings (5,000 square-ft) house specialized research and development laboratories and sample preparation equipment. In addition to the main facility, WRI operates a 22-acre Advanced Technology Center (ATC) site on the north edge of Laramie. The ATC facilities include a 22,000-square-ft combustion and in-situ remediation laboratory, a 5,400 square-ft 0.5 MW gas turbine pilot facility, and a 7,000-square-ft waste management laboratory complex. The ATC also houses seven other pilot plants and complete fabrication and maintenance shops.

The main facility is equipped with over $22 million worth of instruments to perform a full range of ASTM and specialized analytical and laboratory testing. This equipment includes computerized gas chromatographs/mass spectrometers (GC/MS), inductively coupled plasma (ICP) spectrometer, atomic absorption (AA), infrared (IR) spectrometer, high performance liquid chromatograph (HPLC), solids NMR spectrometer, X-ray powder diffraction (XRD), thermogravimetric analysis (TGA), differential thermogravimetric analysis (DTA), differential scanning calorimetry (DSC) and scanning electron microscope (SEM). A HIAC PA720 is available for determining the particle size distribution of the waste materials. WRI has a complete facility for the extraction of leachates from wastes under a range of protocols, including EP, TCLP, and CalWET.

WRI has complete facilities for the evaluation of a range of solid waste and wastewater treatment processes. Water and wastewater treatment and remediation equipment includes filtration, bioremediation, containment, pump and treat technologies, froth flotation, steam stripping, ion exchange, carbon adsorption, reverse osmosis, chemical coagulation and flocculation, and electro-coagulation. Sludge treatment processes include extraction of hydrocarbons from tank bottoms (TaBoRR process), thermal oxidation, wet-air oxidation, soil washing, including steam and hot water flushing and surfactant washing. A range of combustion, pyrolysis, and incineration processes are also available, such as starved air incineration, fluidized bed combustion, and vortex incineration of gaseous pollutants.

The Waste Management Laboratory is located at the Advanced Technology Center and houses a variety of laboratory and pilot-scale waste treatment and testing equipment. The facility was designed to evaluate various waste management options, including stabilization, contaminant removal (soil washing), and solid waste use. WRI has a fully equipped facility allowing performance of all of the related ASTM and AASHTO tests. A summary of the types of equipment is presented in Appendix B. In addition to these facilities, WRI has access to specialized resilient and dynamic modulus and modulus of rupture and elasticity testing facilities at the UW Department of Civil Engineering and the Wyoming Department of Transportation.

Western Research Institute personnel have been involved in the development of technologies and management practices for the disposal and utilization of solid wastes for nearly two decades. The experience includes the solid wastes from shale production and processing, conventional Class C and F fly ashes, and advanced coal combustion and desulfurization technology ashes. The team as assembled for the project has a long history of activity in the area of ash handling, disposal, and utilization. WRI personnel have been involved in the development of ash management options for advanced coal combustion and desulfurization ashes for over a decade. Their experience with conventional and advanced coal combustion and desulfurization technology ashes is well documented. A summary of WRI ash management experience and selected key projects is presented in Appendix B.

Key Personnel

Mr. Duane O. Steen of Montana Dakota Utilities will manage the project. Western Research Institute will conduct the testing as outlined herein under the direction of Dr. Alan E. Bland, who will serve as Principal Investigator. Dr. Terry H. Brown, Dr. Vijay K. Sethi, and Susan Sorini will assist in directing key components of the testing program. A brief description of the key personnel and their project responsibilities is provided below.

Duane O. Steen, B.S. Mechanical Engineering - Mr Steen has been Administration and Projects Manager in the Corporate Office of Montana Dakota Utilities since 1992. The responsibilities of the position are to oversee the accounting end of Montana Dakota Utilities' power plants as well as to manage various projects. Currently he is working on projects for utilization of coal ash, analysis of in-house and outside investment in future generation projects, and a number of economic development projects. Since joining Montana Dakota Utilities in 1974, Mr. Steen has been results engineer and results supervisor at the Lewis and Clark Station, a 50-MW lignite-fired power plant. Steen has also been operations coordinator in the Power Production Department at corporate headquarters, and. station superintendent and manager at both the Lewis and Clark Station and the R. M. Heskett Station. As station manager, he was responsible for the overall operation of these two coal-fired generating units. The R. M. Heskett Station is a two-unit lignite-fired plant consisting of a 20-MW unit and a 66-MW unit. As station manager at the R. M. Heskett Station, Steen was directly involved with the conversion of the 66-MW stoker fired unit to an 80-MW fluidized bed combustion unit. His responsibilities included initial design review, on-site construction supervision, start-up, and operation. Duane Steen is a professional engineer in the State of North Dakota and has over 22 years of experience in the power generation industry, including lignite coal-fired fluidized bed combustion. Mr. Steen has numerous years of project management and is well versed in coal ash management.

Alan E. Bland, Ph.D. - Dr. Bland joined WRI in August of 1991, where he is part of the senior research staff, responsible for solid waste research and development activities. Dr. Bland has over 15 years of experience with ash management issues for advanced coal combustion/desulfurization technology ashes. Current ash management projects include synthetic aggregate production from ash, the production of ash-based flowable fills, pulverized fuel ash (PFA) use in soil stabilization, and cement treated base applications for DOE and PacifiCorp; CFBC ash pelletizing studies for a number of industrial and cogeneration clients; and incinerator ash studies for confidential industrial clients. Dr. Bland is project manager for the U.S. DOE sponsored development of SYNAG^{TM}, a synthetic aggregate for construction applications, In addition, Dr. Bland is the project manager for the evaluation of market potential and use options for pressurized fluidized bed combustion ashes, co-sponsored by U.S. DOE, Electric Power research Institute (EPRI) and Foster Wheeler Energy International. Dr. Bland has authored or co-authored over 50 publications, many of which have been presented at national and international conferences. Dr. Bland serves on the steering committee of the International Conference on Fluidized Bed Combustion and is topic chairman of the environmental issues for that conference. Dr. Bland is a member of SME/AIME and the American Chemical Society.

Dr. Bland will be responsible for the overall project testing by WRI and will provide the point of reporting to MDU and thereby to NDIC.

Terry H. Brown, Ph.D. Dr. Brown, senior research scientist, Environmental Technology Group at Western Research Institute, is responsible for research and development programs in the area of waste remediation, soil washing, waste stabilization and disposal, and solution chemistry aspects of waste management. Dr. Brown has been the project manager on projects involving the physical and chemical treatment of hazardous waste contaminated soils as part of a development program for a soil washing technology termed Haz-Flote^{TM}, which is capable of treating both organic and inorganic contaminated soils. Dr. Brown is presently the project manager for a project with Public Service of Colorado that addresses the disposal and liner compatibility of a number of CCT ashes from the Arapahoe No. 4 Clean Coal Technology demonstration project. Dr. Brown is currently involved in the solution chemistry and phase reaction chemistry for both conventional and FBC ashes. Dr. Brown worked on the preliminary testing of flowable fill materials from FBC ashes. Dr. Brown has authored numerous papers and reports associated with ash and waste management, many of which have been presented to national and international conferences.

Dr. Brown will be involved in all aspects of the project. Dr. Brown will report through Dr. A. E. Bland.

Vijay K. Sethi, Ph.D At Western Research Institute, Dr. Sethi is responsible for projects dealing with corrosion, erosion-corrosion, and other materials degradation problems in advanced coal and biomass utilization technologies. He is also responsible for process development and optimization for advanced coal drying, coal gasification, and higher efficiency coal combustion systems. He is also working with the WRI Oil and Gas Group to develop and test technologies for surface processing of oil sands, tank-bottom recovery, and projects involving remediation of oil/hydrocarbon contaminated soils. Dr. Sethi has worked with the Tennessee Valley Authority in testing materials at the 160-MWe atmospheric fluidized bed coal combustor located at the TVA Shawnee Steam Plant. Dr Sethi designed and supervised the preliminary embed compatibility testing of MDU ash-based flowable fill. Dr. Sethi has over a hundred publications, and nearly that many presentations. He is a member of various trade societies including ASM International, National Association of Corrosion Engineers, AIME.

Dr. Sethi will be responsible for the interpretation of any materials compatibility issues that may arise as part of this project. Dr. Sethi will report through Dr. A. E. Bland.

Susan S. Sorini, BS. S. Sorini is currently principal research scientist in the Environmental Technology Group at Western Research Institute, where she is responsible for waste characterization and methods development and validation. Ms. Sorini has been the project manager of a project to develop and validate a sequential batch extraction method using dilute acid solution simulating acid rain as the extraction fluid. Ms. Sorini has also been involved in a hazardous waste clean-up program for U.S. DOE. The site has been contaminated with both inorganic heavy metals and organic contaminants. Ms. Sorini was task leader for the development and evaluation of EPA Toxicity Characteristic Leaching Procedure (TCLP) and the Liquid Release Test (LRT). Ms. Sorini has managed projects for the preparation of TCLP reference samples and evaluation of regulatory testing equipment and has conducted projects for the Electric Power Research Institute and the Utility Solid Waste Activities Group (USWAG). Ms Sorini is presently involved in the development of instrumentation and environmental protocol for American Society for Testing Materials (ASTM). Ms. Sorini presently serves as the chairperson for the ASTM Task Group D34.02,01 on Waste Leaching Techniques and is the author of the ASTM Method D4793, Standard Test Method for Sequential Batch Extraction of Waste and Water. Ms. Sorini has authored or coauthored 12 publications dealing with solid waste characterization and testing methods.

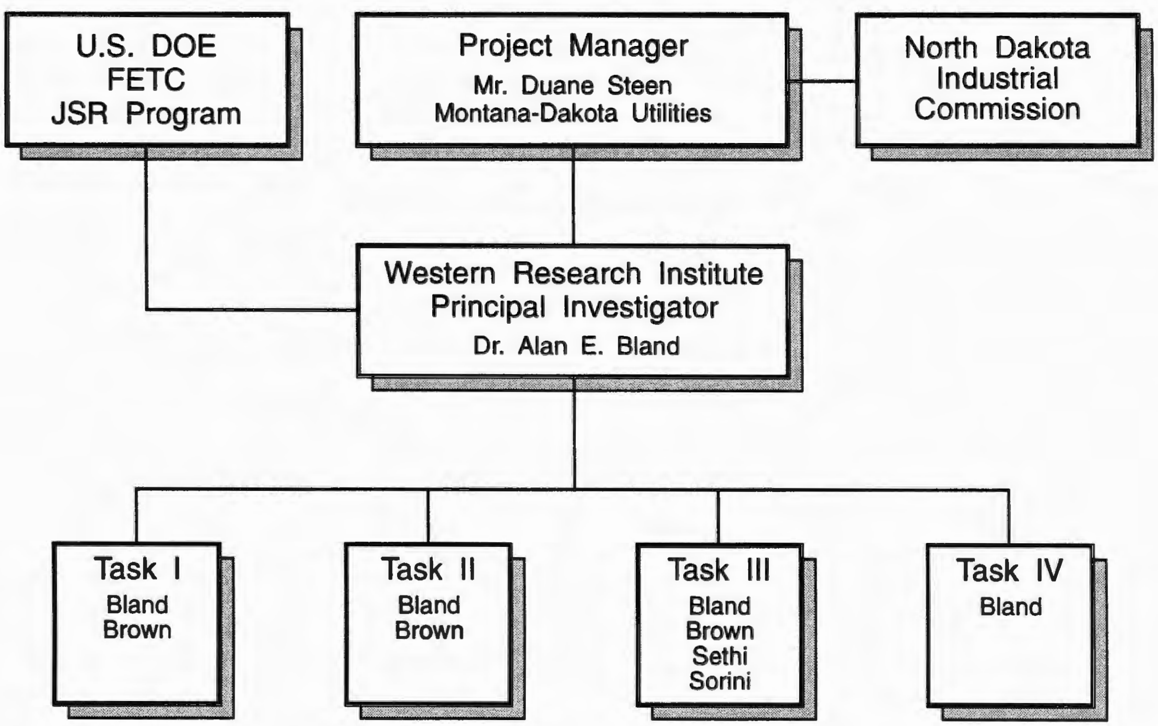
Ms. Sorini will be involved in any environmental monitoring in the project. She will report through Dr. A. E. Bland for this work.

7.0 PROJECT MANAGEMENT

Mr. Duane Steen of Montana-Dakota Utilities will serve as the project manager. Western Research Institute will conduct the testing as outlined herein under the direction of Dr. Alan E. Bland, who will serve as Principal Investigator. The project organizational chart is presented in Figure 1. Mr. Steen will be an integral part of the commercial-scale demonstration activities, as well as project manager reporting to NDIC. U.S. Department of Energy reporting will be through WRI's Jointly Sponsored Research Program administered through Dr. Lee E. Brecher of WRI.

Key WRI personnel include Dr. Alan E. Bland, Dr. Terry H. Brown, Dr. Vijay K. Sethi, and Susan Sorini. All reports, including Interim Reports, as well as Final report will be prepared by Dr. Bland with contribution from these key WRI personnel.

Figure 1.
Project Organizational Chart



8.0 TIMETABLE

It is anticipated that the project will take approximately 24 months to complete with the following milestones.

March, 1999	Contracts awarded.
March, 1999 through July, 1999	Conduct short-term product variability and service environment testing.
July 1999 through June 2000	Conduct long-term laboratory testing.
March through June, 1999	Acquire and construct CDF batch plant
July, 1999	Deliver interim report on short-term testing.
July through December, 1999	Operate batch plant & conduct commercial demonstrations.
July1999 through October 2000	Monitor commercial-scale demonstration sites.
April 2000	Deliver interim report.
November 30, 2000	Deliver draft final report.
December 31, 2000	Deliver final report.

Progress on the project will be reported through brief quarterly reports. These reports will be submitted to North Dakota Industrial Commission and the U.S. Department of Energy after review by MDU personnel. The first quarterly report will be made to coincide with the U.S. DOE reporting schedule in order to minimize the reporting requirements. Teleconference calls with MDU personnel, WRI personnel, and NDIC will take place as the need arises. The first quarterly report will be delivered on or before the 10^{th} of the month on a quarterly basis. Interim reports covering the results of the laboratory testing program and demonstrations will be prepared in the summer of 1999 and the summer of 2000. A draft final report on the project delivered November, 2000 with the finalized version due December, 2000.

9.0 BUDGET AND MATCHING FUNDS

The estimated cost to conduct the project as described in the proposal is $358,375. A summary of the project costs are presented in Table 2.

Table 2.
Summary of Project Estimated Costs

Category	NDIC	WRI/U.S.DOE and MDU	Total Project
Personnel(1)	$62,115	$166,460	$228,575
Supplies/Rental Field Equipment	$1,600	$8,500	$10,100
Travel	$1,600	$9,000	$10,600
Analytics/Field Tests	$1,800	$7,300	$9,100
Capital Equipment	$30,000	$70,000	$100,000
Total	$97,115	$261,260	$358,375

(1) Includes Fringe Benefits, Labor Overhead Costs and G&A Overhead.

The costs for the program are to be shared by MDU, NDIC and WRI through its Cooperative Agreement with the U.S. Department of Energy (FETC). MDU will contribute $82,100 in cash and in-kind services and personnel costs associated with the commercial-scale demonstration activities, as well as project management. It is requested that the NDIC provide $97,115. WRI and U.S. DOE will match both the MDU and NDIC funding for the amount of $179,160. Budget information, including the nature of the cost estimating procedures is presented in Appendix C.

The cost estimate includes the cost of a batch plant, land, office, utilities and other associated MDU CDF batch plant costs. These equipment are essential to the project in that only by constructing these MDU CDF batching facilities can alternate low cost materials be tested in sufficient quantities needed to prove commercial acceptance. Commercial-scale quantities are also needed to allow for real-world economic evaluations. The initial demonstrations used existing ready-mix facilities at the Atlas Ready-Mix Concrete plant. However, neither Atlas nor any of the other commercial batch plants can handle the MDU fly ash and alternate sand materials while maintaining their commercial concrete batch operations. We have discussed these options with the local ready-mix concrete producers and they agree that the only reasonable way to accomplish our objectives is to set up a separate batching plant for the MDU CDF.

10.0 TAX LIABILITY STATEMENT

Neither Montana-Dakota Utilities nor Western Research Institute have any outstanding tax liability with the State of North Dakota. Affidavits are provided in Appendix C.

11.0 CONFIDENTIAL INFORMATION

None of the information in this proposal is considered confidential.

12.0 RELATED REFERENCES

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