GREAT RIVER
ENERGY®

17845 East Highway 10 • P.O. Box 800 • Elk River, Minnesota 55330-0800 • 763-441-3121 • Fax 763-241-2366 • www.GreatRiverEnergy.com

September 30, 2003

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

Subject: Grant Application for the Evaluation of MerCAP™ for Power Plant Mercury Control

Dear Ms. Fine:

Enclosed is a Grant Application requesting North Dakota Industrial Commission (NDIC) co-funding of a study to evaluate the Mercury Capture by Adsorption Process (MerCAP™) at Great River Energy's Stanton Station power plant. Great River Energy (GRE) is requesting matching funds of $150,000 from NDIC's Lignite Research, Development and Marketing Program. A $100 check is also enclosed to cover the application fee.

The project for which we are requesting funding is the progression from work already funded by the NDIC. GRE, EPRI, and URS Group have tested MerCAP™ in various forms and configurations at Stanton Station starting in December 2000. Over the last years of small-scale testing, the technology has consistently demonstrated its ability to effectively remove mercury from the flue gas of the Unit 10 boiler, which is equipped with a spray dryer and baghouse for control of sulfur dioxide and particulates. Because of the success to date, the proposed project has been selected by the U.S. Department of Energy for funding of a long-term test of the technology. The NDIC funds being sought by GRE will help to meet the DOE's cost sharing requirements.

This study will generate data that will help in developing cost-effective, competitive options for reducing mercury emissions from lignite-fired utilities.

If you have any questions regarding the enclosed Grant Application or the proposed project, please call me at 763-241-2491.

Sincerely,

GREAT RIVER ENERGY

Mark Strohfus
Environmental Policy Analyst

Enc. - Grant Application
GRE check #113631, $100

c: Dr. Carl Richardson, URS Group

Grant Application

For the

Evaluation of MerCAP™ for Power Plant Mercury Control

At

Stanton Station, Stanton, North Dakota

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

Submitted by:
Mark Strohfus
Great River Energy
17845 East Highway 10
PO Box 800
Elk River, MN 55330-0800

Principal Investigator:
Dr. Carl Richardson
URS Corporation
PO Box 201088
Austin, TX 78720-1088

Funds Requested from the North Dakota Industrial Commission: $150,000

September 30, 2003

GREAT RIVER ENERGY℠
A Touchstone Energy® Cooperative

TABLE OF CONTENTS

APPENDICES

1.0 Abstract

Great River Energy (GRE) requests funding from the North Dakota Industrial Commission (NDIC) to evaluate the Mercury Capture by Adsorption Process (MerCAP™) at our Stanton Station. This proposed work has already been selected by the U.S. Department of Energy for funding under their program to evaluate longer term, larger scale mercury control technologies (DOE #DE-PS26-03NT41718-4). The NDIC funds being sought by GRE will help to meet the DOE's cost sharing requirements.

The proposed project will test a scaled-up version of the MerCAP™ concept (US patents 5,948,143 and 6,136,072). The MerCAP™ technology has been tested in smaller scales under a number of different configurations at Stanton Station for several years. Results to date suggest that greater than 90 percent mercury control can be achieved with MerCAP™. The proposed configuration in the outlet plenum of one of the baghouse compartments on Stanton's Unit 10 boiler offers a unique approach that maximizes the operational efficiency and maintenance of the technology. The project will also entail testing MerCAP™ at the outlet of a wet flue gas desulfurization (FGD) system at a plant firing Eastern bituminous coal. The NDIC funds will only be used in the testing at Stanton Station. However, GRE is interested in the results of the test on the FGD system since this configuration would have application at our Coal Creek Station. The proposed testing will occur for six months at Stanton Station.

Dr. Carl Richardson of USR Corporation will be the lead investigator for the project. URS has been integrally involved in the testing of MerCAP™ to date at Stanton Station. Apogee Scientific Inc., ADA Environmental Solutions, and EPRI will also serve on the project team.

The budgeted cost of the work at Stanton Station is $843,858. We are requesting $150,000 from the NDIC's Lignite Research Development and Marketing Program in support of this program.

2.0 Project Summary

This proposed project will evaluate the ability of gold-based MerCAP™ (Mercury Capture Adsorption Process) to control mercury in flue gas downstream of dry and wet scrubbers. The general concept for MerCAP™ is to place fixed structure sorbents into a flue gas stream to adsorb mercury and then, as the sorbent surfaces becomes saturated, thermally regenerate the sorbent and recover the mercury. One example includes parallel gold-coated plates, depicted in Figure 1. Mercury forms an amalgam with the gold and is removed from the flue gas flowing past the plates. The captured mercury can be subsequently sequestered using a carbon canister or cryogenic trap during regeneration.

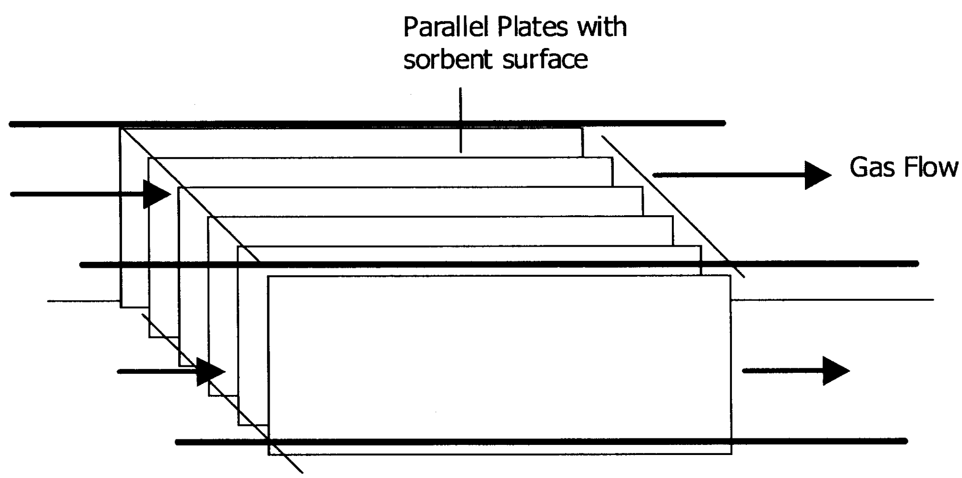

Figure 1. Parallel Plate Configuration of a Fixed Sorbent.

This proposed work has already been selected by the U.S. Department of Energy (DOE) for funding under their program to evaluate longer term, larger scale mercury control technologies (DOE #DE-PS26-03NT41718-4). The narrative portion of the application submitted to the DOE is included as Appendix A. Much of this application to the North Dakota Industrial Commission will reference text within the DOE application.

3.0 Project Description

The U.S. Environmental Protection Agency will propose mercury emission control requirements for coal-fired power plants by the end of 2003. Power plants are expected to be required to comply with the requirements by 2008. To date, there is no commercially available technology that has successfully been demonstrated to remove mercury from coal-fired power plants. This project will evaluate the ability of MerCAP™ to control mercury emission from lignite-fired power plants and move the technology toward commercialization.

GRE, EPRI, and its subcontractors have tested MerCAP™ in various forms and configurations at Stanton Station since December 2000. Over the last years of small-scale testing, the technology has consistently demonstrated its ability to effectively remove mercury from the flue gas of the Unit 10 boiler, which is equipped with a spray dryer and baghouse for control of sulfur dioxide and particulates.

The proposed MerCAP™ design to be installed at the outlet plenum of one baghouse compartment offers a unique approach that will maximize the operational efficiency and maintenance of the unit. By installing the system after the spray dryer and baghouse, acid gases, particulate matter, and other trace flue gas constituents that could reduce the efficiency of the system are minimized. With the compartmentalized baghouse, maintenance to clean or replace the MerCAP™ plates can occur without shutting the unit down simply by isolating the baghouse compartments one at a time. The project is described in the DOE application included as Appendix A, which provides:

- Technology Background: pages 1 - 4
- Project Description: pages 4 - 7, 13 - 29
- Detailed Scope of Work for Stanton Station: pages S1 - S7
- Economics: pages 10 - 11, S13 - S14
- Technology (*Replication and Market Penetration with the Utility Industry*): pages 11 -12
- Environmental Impacts (*Impact on Coal Utilization Byproducts*): page 12

4.0 Standards of Success

The purpose of the proposed project is to obtain sound technical data on the effectiveness of MerCAP™ for controlling mercury emissions and the costs associated with the technology. Successful culmination of this project will be attained with the delivery of the final report. The Project Team has been selected in part due to their exceptional expertise in ensuring credibility and validity of research data. Dr. Carl Richardson as Project Manager will be responsible for ensuring that the appropriate resources and personnel are available for the study to yield sound and valid data. Quality assurance procedures are outlined on pages 18 - 19 of the DOE application included as Appendix A.

5.0 Background

The MerCAP™ technology has been tested at Stanton Station since December 2001. Some of the results of previous tests are summarized in pages 1 - 3 of Appendix A.

6.0 Qualifications

Qualifications for the project participants are presented on pages 30 - 33 of Appendix A.

7.0 Value to North Dakota

The lignite industry plays a significant role in North Dakota's economy. In order to maintain this role, it is important to ensure that lignite remains competitive with other fuel sources. This study will generate data that could prove useful in developing cost-effective, competitive options for reducing mercury emissions from lignite-fired utilities.

8.0 Management

Dr. Carl Richardson, as the Project Manager, will be responsible for directing the project schedule and subcontractors. He will ensure that the project proceeds in a timely manner and within the project budget of $843,858. Dr. Richardson will also lead the project team in preparing the draft and final reports. Project management is discussed on page 34 of Appendix A.

GRE's environmental and engineering staff will be involved in the implementation of the tests and will remain fully apprised of the project status and goals. GRE staff will review and comment on all draft project reports prior to finalization.

9.0 Timetable

The MerCAP™ test will occur over a 6-month period. The overall test schedule is dependent on DOE's schedule for reviewing the project and releasing funds. Currently, URS expects that DOE will release funds authorizing the project to proceed as follows:

- DOE Funding Release and Authorization: October 2003
- Project Planning and Test Plan: November 2003 – February 2004
- Stanton MerCAP™ Installation and Testing: February 2004 – October 2004
- Stanton MerCAP™ Results Topical Report: February 2005
- Plant Yates Planning and Testing: September 2004 – September 2005
- MerCAP™ Economic Analysis: September 2005 – November 2005
- Final Report: March 2006

A more detailed timeline is provided on page 17 of Appendix A.

10.0 Budget

The work at Stanton Station, associated data analysis, and reporting are budgeted at $843,858. We are requesting matching funds of $150,000, which results in a leveraging ratio of more than five to one. The project budget includes only charges associated with conducting and managing the project. Time and expenses incurred during the development of contracts and this application are not charged to the project budget and will not be submitted to NDIC for reimbursement. The project budget breakdown is as follows:

URS Labor	$ 128,810
URS Travel	$ 35,990
URS Other Direct Cost	$ 19,364
Subcontractor Apogee Scientifc	$ 378,484
Subcontractor ADA-ES	$ 52,098
Subcontractor CT&E Inc	$ 9,715
Total Materials and Supplies	$ 113,925
Total EPRI In-Kind Labor, Travel and Overhead	$ 65,472
GRE In-Kind Labor and Services	$ 40,000
Total Project Cost	**$ 843,858**

11.0 Matching Funds

Pending awarding of this request, the following is a summary of funding for the proposed project:

DOE Funds	$ 538,386
GRE Cash Contribution	$ 50,000
EPRI In-Kind Contribution	$ 65,472
GRE In-Kind Contributions	$ 40,000
Total Matching Funds	$ 693,858
North Dakota Lignite Research, Development and Marketing Fund	$ 150,000
Total Project Funding	$ 843,858

12.0 Tax Liability

I, Larry Schmid, certify that Great River Energy does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

Larry Schmid
Chief Financial Officer

Date

13.0 Confidential Information

A final report will be prepared summarizing the project and its findings. All results of the MerCAP™ tests will be released as public information. The MerCAP™ technology is licensed to EPRI. Restrictions on use of the licensed technology apply.

APPENDIX A

URS Corporation
Narrative Application for DOE Grant

"Evaluation of MerCAP™ for Power Plant Mercury Control"

Solicitation Number DE-PS26-03NT41718-4

Submitted by:
URS Group, Inc.
P.O. Box 201088
Austin, Texas 78720-1088

Primary Contact:
James R. Blacksmith, VP
(512) 419-5604 (phone)
(512) 454-8807 (fax)
jim_blacksmith@urscorp.com

April 7, 2003

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ACI	Activated carbon injection
acfm	Actual cubic feet per minute
APC	Air pollution control (device)
Cl	Chlorine
COR	(DOE) Contracting Officer Representative
DOE	Department of Energy
EPA	Environmental Protection Agency
ESP	Electrostatic precipitator
FGD	Flue gas desulfurization
GRE	Great River Energy
HCl	Hydrochloric acid
HF	Hydrofluoric acid
Hg	Mercury
Hg^0	Elemental mercury
Hg^{+2}	Oxidized mercury
ICR	Information Collection Request
ID	Inner diameter
ME	Mist Eliminator
MerCAP™	MERcury Capture Adsorption Process
MWe	Megawatt
ND	North Dakota
NETL	National Energy Technology Laboratory
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
PRB	Powder River Basin
QA/QC	Quality assurance/quality control
QAPP	Quality Assurance Project Plan
SBS	Sodium bisulfite
SCEM	Semi-continuous emissions monitor
SD-BH	Spray dryer – baghouse combination

SO_2	Sulfur dioxide
SO_x	Sulfur oxides
WBS	Work breakdown structure
XRF	X-ray Fluorescence (spectroscopy)

SCIENTIFIC AND TECHNICAL MERIT

Background of Proposed Technology

This program will evaluate the ability of gold-based MerCAP™ (MERcury Capture Adsorption Process) to control mercury in flue gas downstream of dry and wet scrubbers. The general concept for MerCAP™ is to place fixed structure sorbents into a flue gas stream to adsorb mercury and then, as the sorbent surfaces becomes saturated, thermally regenerate the sorbent and recover the mercury. One example includes parallel gold-coated plates, depicted in Figure 1. Mercury forms an amalgam with the gold and is removed from the flue gas flowing past the plates. The captured mercury can be subsequently sequestered using a carbon canister or cryogenic trap during regeneration.

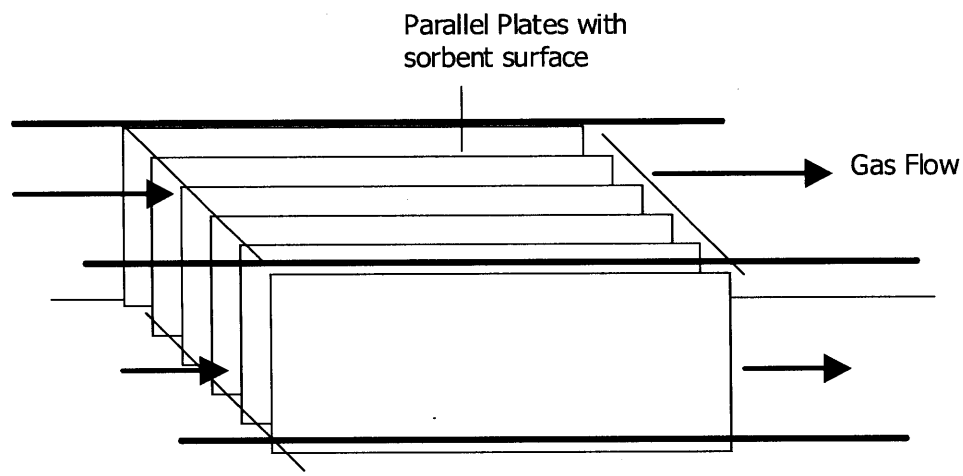

Figure 1. Parallel Plate Configuration of a Fixed Sorbent.

Results from modeling studies and field testing of MerCAP™ by EPRI indicate this technology has the potential to remove >90% of the mercury in the flue gas. The best results to date using gold as the base sorbent surface has been downstream of wet and dry SOx scrubbers. Recent pilot tests conducted with an in-duct test unit in ND lignite flue gas downstream of a spray dryer/bag-house configuration showed 70 to 90% removal at a gas velocity of 30 to 40 ft/s with gold plates only 10-ft long and spaced 0.5 inches apart (Figure 2). Pressure drops at these high velocities were approximately 2 inches water. These results were consistent with mass transfer model predictions and show that high mercury removals can be achievable over relatively short plate lengths at very high velocities. The high removals were also maintained over 3000 hrs of operation without the need for regeneration. Tests have also indicated that gold-coated plates can be thermally regenerated without degradation of the adsorption capacity. The system is very flexible and removal effectiveness can be controlled by varying the plate length, plate spacing, and gas velocities.

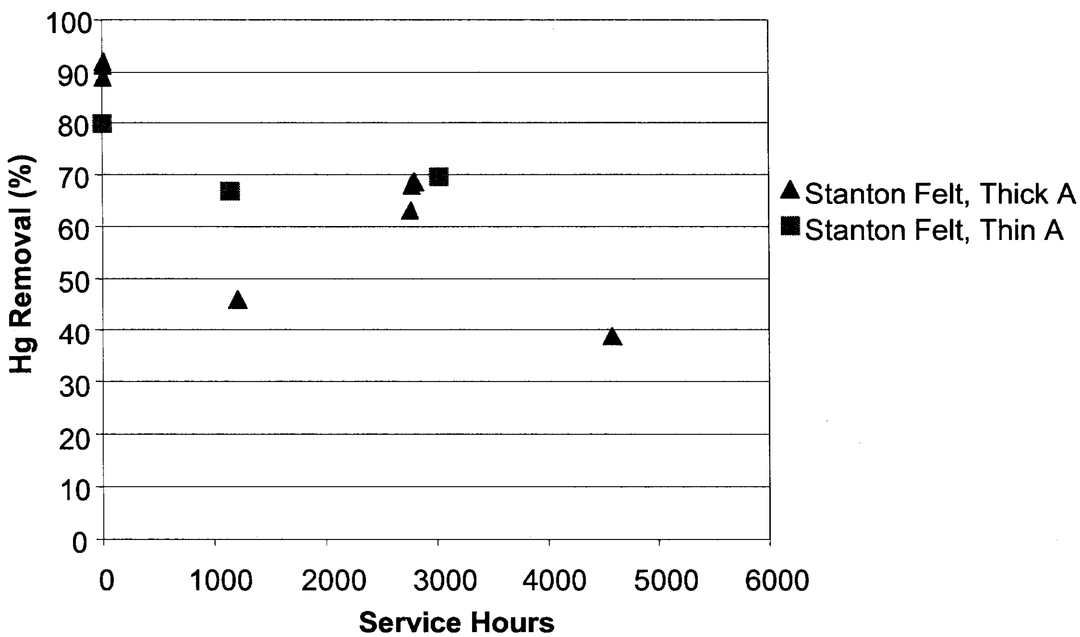

Figure 2. MerCAP™ Gold Plates Removal Effectiveness with Exposure Time. (0.5-inch (1.3-cm) plate spacing, 10 ft long plates, gas velocities over plate 30 to 50 ft/s)

The gold MerCAP™ concept has also been tested downstream of a wet FGD absorber at a plant firing an Eastern bituminous coal. An 8-17 scfm slipstream was obtained downstream of a FGD module and passed through a fixed structure sorbent device consisting of gold-coated plates (1-3 ft length), with a 1/4-inch spacing, which were continuously wetted with wash water from a full-scale mist eliminator. The results shown in Figure 3 showed mercury removals ranging from 63-95% of the mercury present at the full-scale absorber outlet. These results suggest that coupling of the MerCAP™ process with the FGD scrubber (60% mercury removal) could result in a total mercury removal of 90 to 99% at this plant, based on inlet data. These results are encouraging for mercury removal downstream of a wet scrubber, where MerCAP™ plates could be seamlessly incorporated into the mist eliminator module.

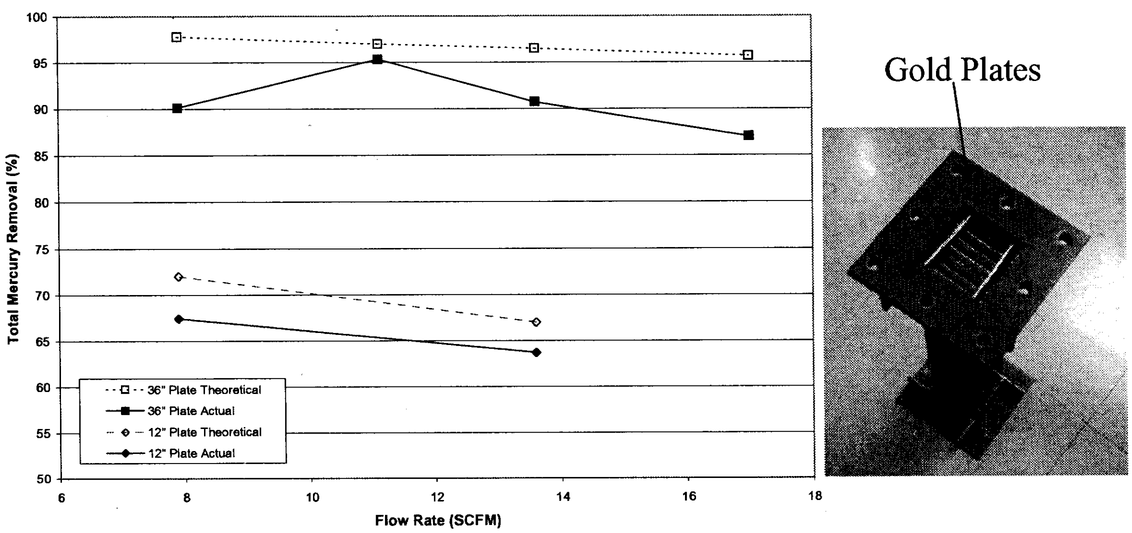

Figure 3. MerCAP™ mercury removal downstream of a wet FGD absorber in bituminous-derived flue gas.

MerCAP™ with gold-coated plates had limited and mixed results in flue gas upstream of wet and dry scrubbers and more tests are being planned. There is also on-going development work to evaluate lower cost sorbent materials such as activated carbon and other metal amalgams to reduce costs and extend the range of applicability of MerCAP™ even further. This project focuses on applications downstream of scrubbers where our data to date has demonstrated that MerCAP™ can be an effective option and can be tested at a larger scale.

Uniqueness of Technical Approach

The MerCAP™ process provides a unique option for controlling flue gas mercury since it uses regenerable fixed sorbent structures. The process is mechanically simple containing no moving parts and can be sized to obtain the level of mercury removal desired at a design pressure drop. Upon approaching mercury saturation, the sorbent surfaces can be thermally regenerated to remove the captured mercury without affecting its adsorption performance. Released mercury can be recaptured and isolated using a small carbon canister or cryogenic trap and then be stored or purified and re-used. Unlike other developing mercury controls, this process uses no activated carbon or other chemical additives and thus does not affect plant combustion byproducts or result in large quantities of waste material. For example, Southern Company Services, one of the host utilities for this project, estimates that the total mercury captured by MerCAP™ for its entire fleet of power plants in one year can be isolated in one 55-gallon drum.

Project Description

In the proposed project, URS Group and its team will conduct tests at two host power plants to evaluate gold MerCAP™ performance downstream of a spray dryer-baghouse and wet scrubber over an extended period of flue-gas exposure. The spray dryer site, identified in this proposal as Site 1, is Great River Energy's Stanton Station which burns a ND lignite coal. At this site, an array of gold-coated MerCAP™ plates will be incorporated into the outlet plenum of one compartment (6 MWe) of the Unit 10 baghouse. Site 2, the wet scrubber site, is Southern Company Services' Plant Yates which burns an Eastern bituminous coal. Gold-coated structures will be configured as a mist eliminator and configured downstream of a pilot (1 MWe equivalent) wet scrubber receiving a flue gas slipstream obtained immediately downstream of a full-scale

FGD absorber. MerCAP™ will be evaluated for mercury removal during normal boiler operation for periods of six months at both sites.

The ability to repeatedly thermally regenerate exposed MerCAP™ plates is a critical component to the overall economics of the technology. Therefore, during the longer-term tests, small-scale tests will be conducted to evaluate the mercury removal effectiveness at both sites following repeated regeneration cycles. Tests will be conducted using a 40-acfm slipstream probe device ("Mini-MerCAP™ probe"). Gold-coated substrates from the same production batch used for the MerCAP™ arrays in the larger longer-term tests will be used in the Mini-MerCAP™ probe.

MerCAP™ technology has been successfully tested in small-scale units installed at the proposed test sites. Results of the proposed study will verify this performance at a larger scale and over a longer period of gas exposure and will provide data required for assessing the feasibility and costs of a full-scale MerCAP™ application.

How Technology Meets Objectives of Solicitation

This proposal addresses needs identified under Area of Interest 4 for the development of other control technologies ready for long-term field testing. The objective of this solicitation is to develop advanced concepts for controlling mercury emissions, with a goal of total mercury reductions of 55+% for lignite, 65+% for subbituminous coal, and 80+% for bituminous coal. Previous EPRI tests showed that gold removal of mercury in air is limited only by mass transfer of the mercury to the gold surface. A mass transfer model was developed to predict MerCAP™ performance. Figure 4 indicates the projected mercury removal for flue gas velocities from 1 to 60 ft/sec at a plate-to-plate spacing of 1-inch. As shown, 80% mercury removal is projected for an installation operating at 60 ft/sec and 15-feet long. At gas velocities of 10 to 15 ft/sec and 1-

inch plate spacing, the model predicts >90% mercury removal with 15-foot long plates. Theoretical pressure drop calculations for plate-to-plate spacing from 0.5 to 2 inches predict between 2.5 to 0.5 inches of water at a gas velocity of 60 ft/s. These values were confirmed in recent field tests with a140-acfm in-duct test probe.

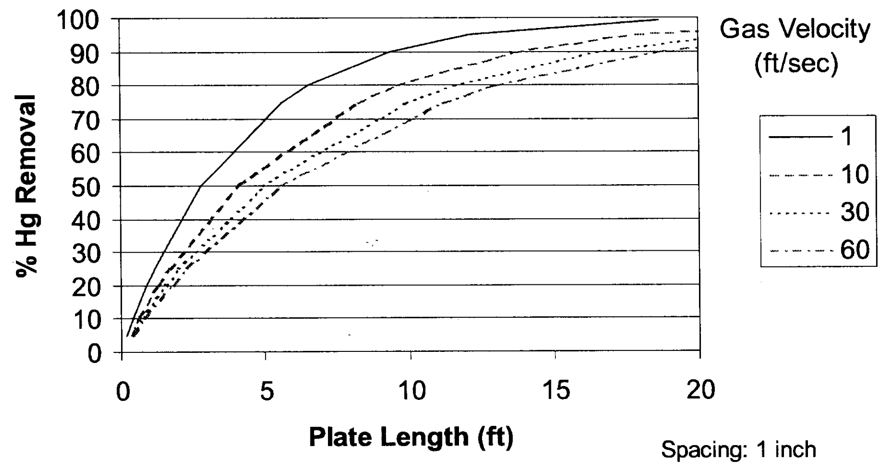

Figure 4. Gas Velocity Effect on Mercury Removal with Rigid Sorbent-Coated Plates.

The mass transfer model indicates that fixed sorbents should be capable of achieving high levels of mercury removal in flue gas. For example, 10-ft plates operating at 60 ft/sec gas flow should provide sufficient removal to exceed program objectives for lignite and subbituminous coals suggesting possible MerCAP™ installation as a primary mercury control. In bituminous-derived flue gas, where appreciable removals may exist across a wet scrubber, MerCAP™ should provide an option as a polishing device to obtain 90% overall mercury removal. These relatively high mercury removal levels have been achieved at smaller scales, demonstrating the potential of the technology to meet the mercury removal objectives identified in the proposal for scrubbed sites. With support from DOE/NETL and cost-sharing partners, MerCAP™ can be demonstrated in an actual configuration that could be used in a commercial application. Successful demonstrations at the two sites will be an important measurable advancement towards achieving the objectives of the solicitation. The results and engineering data will be directly applicable to full-scale applications as the plate dimensions and gas velocities used will reflect those for the full unit and improvements to the installation can be incorporated into a future commercial installation. This will minimize the time and expense required between demonstration and application.

How Project Meets DOE Data Gaps

The proposed host sites will fill strategic data gaps for configuration and coal type specified by DOE. Table 1 lists boiler and fuel parameters for each site. GRE's Stanton Station Unit 10 is a 60 MW boiler firing ND lignite with a spray dryer-baghouse combination for SO_2 and particulate control, as illustrated in Figure 5. Southern Company Services' Plant Yates Unit 1 consists of a 100 MW boiler firing eastern bituminous coal with a cold-side ESP for particulate control and a Chiyoda jet bubbler absorber for SO_2 control, as illustrated in Figure 6. Both plant configurations are included in DOE's list of suggested configurations for mercury control evaluation.

Table 1. Boiler and Fuel Parameters for Proposed Host Test Sites.

Unit Name	Boiler Parameters		Fuel Parameters		
	Capacity (MWe)	Type	Type	Fuel Hg (ppm)	Fuel Chlorine (ppm)
Stanton 10	60	T + LNB	ND Lignite	0.06 – 0.1	70
Yates 1	123	T	E. Bituminous	0.16	300-1400

Both host sites have been characterized for mercury speciation and removal during various tests over the past two years. Both plants participated in EPA's ICR effort. Recent mercury data for each plant is summarized in Table 2. Although no Ontario Hydro samples have been obtained at Stanton Station since the ICR, a number of test EPRI programs have been carried out on Unit 10 during the past couple of years where semi-continuous emission monitors (SCEMs) have been used to characterize speciated mercury (Table 2). Tests have shown that mercury levels at the Unit 10 spray dryer inlet ranged from 5.4 - 7.2 μg Hg/Nm^3 while elemental mercury showed consistent oxidation levels below 10%. Flue gas HCl concentrations were less than 1.2 ppm at this location. Results downstream of the baghouse showed a range of 4.6 – 7 μg Hg/Nm^3 indicating only 3-14% mercury removal across the SD/BH. This data illustrates the inherent difficulty of removing mercury from flue gas derived from low rank coal. SCEM data at Stanton showed reasonable agreement with measurements made using EPA Method 29.

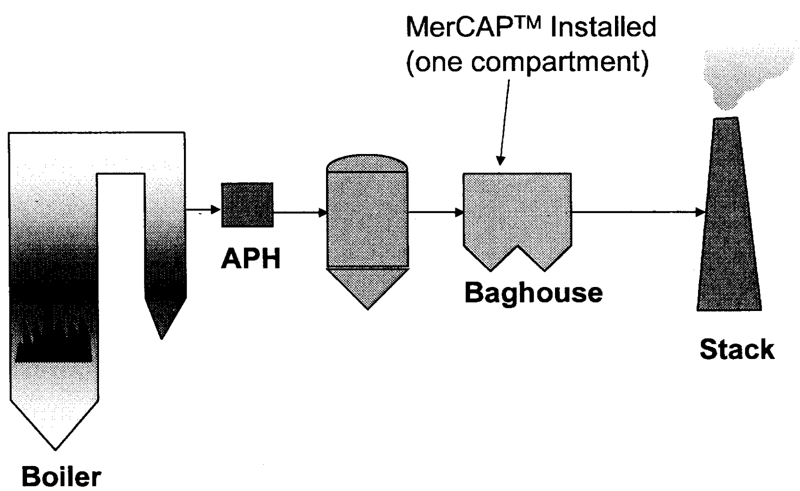

Figure 5. Schematic of Stanton Unit 10 Gas Path..

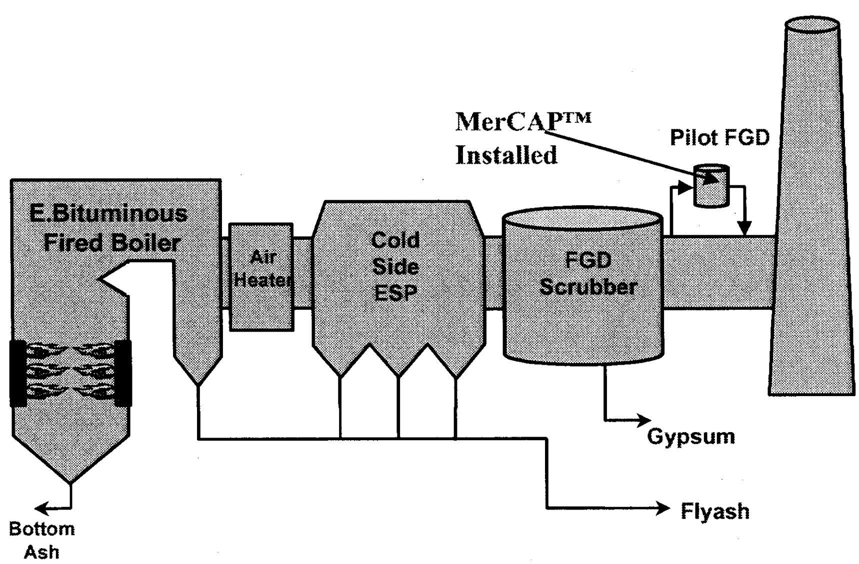

Figure 6. Schematic of Plant Yates Unit 1 Gas Path.

Table 2. Mercury Speciation and Removal Data for Proposed Host Test Sites.

Unit	APC Inlet Flue Gas			Stack Flue Gas			APC Hg Removal (%)
	Total Hg ($\mu g/Nm^3$)	Hg(0) ($\mu g/Nm^3$)	Percent Oxidation	Total Hg ($\mu g/Nm^3$)	Hg(0) ($\mu g/Nm^3$)	Percent Oxidation	
Stanton 10 (SCEM*)	6.07	5.73	5.5	5.47	3.99	27.1	10.5
Stanton 10 (Method 29)	6.39	NA	NA	4.92	NA	NA	22.4
Yates 1 (SCEM**)	5.68	2.14	62.4	1.88	1.53	18.9	66.7
Yates 1 (OH Method)	6.95	4.56	34.4	2.79	2.69	3.6	60.0

* - 2002 data; ** - 2003 data

Recent mercury measurements at Plant Yates included Ontario Hydro and SCEM measurements. Results from upstream of the wet absorber indicated total mercury concentrations and oxidation ranging from 5–7$\mu g/Nm^3$ and 34-62%, respectively. Both measurement types show mercury removals around 60% across the FGD absorber.

At Stanton Station the MerCAP™ will be installed within one compartment of the fabric filter baghouse configuration, giving a 6 MWe test arrangement. At PlantYates the MerCAP™ technology will be installed in an existing 1 MWe pilot absorber unit downstream of an FGD scrubber. The MerCAP™ demonstrations proposed will be polishing applications designed to remove mercury remaining in the gas downstream of the last existing control device. At Site 1, the presence of the spray dryer and baghouse has demonstrated the tendency to improve the performance of the MerCAP™ sorbent material compared to results from tests conducted upstream of the spray dryer and baghouse. Based on previous results (Table 2), a polishing device will have to remove approximately 60% of the total flue gas mercury present downstream of the SD-BH in order to achieve a total system removal target of 55%. At Site 2, most of the oxidized mercury is removed by the existing wet scrubber. The MerCAP™ mist eliminator should effectively removal a significant fraction of the remaining mercury, depending on the size installed. In addition, since the scrubber outlet is very clean and low in acid gases and particulates, the plate life may be extended. Here, based on Ontario Hydro data (Table 2) the installed MerCAP™ process would need to remove approximately 65% of the mercury present in the scrubber outlet flue gas to achieve a total system target removal of 90%.

Economic Benefits

Our tests to date show that a SD-BH reduced the effectiveness of activated carbon mercury control by almost an order of magnitude for Western coal (ND lignite and PRB) fired units. To achieve 55% removal across a SD-BH with ACI, >$2 million/yr will be needed for a 500 MWe Western coal-fired power plant. The cost of the gold plates (for 70 to 90% mercury removal) for a 500 MWe power plant is estimated to be $3.5 to 7 million depending on the regeneration frequency. If the gold plates are assumed to last 5 years, the annual gold plate cost would be $700,000 to $1.4 million. This is a conservative estimate in that the gold plates should last much longer in flue gas downstream of the particulate collector and the scrubber. Even for the conservative case, the cost of the gold plates (for 70 to 90% removal) is significantly less than the cost of the carbon needed to achieve 55% removal. The simple comparison does not take into account that no waste streams are generated with MerCAP™ compared to ACI and that the captured mercury can be isolated readily.

For application downstream of a wet scrubber, MerCAP™ allows an additional 50 to 80% removal when used in the mist eliminator section. In the case of Eastern bituminous coal flue gas, baseline mercury removals are around 65% for ESP-wet FGD units. It can be very costly to achieve 80 to 90% overall removal as oxidation catalysts, boiler chemical addition, or ACI may be needed. MerCAP™ can be readily retrofitted as a final stage polisher.

A fixed sorbent process should consume very little energy. The pressure drop across the sorbent structures will be determined by the required plate length and spacing. Past field-test and model results showed that the pressure drops across parallel plates with the dimensions described for MerCAP™ are <2.5 inches of water. Results from the proposed test program will help define configuration and design considerations necessary to minimize pressure drop across the sorbents. A fixed sorbent process would consume electrical energy associated with regeneration. The extent of the power requirements is not known at this time and will depend on both the frequency and ease of regeneration (e.g., temperatures required). An objective of this test program is to obtain sufficient data for estimating these costs.

Rationale for Further Testing MerCAP™

Previous small-scale EPRI tests have shown that high levels of mercury removal are attainable in scrubbed flue gas using gold MerCAP™ technology. The proposed program offers an opportunity to evaluate gold-plate sorbents over an extended time period in two different flue gas environments in a configuration that could be applied to a commercial installation. Mercury removal exceeding the levels indicated as objectives in the solicitation has been obtained at the probe-scale at the two proposed test sites. This technology can be scaled up to the compartment-scale (Site 1) and pilot-scale (Site 2) at a reasonable cost to provide an opportunity to test over an extended period. Both chosen sites are ideal for these tests because their design allows for a portion of the flue gas to be isolated so that installation and testing can occur at pilot- or full-scale, without interruption of the normal plant processes.

Replication and Market Penetration within the Utility Industry

The proposed MerCAP™ technology is targeted as the primary mercury control process on plants burning low-rank coals, and as a polishing technology for plants with wet scrubbers or employing other mercury control technologies. Thus, its applicability represents a significant fraction of the

U.S. generation capacity. The proposed project would provide information about gold MerCAP™ performance in dry-scrubbed lignite flue gas and bituminous flue gas scrubbed by wet FGD thus representing a large fraction of scrubbed U.S. power plants.

Impact on Coal Utilization Byproducts

A major advantage of the proposed process is that it uses a fixed sorbent that can be regenerated. The captured mercury is concentrated on the fixed sorbent and is not mixed with fly ash or scrubber sludge. Thus, mercury is not transferred to another media within the power plant process using MerCAP™. Sorbent injection may reduce the ability to sell fly ash due to increased carbon content thus resulting in large increases in disposed material. A fixed sorbent process will not impact fly ash quality and will use much less material than required for a duct injection process, particularly if successful regeneration is achieved. This will provide great benefit by reducing the amount of sorbent requiring disposal. Furthermore, mercury captured on the sorbent can be collected and concentrated during the regeneration process. A simple condenser unit or carbon canister will enable utilities to isolate the mercury for storage and proper long-term containment.

TECHNICAL APPROACH/WORK PLAN DEVELOPMENT

Current Availability of Technology and Rationale for Duration of Testing

MerCAP™ technology is currently available at the scale evaluated in previous EPRI tests have been conducted primarily with gold-coated stainless steel material and fixed-structures manufactured from other sorbents such as activated carbon. Existing vendors using standard equipment have already produced gold-coated substrates of the size and type needed for this demonstration. The primary limitation to meet large market demand will be establishing facilities capable of fabricating large quantities of plates with gold. Commercial companies currently exist that can immediately provide material to a few plants and the technology to fabricate new manufacturing facilities is well established. The ultimate market demands will be determined by the effectiveness of thermal regeneration for multiple cycles and, subsequently, the gold sorbent lifetime. Upon replacement, the gold on the plates can be recovered and re-used. Other materials used in the MerCAP™ process are readily available construction materials.

The 6-month test duration proposed for each of two sites will be necessary to attain important performance and operational data needed for estimating process costs and feasibility. A longer duration is ultimately required for this process because its economics are driven by sorbent lifetime. However, we believe the proposed duration is appropriate given the cost per site limitations provided in the solicitation.

Detailed Project Description

The proposed project will take the current level of MerCAP™ development to the next logical step: Demonstrating mercury removal by gold MerCAP™ downstream of dry and wet scrubbers using configurations expected for full-scale applications. Six-month tests will be conducted at both Great River Energy's lignite-fired Stanton Station and at Southern Company Services' bituminous coal-fired Plant Yates to evaluate performance downstream of a SD-BH and wet FGD scrubber, respectively. Tests will evaluate mercury removal performance as a function of plant operating parameters and flue gas exposure time, the ability to effectively regenerate the gold sorbents, and any effects on plant operations.

Tests at Stanton Station will evaluate mercury removal from a 6 MWe equivalence of flue gas. A MerCAP™ collection array will be installed within an existing Unit 10 baghouse compartment, such that flue gas passes through the bags and then contacts the MerCAP™ plates, as shown in Figure 7. A detailed site survey to document or identify any "as built" changes in the baghouse unit will be used with the construction drawings to refine the current process design. This design will be evaluated using flow modeling and the existing mass transfer models prior to final review. Fabrication and production of the gold modules and MerCAP™ support structures and installation of sample extraction systems will be carried out by project staff and plant personnel.

Tests at Plant Yates will evaluate mercury removal from a 1 MWe pilot unit receiving flue gas downstream of the Unit 1 FGD absorber. A MerCAP™ collection array will be configured as a mist eliminator within a self-contained 24-inch (ID) pipe module to be installed downstream of the pilot absorber, as shown in Figure 8. A detailed design for the pilot mist eliminator gold plate structure will be made based on the operating parameters of the full-scale mist eliminator. This will include plate length and spacings to achieve 80% mercury removal at a linear gas velocity of 20 ft/sec. In addition, a plate-washing system, designed to operate with actual plant mist eliminator wash water, will be used to provide a similar liquid-to-plate wash ratio as used in the full-scale unit. To install the MerCAP™ unit, an existing pipe module from the pilot unit will be replaced with the test module and supported accordingly.

After the gold array modules are designed, fabricated, and installed at each plant, flue gas will be characterized using SCEMs for baseline total and elemental gaseous mercury concentrations at the inlet and outlet of the MerCAP™ array without gold plates to establish baseline conditions. The gold MerCAP™ modules will then be installed and tested for mercury removal. An initial week of intensive flue gas and process characterization will then be followed by a 6-month long-term testing period. During regular operation, the MerCAP™ arrays will require no special care or maintenance, which is another benefit of its design. The pressure drop across the arrays will be monitored and logged continuously and periodic measurements of the mercury removal efficiency will be conducted during the duration of the test program.

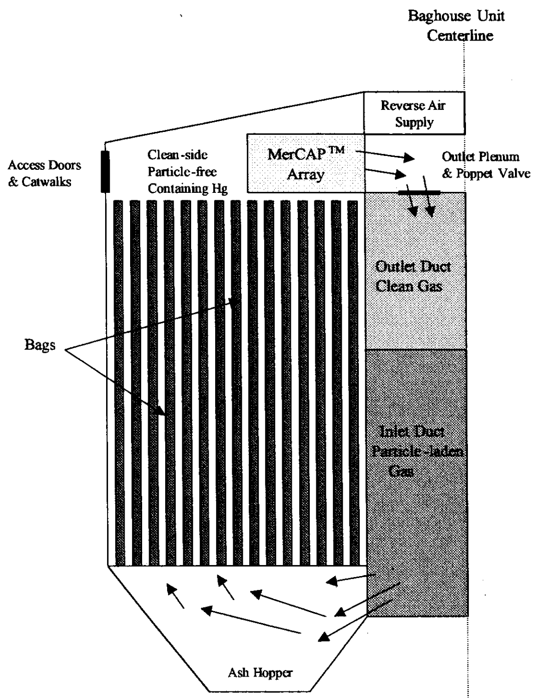

Figure 7. Schematic of MerCAP™ Technology Installed in a Baghouse Compartment.

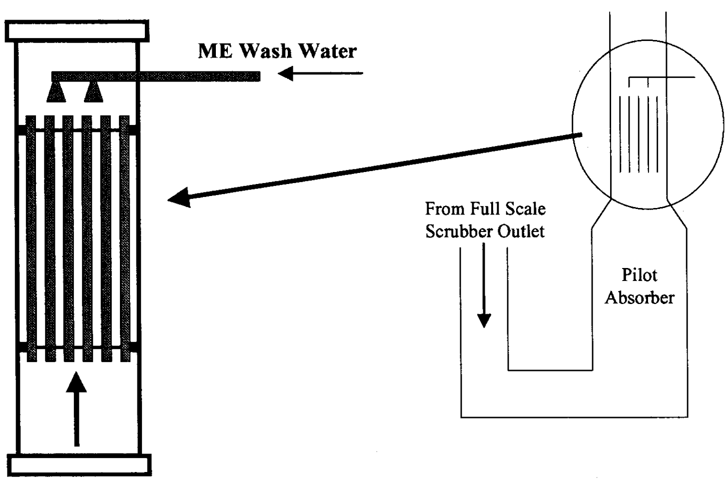

Figure 8. Schematic of Pilot MerCAP™ Module Configured as a Mist Eliminator.

Simultaneous with the long-term tests, multiple-cycle thermal regeneration of the gold sorbent structures will be evaluated using a small scale (5 –50 acfm) EPRI Mini-MerCAP™ probe, illustrated in Figure 9. The probe will be used to treat small gold plate structures with flue gas, obtained from the same flue gas source reacting with the larger-scale MerCAP™ units. The resulting data should indicate if there is a finite number of effective regeneration cycles achievable with the gold structures.

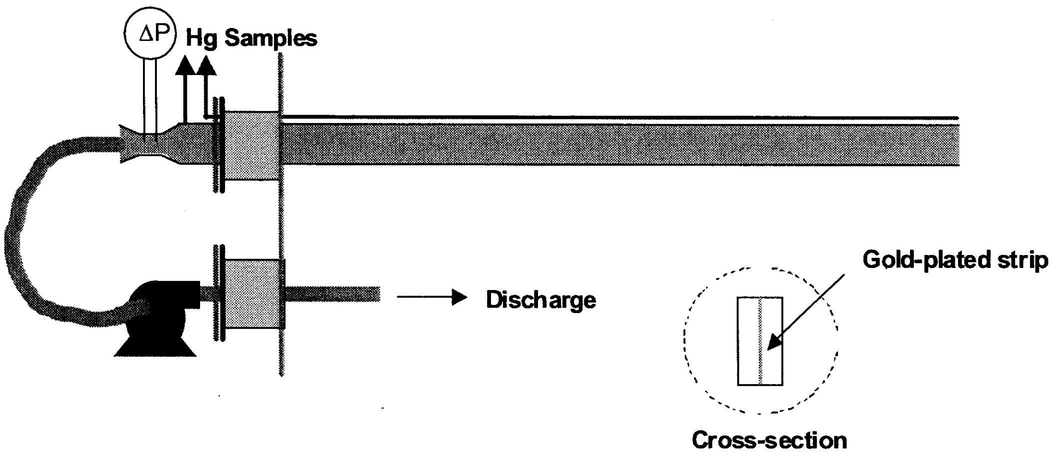

Figure 9. EPRI Mini-MerCAP™ Probe for Evaluating Thermal Regeneration.

Statement of Work

Objectives of this program will be accomplished through five primary tasks as described below. Figure 10 illustrates the overall project and milestone schedule. Table 3 summarizes the labor distribution plan, including subcontracted efforts, and Table 4 summarizes the planned travel.

Task 1 – Project Planning. This task includes the planning and reporting required at project initiation. Included will be Host Site Agreements, Environmental Questionaires, Test Plans for field and laboratory evaluations, a QA/QC plan, as described below, a Health and Safety Plan, and MerCAP™ design basis. A project kickoff and test plan review meeting will be held in Pittsburgh, and attended by the URS Project Manager and Principle Investigators from each project team organizations. Individual site kickoff meetings will be held at both Host Sites.

Figure 10. Project and Milestone Schedule.

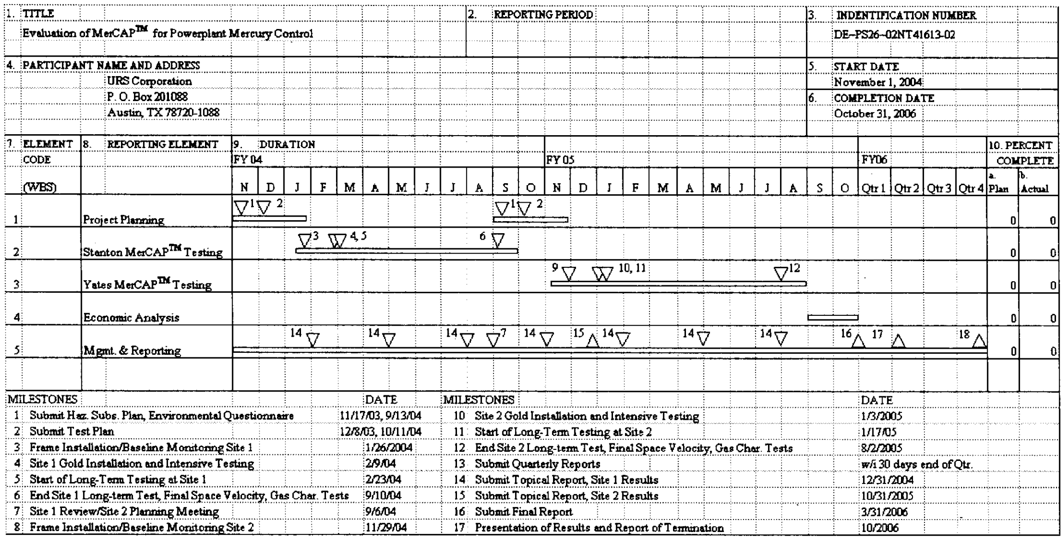

Table 3. Labor Distribution Plan for MerCAP™ Evaluation Program.

Project Team Member	Task 1 Project Planning	Task 2 Stanton Tests	Task 3 Yates Tests	Task 4 Economic Analysis	Task 5 Mgmt & Reporting	Total by Person
Gary Blythe, Peer Review	2	-	-	2	-	4
Carl Richardson, Project Mgr.	152	-	258	32	438	880
URS Process Engineers	48	-	1376	96	440	1,960
URS Process Chemists	12	305	399	-	60	776
URS Electrical Designer	-	-	60	-	-	60
URS Technicians	-	408	408	-	-	816
URS Field Chemists	-	596	596	-	-	1,192
URS Project Adminstration	8	-	-	-	260	268
URS TOTAL by Task	*222*	*1,309*	*3,097*	*130*	*1,198*	*5,956*
ADA	*192*	*80*	*80*	*80*	*304*	*736*
Apogee Principal Investigator	-	-	-	-	-	948
Apogee Project Engineers	-	-	-	-	-	916
Apogee Engineering Specialists	-	-	-	-	-	1,052
Apogee Administration	-	-	-	-	-	172
Apogee Total	-	-	-	-	-	*3,088*
EPRI Total	-	-	-	-	-	*290*
Project Total by Task	**414**	**1,389**	**3,145**	**210**	**1,502**	**10,070**

Table 4. Travel Summary.

Purpose	No. of Trips	Origin/Destination	Days	Number of Personnel
Project Kickoff Meeting	1	Austin, Tx/Pittsburgh, PA	3	1
		Denver, CO/Pittsburgh	2-3	3
		Palo Alto, CA/Pittsburgh	3	1
Stanton Site Visit	1	Austin, Tx/Beulah, ND	3	1
		Denver/Beulah	3	2
		Palo Alto/Beulah	3	1
Yates Site Visit	1	Austin /Newnan, GA	3	1
		Denver/Newnan	3	2
		Palo Alto/Newnan	3	1
Stanton Site Survey	1	Denver/Beulah	2	2
Stanton Install/Test Equipment	1	Denver/Beulah	3-11	3
Stanton Intensive/Regeneration Tests	1	Denver/Beulah	15	2
Stanton Long-Term/Regeneration Tests	4	Denver/Beulah	16	2
Stanton Gas Characterization Testing	3	Austin/Beulah	5-6	5
Stanton Long-Term Test/De-mobilization	1	Denver/Beulah	7	2
Yates Site Survey	1	Denver/Newnan	2	2
Yates Install/Test Equipment	1	Austin /Newnan	6	2
		Denver/Newnan	3-4	2
Yates Install Gold/Baseline	1	Austin /Newnan	7	2
Yates Intensive/Regeneration Tests	2	Austin /Newnan	8	4
Yates Long Term Testing	3	Austin /Newnan	8	2-4
Yates Gas Characterization Testing	3	Austin /Newnan	5-6	5
Review Meeting at DOE	3	Austin /Pittsburgh	3	1
	2-3	Denver /Pittsburgh	3	1-2
	2	Palo Alto/Pittsburgh	3	1
Technical Conference	3	Austin/Washington, D.C.	4	1
	2-3	Denver/Washington, D.C.	4	1-2

Quality Assurance/Quality Control (QA/QC) Plan. A comprehensive and detailed QA/QC plan for a measurements program of this magnitude could, in itself, exceed the page limit of this narrative. Therefore, the QA/QC plan presented in this subsection provides only overview information. Wherever possible, the information is presented in summary tables.

The quality objectives for this project will primarily address the following critical measurement parameters: 1). Speciated Hg in the flue gas at the host unit APC device inlet and scrubber outlet and the MerCAP™ unit inlet and outlet; 2). Hg content in the host site fuel and fly ash, scrubber byproducts; and 3). HCl, chlorine, and HF concentrations in the flue gas upstream and downstream of each MerCAP™ test unit. These are the primary measurement parameters that will address mercury removal performance and verification, determine Hg material balances and Hg capture downstream of the MerCAP™ process.

URS has a standard outline for Quality Assurance Project Plans (QAPPs), developed from over 20 years of quality-assured work for industry and government. A URS QAPP addresses the following components: 1). Project description; 2). Project organization; 3). Quality Assurance objectives; 4). Sampling and analytical procedures; 5). Sample handling, traceability, and holding times; 6). Calibration procedures for sampling equipment; 7). Analytical procedures; 8). Internal quality control checks; 9). Data reduction, validation, and reporting; 10). Assessment of precision, accuracy and completeness; and, 11). Audit procedures, corrective action, and QA reporting.

Table 5 summarizes quality assurance objectives for critical measurement parameters for the proposed project. Other QA objectives include representativeness and comparability. The former is primarily a function of sampling strategy. Representative samples will be collected by following specified methods and by only sampling under stable and normal operating conditions. Comparability of project data with similar studies conducted by URS and others will be ensured by adherence to standard methods and materials. Table 6 summarizes the planned sampling. The QA/QC plan will include provisions for calibrating sampling and process equipment. Quality control procedures will be included in the QA/QC plan. In most instances, strict adherence to prescribed procedures for each sampling and analytical effort is the most applicable QC check. However, in some cases specific QC samples are planned to assess overall measurement data quality. QC samples planned for the critical measurement parameters are summarized in Table 7. Host site process data will not have separate QA/QC procedures as part of this project. However, primary site data of interest are unit load and flue gas flow rate and composition (SO_2, NO_X and diluent gases). Because the former is a key performance metric for the host unit, and the latter is reported from a certified CEM system, these data are expected to be of known, high quality.

Table 5. Quality Assurance Objectives for Critical Measurement Parameters.

Critical Parameter (Method)	Sampling Method	Experimental Conditions	Precision	Accuracy	Completeness
Mercury in Flue Gas (Method 7470 Digestion; CVAA Analysis)	Ontario Hydro Method	Matrix Spike/Matrix Spike Duplicates	20% Relative Percent Difference	80-120% Recovery	100%
Mercury in Flue Gas (SCEM, CVAA Analysis)	Semi-continuous Emissions Monitor	Matrix Spike (Method of Standard Additions)/ Replicate Assays/ Relative Accuracy Testing	20% Relative Percent Difference	80-120% Recovery	80%
Mercury in Coal/Lignite, Fly Ash, FGD Liquor, FGD Solids (ASTM 3684 Digestion (solids): CVAA Analysis)	Simultaneous Grab Samples	Matrix Spike/Matrix Spike Duplicates	25% Relative Percent Difference	70-130% Recovery	100%
$HCl/Cl_2/HF$ in Flue Gas (Ion Chromatograph Analysis)	EPA Method 26a	Replicate Assays/ Matrix Spike/Matrix Spike Duplicates	20% Relative Percent Difference	80-120% Recovery	100%
Flue Gas Flow Rate, O_2/CO_2 Concentrations	EPA Methods 2 and 3	Replicate Assays	10% Relative Percent Difference	85-115% Recovery	100%

During the course of the project, it will be the responsibility of the field team leader and individual team members to ensure that all measurement procedures are followed as specified, and that measurement data meet the prescribed acceptance criteria. If problems arise, the field team leader will initiate prompt corrective action. In some circumstances, off-site senior personnel may be consulted to help define correction actions.

Laboratory supervisors will initiate corrective actions if analytical performance does not meet method specifications. Since these QC checks generally occur before analysis of any samples, little or no effect would be expected on project data quality. If there was an impact expected on actual project data, the URS Project Manager and QA/QC coordinator for the project would be contacted, and the problem resolved. If matrix-specific QC checks indicate that the measurement

Table 6. Sampling Matrix for Flue Gas Characterization Tests.

Sampling Location	Number of Runs (per Sampling Event)	Sample/ Type	Sampling Method	Sample Run Time (min)	Analytical Method
SD-BH Inlet and MerCAP Outlet (Stanton); MerCAP Pilot Unit Inlet and Outlet (Yates)	3[a]	Particulate Matter	EPA Method 5	120	Gravimetric
	3	Speciated Mercury	Ontario Hydro	120	M7470 Digestion, CVAA Analysis
	3[a]	Flue Gas Flow Rate	EPA Method 2	Concurrent with Isokinetic Sampling	NA
	3[a]	O_2, CO_2 (Orsat)	EPA Method 3	Concurrent with Isokinetic Sampling	NA
	3[a]	Flue Gas Moisture	EPA Method 4	120	Gravimetric
	3	HCl, HF	EPA Method 26a	120	Method 300 (Ion Chromatograph), Ion Specific Electrode
	>5	Total Mercury	Semi-continuous Extractive	3-10	SnCl2 Impinger Train, CVAA Analysis
	>5	Elemental Mercury	Semi-continuous Extractive	3-10	KCl Impinger Train, CVAA Analysis
Boiler Fuel Feeder	3	Coal/ Lignite	Grab	Concurrent with Isokinetic Sampling	Digestion by ASTM D4208, Chloride by Method 300, Mercury by ASTM 3684
SD-BH Hoppers	3	Fly Ash; SD Solids	Grab	Concurrent with Isokinetic Sampling	Digestion by Method 3052; CVAA Hg Analysis
FGD Absorber	3	Solids/Liquid	Grab	Concurrent with Isokinetic Sampling	Digestion by EPA Method 7470; CVAA Hg analysis

[a]Sample obtained during Ontario Hydro and Method 26a runs

Table 7. QC Samples for Critical Measurement Parameters (per Sampling Event).

	Field Blank	Trip Blank	Matrix Spike/ Matrix Spike Duplicate	Standard Material Analysis
Mercury in Flue Gas (Ontario Hydro method)	1	1	1	
Mercury in Flue Gas (semi-continuous emissions monitor)			1	
Mercury in Coal/Lignite, Fly Ash, FGD Liquor, FGD Byproducts			1	1
Chlorine in Coal/Lignite			1	1

data will not meet the QA objectives, the Project Manager will be notified immediately. The Project Manager, laboratory analytical coordinator, and the project QA/QC coordinator will then meet and resolve the issue. Impacts of measurement bias or matrix effects on project objectives, and any endeavors to mitigate these problems, will be assessed and reported in project reports. The final project report will include a separate section addressing QA/QC aspects of the project. The section will address results of all QA/QC activities and will compare results with the data quality objectives stated in the plan. The impact of any data quality objectives not achieved will be discussed in detail, along with effects on the project data and conclusions. Any incidents or requirements for corrective action will be documented.

Task 2 – Site 1 Testing. Site 1 testing will be Great River Energy's lignite-fired Stanton Station. Gold MerCAP™ plates will be installed in one of the compartments in the Unit 10 baghouse, such that flue gas passes through the bags and then contacts the MerCAP™ plates. The Stanton baghouse is comprised of ten individual compartments each of which treat nominally 33,000 acfm of gas (6 Megawatt equivalent). Task 2 includes activities required for the design, installation, operation, and testing of the MerCAP™ array at Site 1.

A Gold MerCAP™ array will be designed, based on flow modeling results and previous EPRI testing results, to achieve at least 70% mercury removal. The detailed design will include a plan for installing process frames and plates and the gold array. Once designed, the array frames and supports will be installed in the clean side of a single compartment of the Stanton Unit 10 baghouse. Gold sorbent structures will be prepared by electroplating gold onto a stainless steel substrate at a pre-determined coating thickness.

Baseline test measurements will be made to evaluate mercury speciation and concentration across the baghouse compartment housing the MerCAP frames. Mercury measurements will be carried out using both automated SCEMs, provided to the project by EPRI, and the manual Ontario

Hydro method. Other measurements will be made to characterize flue gas flow, HCl concentration, and various process parameters across the respective baghouse compartment. Following completion of the baseline measurements, the gold-coated plates will be installed into the array. Flue gas will then be directed across the MerCAP™ structure. During the initial week of gas exposure, intensive flue gas characterization will be carried out to evaluate removal performance and effects on various operational parameters. Mercury SCEM measurements will be made around the clock to follow any changes in performance. Comparison will be made to plant process data to evaluate any process effects on performance. Flue gas, fuel, and byproduct sampling will be carried out as indicated in Table 6.

Additional tests will be carried out using a small-scale (5-50 acfm) test probe to evaluate the effectiveness of multiple adsorption/thermal regeneration cycles with gold structures prepared from the same batch as the large-scale unit. During each site visit, tests will be performed using an EPRI Mini-MerCAP™ test unit designed to evaluate in situ regeneration of fixed structure sorbents. Parametric tests will be conducted at flue gas temperature and the flow rate of gas through the probe will be varied between 5 and 50 ft/sec. The resulting mercury removal across the probe will be measured. Following performance testing, the gold plates in the probe will be thermally regenerated in-situ multiple times to determine if there is any resulting degradation of the MerCAP™ system adsorption capacity. At the conclusion of each site visit, the Mini-MerCAP™ probe will be left in-service.

Following completion of the intensive characterization period, the baghouse MerCAP™ array and Mini-MerCAP™ probe will continue to operate continuously for a period of six months during which intermittent performance checks will be carried out. Mercury concentration and speciation measurements will be made using SCEMs every 700 –1000 hours to evaluate performance over time. Results will be compared to those of lignite and byproduct analyses as well as plant process data. During each site visit, regeneration tests will be performed with the Mini-MerCAP™ unit to evaluate the combination effect of exposure time and number of regeneration cycles. At several times during the long-term test, samples of byproduct solids will be obtained from the Unit 10 SD-BH compartment fitted with the MerCAP™ array and sent to a DOE contractor for mercury stability testing. During the final week of the long-term test, additional manual samples will be obtained along with the SCEM measurements, as outlined in Table 6. Following completion of this characterization, the test will be stopped and the gold plates removed from the spray dryer. Small sections of the reacted gold plates will be analyzed in a series of laboratory tests in order to determine if any changes occurred to the surface of the plates during flue gas exposure. Tests will include various surface analyses, such as Auger or X-ray fluorescence spectroscopy, as well as laboratory regeneration evaluations.

Data collected and reduced during the Stanton test program will be used to complete a Site Report outlining all site activities, test procedures and results, problems encountered, and any deviations from the initial plans. Mercury data collected from flue gas measurements will be compared to fuel and byproduct solid data to calculate mercury material balances across the Unit 10 gas path. Data from Site 1 will be used to perform the economic analysis, described below.

Task 3. Site 2 Testing. Site 2 will be conducted at Southern Company Services' low-sulfur bituminous-fired Plant Yates in Newnan, Georgia. Gold-plated structures will be configured as a mist eliminator in an existing pilot scale absorber unit that receives flue gas downstream of the Unit 1 FGD absorber. The Site 2 test program will be structured in a similar manner as the Site 1 program, described above.

A pilot MerCAP™ array will be installed as a mist eliminator module configured in an existing pilot unit. The test module will be designed within a 24-in (ID) pipe section that will replace a section of ductwork on an existing pilot unit provided to the project by Southern Company. A detailed design for the pilot mist eliminator gold plate structure will be made based on the operating parameters of the full-scale mist eliminator. This will include plate lengths and spacings to achieve 80% mercury removal at a linear gas velocity of 20 ft/sec. In addition, a plate washing configuration will be designed to provide a similar liquid to plate wash ratio as used in the full-scale unit. The MerCAP™ mist eliminator module will be constructed by a sub-contracted fabricator based upon the final design. Gold-coated structures will be prepared using the same process as for Site 1 and inserted into the test module by the fabricator. The completed test module will be shipped to Plant Yates for final installation.

Baseline measurements will be made across the Yates pilot absorber unit prior to installation of the MerCAP™ test module. Mercury measurements will be made at both the inlet and outlet to the pilot unit. Plant data and samples will be obtained as described above in Table 6. Plant process data will include points downstream of the FGD system. Following baseline measurements the completed test module will be installed into the gas path of the pilot absorber unit. This will be followed by a 1-week intensive gas characterization as described for Site 1 above. As at Site 1, a Mini-MerCAP™ probe will be configured downstream of the full-scale scrubber to evaluate regeneration of the gold structures.

Procedures for long-term tests, gas characterization, gold characterization, and data reduction will be carried out similarly as described above for Site 1. At several times during the long-term test, samples of byproduct solids will be obtained from the Unit 1 ESP and wet absorber and sent to a DOE contractor for Hg stability testing.

Task 4.0. Economic Analysis. Data gathered from Sites 1 and 2 will provide information needed to refine cost estimates for using MerCAP™ technology mercury control in flue gas. EPRI models based upon current pilot-scale data will be refined by incorporating performance and operating data from the full-scale baghouse compartment and pilot ME demonstrations. Results obtained during the long-term performance tests, Mini-MerCAP™ regeneration tests, and post-test surface analyses should provide data necessary for better predicting MerCAP™ sorbent lifetime. All of the test program data will be compiled to provide an analysis of the economic merits of MerCAP™ technology for use downstream of baghouses and wet scrubbers.

Task 5.0. Program Management & Reporting. URS Group will manage the test program including coordination of all program tasks. The project team will prepare all management reporting documents as required by DOE/NETL, and will prepare two key report types: Topical Reports that summarize and discuss results from each host site and a project Final Report. The project team will also participate in project review meetings as required, and will prepare and present 1-2 technical presentations of project results during each year of the project duration.

Quality of Expected Data / Plan for Evaluating Effectiveness of Technology

Speciated Hg measurements will be made at the inlet and outlet of the MerCAP™ arrays to determine removal at discrete points during the test period using EPRI SCEM analyzers which have been used and verified to produce quality data at over 25 power plants. SCEM data will be verified in this program using appropriate QC measures, as defined in the project QA/QC plan, as well as with Ontario Hydro measurements at specified points in the test program. Measurements will be compared with plant process data and fuel and byproduct analyses to determine possible effects on data variability. Collected plant data will include coal burn rate, boiler load, boiler oxygen, duct temperature, plant SO_2 and NO_x concentrations, and stack flow. Balance-of-plant impacts such as pressure drop across the MerCAP™ plates will also be monitored continuously. This program will evaluate changes in the ability of gold-plated structures to remove mercury from flue gas over an extended period. Results from long-term exposure and regeneration tests will be used to estimate sorbent lifetime in flue gas. This parameter will likely be the most important in determining the cost of this technology. Recent cost estimates have shown that gold MerCAP™ can provide appreciable cost benefits over other mercury control technologies providing gold lifetimes of 5 years are attained. Therefore, technology effectiveness in this program will be judged by the sorbent ability to maintain high levels of mercury removal during 6-month exposure tests while showing effective regeneration properties.

The results of this program should be applicable to full-scale applications of the technology. At Site 1, MerCAP™ is being installed into the existing duct structure and tested at full-scale on a portion of the actual flue gas. Data obtained from this project will be translatable for treatment of the entire flue gas stream. It is believed that results obtained from the 1 MWe pilot unit will also be scaleable to a full-scale process. Although there is no current precedence for scaling fixed-structure sorbents, there is considerable evidence of good agreement between pilot and full-scale results with fixed-structure catalyst materials.

During each site visit to monitor the full-scale setup, parametric tests will be conducted using a Mini-MerCAP™ probe at BH compartment temperature with gas flow rate through the probe varied between 5 and 50 ft/sec. The resulting mercury removal across the probe will be measured. Following performance testing, the gold plates will be thermally regenerated in-situ multiple times to determine if any degradation of MerCAP™ adsorption performance occurs. At the conclusion of each site visit, the Mini-MerCAP™ probe will be left in-service.

Reporting and Transfer Activities

Project progress will be transferred to the COR through regular reports throughout the lifetime of the project and by a final report at the end of the project. Site managers will be responsible for generating project activity and data summary reports that will be disseminated to the project team. The URS project manager will be responsible for preparing NETL-required reports which will be reviewed by the entire project team. Report dissemination will be followed by a webcast team meeting to discuss project status and any question arising from the summary. A final draft will then be prepared and submitted to the COR.

Chain of Command for Decisions

As the prime contractor, URS Group will have responsibility for overseeing technical and logistical decisions made during the project. The URS project manager will work closely with representatives from the host utility, the EPRI project manager and subcontract leads from Apogee Scientific and ADA-ES to ensure that all technical issues are appropriately addressed prior to making final decisions. Routine decisions will be made by the project manager or the on-site leads. If a decision requires changes in the nature of the test program, it will be discussed and agreed upon with the COR.

By-products Impacts and Sampling

The Gold MerCAP™ process will have no effect on combustion byproducts when installed downstream of dry or wet scrubbers since it will be configured downstream of byproduct removal locations. The MerCAP™ process will remove mercury emitted from upstream environmental control processes. Thus, any mercury currently being removed with the byproducts will continue to do so. Mercury removed across the MerCAP™ process will be recovered during thermal regeneration of the gold-coated structures. A low-volume concentrated stream of air and Hg will be treated using either a small carbon cartridge or a cryogenic trap. The resulting waste material will be concentrated with mercury and can thus be disposed of in a safe and secure manner. Combustion byproduct samples will be collected at both test sites for subsequent mercury stability testing by a DOE/NETL-designated laboratory. Samples will be obtained during each of three intensive gas characterization periods at both sites. At Site 1, samples will be collected from the Unit 10 spray dryer and the baghouse compartment fitted with the MerCAP™ array. At Site 2, samples will be collected from the Unit 1 ESP and from the FGD absorber reaction tank.

Plan for Maintaining System at End of Project

The MerCAP™ plates, frames, and test modules will be saved at the conclusion of the projects for future regeneration and use. Successful operation during this program may warrant continued testing to attain operating data at longer gas exposure times. In addition, the project team has had contact with power generation companies, operating PRB coal-fired boilers with scrubber-baghouse combinations, that have expressed interest in performing future MerCAP™ demonstrations. If DOE decides it does not want to continue developing this process, it is likely that there will be a market for sale of the coated sorbent plates.

Technology Transfer Path to Utility Industry

Our team members are the inventors and owners of the technology considered in this proposal. Team members also have experience with licensing and commercializing environmental control processes. MerCAP™ is an EPRI-patented technology and EPRI has an existing infrastructure and track record for licensing technologies for use in power plants. In the event that the technology is proven successful, URS is a willing licensee of this technology. URS has a longstanding relationship with utility owners and operators who would employ this technology. The scope, breadth, and dollar value of fixed sorbent technology retrofits would fall within the magnitude of turnkey engineered systems that URS has supplied to power generators including Syngyp™ FGD conversions and SBS sulfuric acid control installations.

In summary, once mercury regulations were imposed, and if MerCAP™ proves to be successful, commercialization of the technology would require licensing it to qualified engineering design firms and production of MerCAP™ units on a larger scale. The proposed team consists of proven performers serving the U.S. power generation industry that would be ready to license, design, procure, design, and construct all of the components necessary to commercialize this technology.

PROJECT MANAGEMENT, FACILITIES, AND EQUIPMENT

Project Organization and Roles and Responsibilities

A project organization chart is provided in Figure 11 with key personnel shown in bold and the numbers in parentheses show their time commitment to the project, averaged over the total project duration. The chart illustrates the proposed project WBS structure and lists the planned key subcontracts. Resumes for key project personnel are provided in an attached file. URS Group will manage the project and will oversee testing at Site 2. Apogee Scientific will oversee testing at Site 1 and post-test gold characterization testing. ADA-ES will oversee data reduction activities and the economic analysis task. EPRI will provide technical guidance and peer review for the entire program. Host utilities will provide technical peer review along with the host test sites. A brief discussion of key project staff and their proposed roles in the project are provided below.

Credentials, Capabilities and Experience of Key Personnel

URS Group. Dr. Carl Richardson will be the URS Project Manager for the proposed effort. He will be the primary point of contact between the URS project team and the DOE COR, EPRI, and the two utilities. He will be responsible for the successful and timely execution of the project, and will lead the project planning and management/reporting tasks. Dr. Richardson has a Ph.D. in physical chemistry and has worked for URS for the past twelve years as a process chemist and project manager in the areas of SO_2 and mercury control for coal-fired utilities. He has managed a number of EPRI-sponsored mercury control projects ranging from bench scale programs evaluating novel sorbents to slipstream and full scale evaluations at coal-fired power plants. He is the principal investigator on a DOE/NETL-sponsored pilot project to evaluate catalytic oxidation of elemental mercury for enhanced removal in FGD scrubbers.

Tom Machalek will lead the field-testing efforts at Site 2. He will participate in the development of test plans to determine the number, location, and types of samples to be collected. He will schedule and coordinate test and sampling personnel involved in the program and ensure data quality by communicating the QA/QC requirements to all involved parties. He will be responsible for analyzing and reporting pertinent data to the project team in a timely manner. Mr. Machalek received a B.S. in Chemical Engineering and has led a number of URS field test programs investigating various mercury controls.

EPRI. EPRI is providing a large portion of the co-funding for this project, and will co-manage the URS effort. Dr. Ramsey Chang will be EPRI's Project Manager for this project. Dr. Chang is the manager of Air Pollution Control in the Generation Group at EPRI. He is responsible for assessing and developing particulate, NO_x, SO, and air toxics control technologies for power plant emissions. Dr.Chang is one of the inventors of the MerCAP™ concept. In the last 6 years, Dr. Chang has investigated air toxics and mercury control processes including fundamental studies, bench and pilot-scale work, novel concept development and engineering economic analysis. Dr. Chang received his B.Sc. in Chemical Engineering from Lehigh University in 1971, and his M.S. and Ph.D. degrees, also in Chemical Engineering, from Stanford University in 1972 and 1975 respectively. He has authored over two hundred reports, papers, and book chapters and is a holder of 6 patents in air pollution control technology.

EPRI has been investigating mercury emissions and control since 1990 and has spent over $50 million in R&D to develop mercury measurement methods, characterize mercury emissions from power plants, assess the health effects and risks of the mercury emitted, and develop options to reduce mercury emissions. Ten mercury control patents have been issued or are pending.

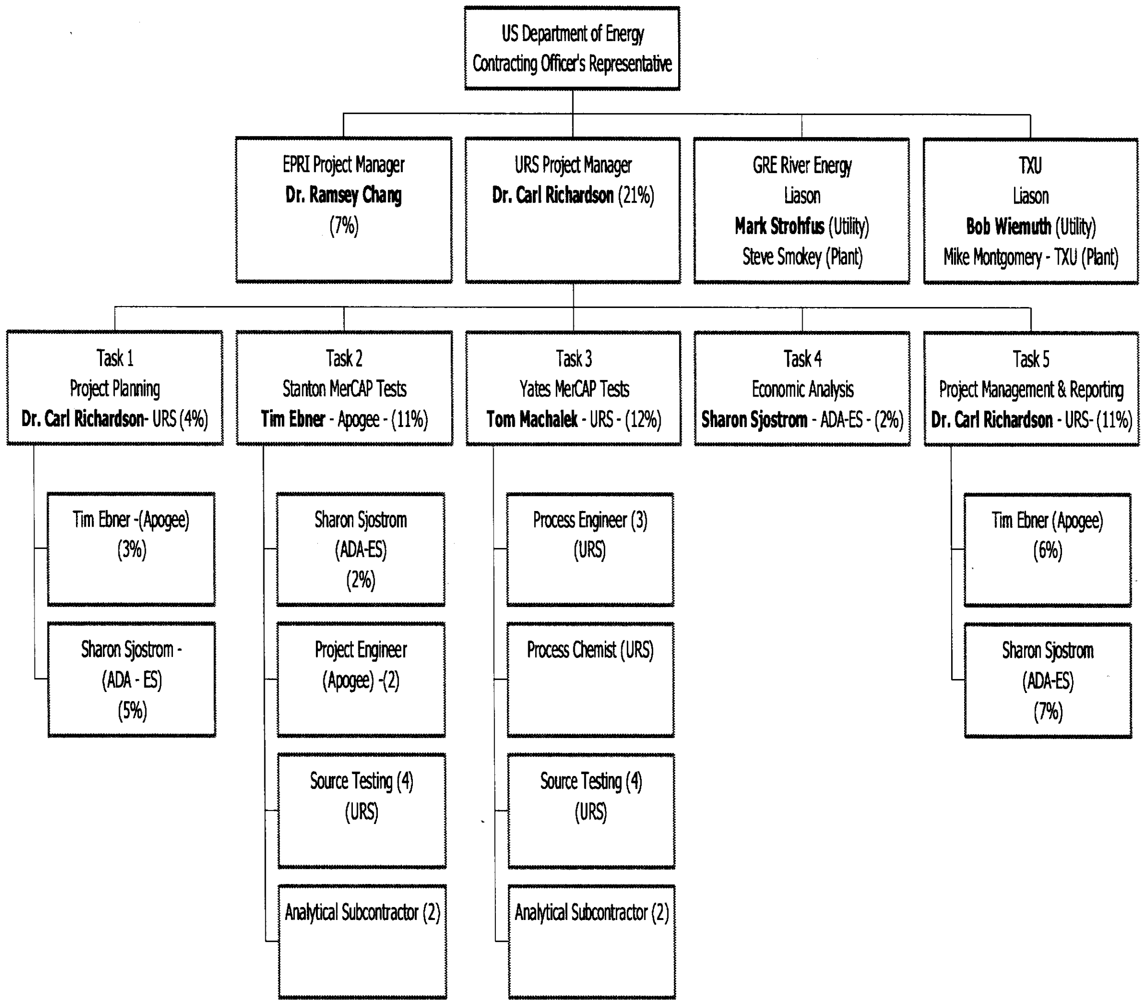

Figure 11. Organization Chart.

ADA Environmental Solutions (ADA-ES). ADA-ES will be a subcontractor on the proposed project. Ms. Sharon Sjostrom of ADA-ES will be a technical advisor for the project and will participate with test plan development and project reporting and will assist during field-testing as needed. Ms. Sjostrom is one of the inventors of MerCAP™ and has over eleven years of experience in managing research and development programs for measuring contaminants and controlling particulate and gaseous emissions from power plants and other combustion sources. Prior to joining ADA-ES in April, 2003 as the Director of Contract Research, she was the President of EMC Engineering in 2002. From 1998 through the fall of 2002, she was the

Director of Emission Control Technology Development at Apogee Scientific where she established a group to develop and evaluate pollution control technologies. She managed three full-scale evaluations of ACI for mercury control during 2000 and 2001 and designed the analyzers used during all five full-scale activated carbon injection tests. She has managed several DOE and EPRI programs at coal-fired power plants characterizing the performance of novel sorbents and commercially activated carbon with a small-scale sorbent injection system, and with MerCAP™ at over twelve utilities over the past three years.

Apogee Scientific, Inc. Apogee will be a subcontractor for this effort having designed and fabricated the MerCAP™ evaluation equipment for most tests conducted to date. Tim Ebner, P.E., Principal Engineer, and Rick Slye, Sr. Engineering Specialist, are experts at designing prototype equipment for evaluating pollution control technologies at the bench and pilot scale. The 140-acfm MerCAP™ Probe and the 30-acfm Mini-MerCAP™ Probe that have been used at several locations for in-situ evaluation of the gold/mercury amalgamation process were designed, fabricated, installed, and operated by Mr. Ebner and Mr. Slye. For this proposed program, Apogee will also participate in test planning activities, in conducting the on-site field testing, be involved in the economic analysis, and participate in the project reporting. Furthermore, Mr. Ebner and Mr. Slye have been conducting sorbent injection evaluations for mercury control in utility flue gas since 1992. These tests have been conducted at operating utilities on pilot- and bench-scale baghouses and ESPs ranging in size from 10 acfm to 5000 acfm. They designed and operated a pilot unit installed at Xcel's Comanche Station and used for much of the initial DOE ACI studies in the 1990s. They designed and operated EPRI's PoCT system that has been instrumental in gathering data for DOE and EPRI on the potential of activated carbon and novel sorbents for mercury control. Mr. Slye fabricated the mercury analyzers used during all of the full-scale DOE and EPRI studies for activated carbon injection in 2000 and 2001.

Management, Coordination, Control Procedures

URS has a long record of conducting successful research projects of this magnitude at coal-fired power plants for DOE/NETL and EPRI. In addition, Apogee Scientific and ADA-ES, team members for this effort, have similar experience. Keys to successful management of these projects include: 1). An experienced Project Manager that is technically involved in the research, and budgeted adequately to maintain control of the project; 2). Detailed project planning based on previous experience conducting similar research; 3). Preparation of a detailed Project Management Plan that is distributed to all team members to relay schedule, budget, staffing, and technical requirements; 4). Project kickoff and regular project review meetings to keep all team members current on plans, schedules and technical issues; 5). Earned Value project cost tracking, and 6). A Management Information System (MIS) that captures and reports project cost data on a timely basis. The last item is very important for keeping large projects on budget, particularly during periods of high project activity. MIS tools available on-line within URS allow the Project Manager to review labor hours charged to a project on a daily basis, and to review all project charges, including labor, travel, subcontracts and other direct costs, on a weekly basis. The availability of accurate and timely cost data allows the Project Manager to make corrective action to avoid cost overruns. Also, URS Project Manager approval is required for all subcontracts, purchase orders, and travel vouchers, which provides another opportunity to control project costs.

Appropriateness of Existing Facilities, Equipment

The expertise and equipment for evaluating MerCAP™ in laboratory and in actual flue gas slipstreams were developed by URS and Apogee for EPRI. This equipment includes semi-continuous mercury analyzers and specialized test equipment currently in use at coal combustion facilities in support of DOE and EPRI programs, such as the Mini-MerCAP™ probes, which will be made available for this program. MerCAP™ plates will be specially fabricated for each site. Techniques for fabricating the plates have been developed during previous EPRI programs.

Host sites for the proposed tests have been previously described and are representative examples of the existing coal fleet with respect to boiler type and existing air pollution control equipment. Hg SCEMs and MerCAP™ probes, to be provided by EPRI to support this work, have also been described and are well suited to achieving the objectives of the solicitation. Great River Energy has committed to providing Unit 10 at Stanton Station as a host site where a MerCAP™ array will be installed in one compartment of the Unit 10 baghouse. Southern Company Services has agreed to provide Unit 1 at Plant Yates, including use of an existing 1 MWe pilot unit which will be retrofitted with a MerCAP™ test module. Use of the pilot unit will result in an appreciable cost-savings to DOE. Commitment letters for both utilities are included in an attached file.

Source sampling equipment will be required to conduct Ontario Hydro and other manual flue gas measurements as part of the work scope. URS maintains a well-equipped source-sampling lab that includes multiples of all sampling equipment that will be required to complete the proposed scope. This equipment will be provided to the project in maintained and calibrated condition at established and standardized rates as reflected in our budget narrative.

URS, Apogee, and ADA-ES maintain laboratory facilities dedicated to evaluating mercury control processes. URS has maintained a 1600-ft^2 lab dedicated to investigating Hg measurement and control processes for over 10 years. All of these facilities are being provided to the project at no direct charge. All three groups have experience operating test equipment used for mercury control evaluations, ranging from small slipstream tests to full-scale demonstrations, and maintain an inventory of mercury SCEMs. Apogee designed and constructed the mini-MerCAP test probes to be used in this program and has used them in a number of EPRI test programs.

STATEMENT OF PROJECT OBJECTIVES

A. Objectives

URS Group and its test team are submitting this proposal to further develop the novel Mercury Control via Adsorption Process (MerCAP™). The general MerCAP™ concept is to place fixed structures into a flue gas stream to adsorb mercury and then periodically regenerate them and recover the captured mercury. EPRI has shown that gold-based sorbents can achieve high levels of mercury removal in scrubbed flue gases. URS is proposing tests at two power plants using gold MerCAP™, installed downstream of either a baghouse or wet scrubber, to evaluate mercury removal from flue gas over a period of 6 months. At Great River Energy's Stanton Station, gold-coated MerCAP™ plates will be incorporated into one entire compartment of a full-scale baghouse such that flue gas contacts them after passing through the filter bags. At Southern Company Services' Plant Yates, gold-coated plates will be configured as a mist eliminator located downstream of a 1 MWe pilot wet absorber. Additional tests are proposed to determine the ability to repeatedly thermally regenerate exposed gold MerCAP™ plates in a 40-acfm test probe.

The results of this study will provide data required for assessing the feasibility and estimating the costs of a full-scale MerCAP™ process for flue gas mercury removal. It will provide information about optimal operating conditions for different flue gas conditions, the effectiveness of sorbent regeneration, and the ability of the gold sorbent to hold up to flue gas over an extended period. In addition, if successful, the novel approach of incorporating MerCAP™ structures in existing baghouse compartments will demonstrate a cost-effective means for achieving mercury control using existing baghouse technologies.

B. Scope of Work

The proposed project will test the gold MerCAP™ concept at two utility host sites firing ND lignite or Eastern bituminous coal. Following initial design, gold-coated sorbent structures will be fabricated and configured at each plant to contact flue gas downstream of particulate and acid gas scrubbing. At Stanton Station (lignite), sorbent structures will be retrofitted into a single compartment in the Unit 10 baghouse enabling reaction with a 6 MWe equivalence of flue gas. At Plant Yates (bituminous), the fixed sorbent structures will be configured as a mist eliminator in an existing 1 MWe pilot absorber unit, which receives flue gas from Unit 1.

Sorbent structure installation at each site will be followed by a 1-week intensive gas characterization period including use of semi-continuous emission monitors (SCEMs) to evaluate mercury removal from flue gas flowing across the fixed sorbents. The sorbents will then remain in service for approximately 6 months during which periodic sampling trips will be made to evaluate performance.

Additional tests will be performed at each site to evaluate the ability to thermally regenerate the gold-coated plates. These tests will be carried out using 40-acfm extraction probes, treating flue gas obtained immediately upstream of the pilot test units, and will evaluate the effect of multiple regeneration cycles on sorbent performance.

C. Tasks to be Performed

The objectives of this program will be accomplished through five primary tasks including: Project planning; Site 1 field testing; Site 2 field testing; economic analysis; and management and reporting. The expected duration of the program is 36 months. A detailed description of each task is provided below.

Task 1.0 Project Planning

Following contract award, a detailed test plan will be developed by the project team outlining all planned activities for the project. The test plan will include host site background information, a detailed description of the test locations at both sites, planned test conditions, measurement devices and frequencies, samples to be collected, responsibilities of each subcontractor and co-funder, and the project schedule. Included with the test plan will be a stand-alone QA/QC plan describing all sampling and analytical methods and defining how data quality will be assured. Site-specific health & safety plans will also be prepared. The DOE Contracting Officer's Representative (COR) will be included in project team planning discussions to ensure that project objectives are clearly defined and that the proposed plan will enable project objectives to be met. A project kickoff meeting involving the entire team and the COR will be held at either NETL's Pittsburgh facility or at one of the host site locations. Site kick-off meetings will be held at each host site to discuss and coordinate arrangements for the installation and operation of test equipment for the test program.

Deliverables for this task will include the detailed test plan, QA/QC plan, and health and safety plan. Other plans and environmental documents required by the Reporting Checklist in the Cooperative Agreement issued by the Department of Energy will also be prepared under this task. The URS contracting department will set up all sub-contracts under this task.

Task 2.0 Site 1 Testing: Stanton Testing

Site 1 testing will be conducted at Great River Energy's lignite-fired Stanton Station in Stanton, North Dakota. Gold MerCAP™ plates will be installed in one of the compartments in the Unit 10 baghouse, such that flue gas passes through the bags and then contacts the MerCAP™ plates. The Stanton baghouse is comprised of ten individual compartments, each of which treat nominally

33,000 acfm of gas (6 Megawatt equivalent). Task 2 includes activities required for the design, installation, operation, and testing of the MerCAP™ array at Site 1. Details of each of these subtasks are given below:

Task 2.1 Detailed Design & Flow Modeling

The MerCAP™ array will be installed in the clean side of a single compartment of the Unit 10 baghouse. A schematic drawing of the proposed configuration is shown in Figure 1. Utilizing the clean side of the baghouse compartment allows for access to the array for installation, maintenance, and periodic inspection since individual baghouse compartments can be easily isolated and ventilated for safe and simple personnel access without affecting the host combustor operation. This concept would additionally enable removal of the MerCAP™ elements for regeneration or replacement and provides for an economical retrofit technology at units utilizing baghouses. The support frame for the MerCAP™ arrays is currently sized and cost-based on an assembly of parallel plates projecting from the outlet poppet valve into the top of the baghouse. The current design is based on the 140-acfm pilot unit results and would use a minimum of 10 linear feet of plate length with a 1-inch plate separation. Modeling of the mercury capture and the gas flow affects of the MerCAP™ array will be conducted and used to refine the design. The final design will be determined from flow modeling studies based on the geometry, flue gas flow conditions, and mercury diffusivity. The plates will be sized and spaced to achieve at least 70% mercury removal. The flow-modeling portion of this effort will be used to confirm current measured and predicted values of pressure drop across the MerCAP™ array as well as assure that the final design provides a uniform and optimized flow field across the array to achieve maximum removal. This subtask will also include a plan for installing the MerCAP™ frames and plates, and for designing the sampling arrays. Inlet and outlet sampling arrays will be designed to allow continuous extraction of a gas sample from the inlet and outlet of the MerCAP™ array. These sampling arrays will utilize bulkhead feed-throughs on the outer wall of the baghouse compartment so that continuous samples of mercury concentrations (total and elemental gaseous) are available for analysis by semi-continuous analyzers or manual methods. These sampling arrays will be designed to provide short residence times, inertia particulate separation, and independent temperature control of the sample gas to minimize any bias of the mercury level in the sample gas.

Task 2.2 MerCAP™ Fabrication & Frame Installation

The MerCAP™ array will be fabricated by electroplating gold onto a series off stainless steel plate substrates that are each 1-foot squares. The thickness of gold on the plates will be 13 micro-inches based on results from MerCAP™ probe tests. Four of the 1-foot square panels will be mounted in a light 2-foot square frame to facilitate handling and installation through the baghouse compartment access doors. The modules will slide into tracks mounted in the back section of the baghouse compartment. All components of the system will be fabricated off site in sections to allow access through the baghouse access doors. The host baghouse design and size allows for up to two full compartments to be off-line and isolated at any one time. Therefore, the MerCAP™ array can be installed without affecting host unit operation.

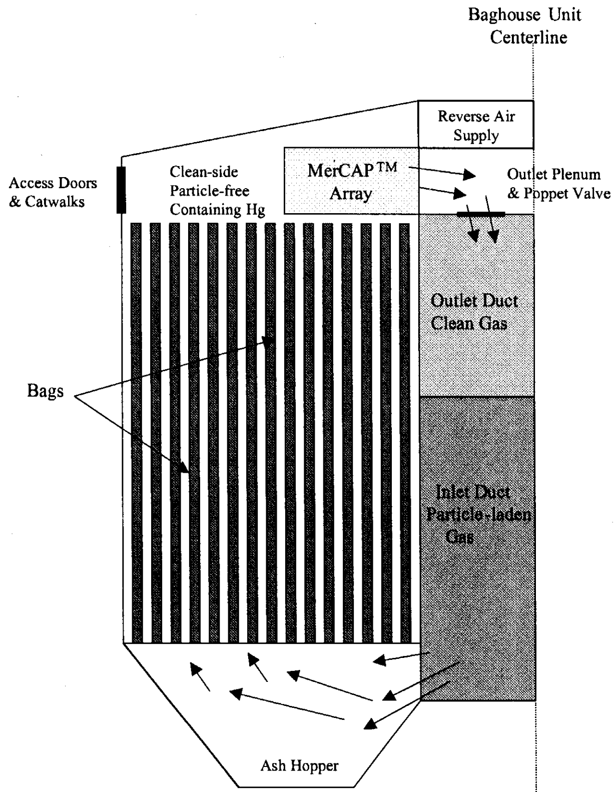

Figure 1. Schematic of MerCAP™ Technology Installed in a Baghouse Compartment.

Task 2.3 Baseline Testing

Following installation of the track and prior to installation of the MerCAP™ arrays, the flue gas will be characterized using EPRI semi-continuous emission monitors (SCEMs) for baseline total and elemental gaseous mercury concentration at the inlet and outlet of the MerCAP™ array. Oxidized mercury is calculated as the difference in total and elemental vapor-phase concentrations. Ontario Hydro (ASTM D6784-02) samples will be obtained to characterize baseline mercury speciation and removal across the Unit 10 SD-BH. Plant operational data will be collected to determine if variations in measured mercury can be attributed to changes in system operation. Plant data collected will include coal burn rate, boiler load, boiler oxygen, duct temperature, plant SO_2 and NO_x concentrations, and stack flow. Lignite and combustion byproduct samples (e.g., spray dryer/baghouse solids) will be collected daily for characterization. Lignite characterization will include ultimate and proximate analyses as well as mercury and chlorine content. Byproduct samples will be analyzed for mercury to enable material balance calculations to be made. Additional spray dryer and baghouse byproduct samples will be collected and shipped to a selected DOE/NETL contractor for mercury stability testing.

HCl concentration measurements will also be collected using EPA Method 26A. Flue gas duct velocity measurements will be obtained by EPA Method 1; this will include gas velocity at the outlet to the SD compartment to be used in the MerCAP™ tests. Pressure transducers will be installed to measure differential pressure drop across the MerCAP™ array, compartment differential pressure drop, the adjacent compartment differential pressure drop, and inlet flow rate and temperature of the treated compartment. These will be logged continuously. A summary of data to be collected during baseline testing is included in Table 1.

Task 2.4 MerCAP™ Module Installation

Following initial baseline testing MerCAP™ modules will be mounted into the frames installed in Task 2.2. Installation will occur while the plant is operating since the baghouse compartment can be isolated from the system. The 2-ft by 2-ft modules will be carried into the isolated compartment and slid and secured into the track frame structure. Based on the prelimary design the MerCAP™ modules, the installation time for one compartment should be completed by three personnel in approximately 8 hours.

Table 1. Gas Characterization and Process Parameters to be Monitored at Site 1.

Parameter	Sample/signal/ test	Initial Baseline	Intensive Test Period	Long-Term Test
Lignite Fuel	Batch sample Ultimate, proximate, Hg, Cl	Yes	Yes	Yes
Spray dryer solids and baghouse ash	Mercury	Yes	Yes	Yes
Coal	Plant signals: burn rate (lb/hr) quality (lb/MMBTU, % ash)	Yes	Yes	Yes
Fly ash	Batch sample	Yes	Yes	Yes
Unit operation	Plant Signals: Boiler load Flue gas flow; (i.e. fan amps)	Yes	Yes	Yes
Temperature	Plant signal at baghouse outlet	Yes	Yes	Yes
Duct Gas Velocity	MerCAP™ compartment outlet	Yes	Yes	Yes
Mercury (total and elemental)	Inlet & outlet Ontario Hydro	Yes	Yes	Yes
Mercury (total and elemental)	SCEM	Yes	Yes	Yes
Pressure	MerCAP Pressure Drop Baghouse Pressure Drop	Yes	Yes	Yes
CEM data (NO_x, O_2, SO_2)	Plant data – stack	Yes	Yes	Yes
HCl	EPA Method 26A	Yes	No	Yes
Stack Opacity	Plant data	Yes	Yes	Yes
Pollution control equipment operation	Plant data (Baghouse cleaning frequency, pressure drop, etc.)	Yes	Yes	Yes

Task 2.5 Intensive Flue Gas Testing and Parametric Testing

Following installation of the gold plates at Site 1, a seven-day intensive test will be conducted to characterize the flue gas flowing across the MerCAP™ array in the baghouse compartment. Total and elemental vapor-phase mercury measurements at the inlet and outlet of the MerCAP™ array will be made around the clock to determine the extent of removal achieved. Manual gas samples will be also be obtained during this period, as described above, to verify flow through the

MerCAP™ array and the extent of mercury removal achieved. The plant will operate under constant load conditions during the intensive period, if possible. Plant and MerCAP™ operating data will be monitored for comparison to the SCEM and manual sampling results as defined in Table 1.

As part of this sub-task, a Mini-MerCAP™ probe will be used to evaluate the stability of the MerCAP™ plates following multiple regeneration cycles and to measure the effect of velocity on mercury removal. This probe is designed to operate attractively or in-situ. During parametric testing, the probe will be operated installed through the wall into the top of the baghouse compartment (clean side). A sketch of the probe is presented in Figure 2. A 10-foot by 2-inch gold-coated plate is installed in the probe.

During parametric testing, the flow rate of gas through the probe will be varied between 5 and 50 ft/sec. Tests will be conducted at compartment temperature. The resulting mercury removal across the probe will be measured. The probe will be removed from the duct to thermally regenerate the plates. Between each regeneration cycle, the mercury removal across the probe will be measured. At the conclusion of the parametric testing, the Mini-MerCAP™ probe will be re-installed in the duct and left in operation for extended testing.

Plant data, such as coal burn rate, boiler load, boiler oxygen, duct temperature, plant SO_2 and NO_x concentrations, and stack flow, will be monitored to identify conditions that may affect the performance of the MerCAP™ array and Mini-MerCAP™ probe.

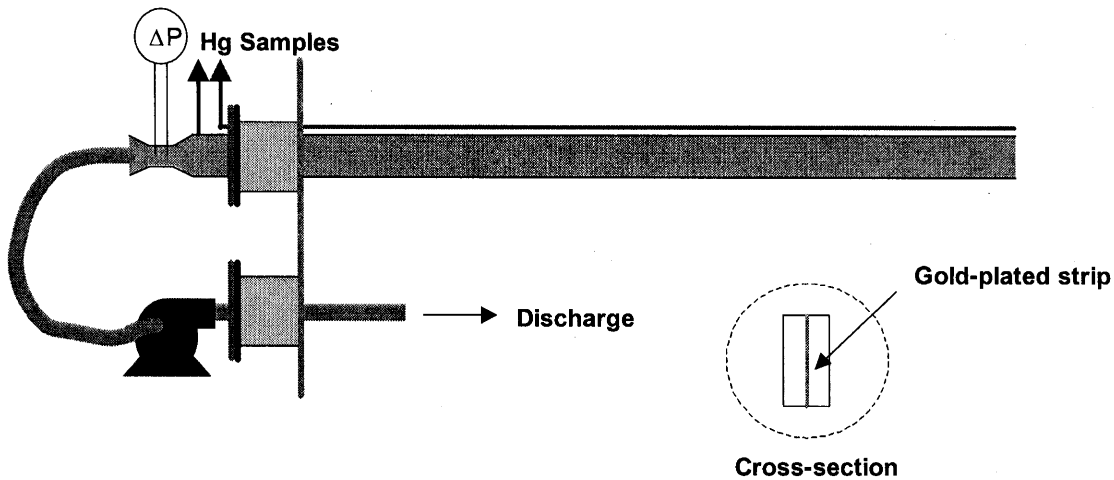

Figure 2. Schematic of Mini-MerCAP™ Test Apparatus.

Task 2.6 Long-term Tests

Following intensive testing, the baghouse MerCAP™ array and the Mini-MerCAP™ unit will be operated continuously over a six-month period, during which intermittent checks on performance will be conducted. Mercury concentration and speciation measurements will be made every 700 to 1000 hours of service. Inlet and outlet mercury measurements across the MerCAP™ array will be conducted in order to determine if there is any decrease or change the mercury removal efficiency. During each site visit, regeneration tests will be conducted with the mini-MerCAP™ unit, as described in Task 2.5. During long-term testing, the flow rate and temperatures across the MerCAP™ unit will be monitored continuously and recorded to a data logger system. The Unit 10 boiler will operate under normal conditions during the long-term test period. Plant operating data will be monitored throughout the test program for comparison of performance data. This will provide indication of mercury removal as a function of boiler load. At several times during the long-term test, samples of byproduct solids will be obtained from the Unit 10 SD-BH compartment fitted with the MerCAP™ array and sent to a DOE contractor for mercury stability testing.

Task 2.7 Gold Characterization

At the conclusion of the long-term tests, the gold plates will be removed and sections of the plates will be analyzed in the laboratory. Small sections will be characterized with surface analytical methods, such as Auger spectroscopy or X-ray fluorescence spectroscopy (XRF), in order to determine the nature of any species bonded to the gold surface. This data will provide important information for estimating the gold-plate lifetime in flue gas. Other sections of the gold plate will undergo laboratory adsorption and regeneration testing. Comparison of results of unreacted (in flue gas) samples will provide indication of the impact of flue gas exposure on the gold-mercury surface reactions.

Task 2.8 Data Reduction and Site Report

Data gathered from the various gas characterization efforts made during each of the site visits will be analyzed immediately. These data will be correlated with plant and MerCAP™ operating data obtained from each respective test period. Mercury data collected from flue gas measurements will be compared to fuel and byproduct solid data to calculate mercury material balances across the Unit 10 flue gas path. While the baghouse MerCAP™ array and Mini-MerCAP™ probe are operating unattended, data will be downloaded from the respective data loggers by plant personnel and forwarded to project engineers for data analysis. A site report will be prepared documenting measurements, test procedures, analyses, and results obtained in Task 2.

Task 3.0 Field Testing at Site 2: Yates Testing

Site 2 testing will be conducted at Southern Company Services's low-sulfur bituminous-fired Plant Yates in Newnan, Georgia. Gold-plated structures will be configured as a mist eliminator in an existing pilot-scale absorber unit that receives flue gas downstream of the Unit 1 FGD absorber. The Site 2 test program will be structured in a similar manner as the Site 1 program, described above. Thus, many of the Task 3 subtasks will be identical to those in Task 2.0 for Site 1. Differences between the two sites are summarized below.

Task 3.1-Detailed Design & Flow Modeling

A pilot MerCAP™ array will be installed as a mist eliminator module configured in an existing pilot unit. The test module will be designed within a 24-in (ID) pipe section that will be inserted to replace an existing section of ductwork on the existing pilot unit. A schematic drawing of the proposed test module in shown in Figure 3. A detailed design for the pilot mist eliminator gold plate structure will be made based on the operating parameters of the full-scale mist eliminator. This will include plate length and spacings to achieve 80% mercury removal at a linear gas velocity of 20 ft/sec. In addition, a plate washing configuration will be designed to provide a similar liquid-to-plate wash ratio as used in the full-scale unit.

Task 3.2 MerCAP™ Fabrication & Frame Installation

The MerCAP™ mist eliminator module will be constructed by a sub-contracted fabricator based upon the final design. Gold-coated structures will be prepared using the same process as for Site 1 and inserted into the test module by the fabricator. The completed test module will be shipped to Plant Yates for installation.

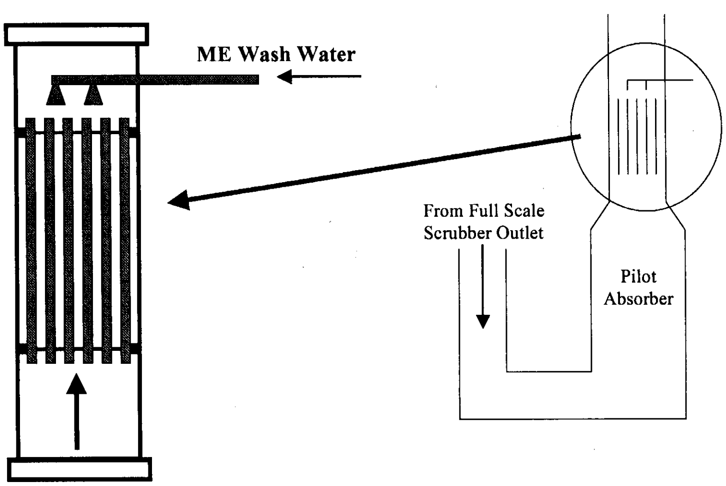

Figure 3. Schematic of Gold MerCAP™ Configured as a Mist Eliminator.

Task 3.3 Baseline Monitoring

Baseline measurements will be made, as described in Task 2.3, across the pilot absorber unit prior to installation of the test module. Mercury measurements will be made at both the inlet and outlet to the pilot unit. Plant data and samples will be obtained as described above in Table 1; plant process data will include points downstream of the FGD system.

Task 3.4 MerCAP™ Module Installations

The completed test module will be inserted into the gas path of the pilot absorber unit (Figure 3). It is anticipated that installation will not impact the operation of the full-scale unit as pilot unit tie-ins are already in place

Task 3.5 Intensive Flue Gas Testing

Following installation and startup of flue gas through the MerCAP™ test module, a 1-week intensive flue gas characterization test will be performed, as described in Task 2.5. As at Site 1, a Mini-MerCAP™ probe will be configured downstream of the full-scale scrubber to evaluate regeneration of the gold structures.

Tasks 3.7 – 3.8

Subtasks for long-term tests, gas characterization, gold characterization, and data reduction will be carried out similarly as described in the respective tasks for Site 1. At several times during the long-term test, samples of byproduct solids will be obtained from the Unit 1 ESP and wet absorber and sent to a DOE contractor for Hg stability testing.

Task 4.0 Economic Analysis

The data gathered from the test programs at Sites 1 and 2 will provide information needed to refine cost estimates for using MerCAP™ technology for controlling mercury in flue gas. EPRI models based upon current pilot-scale data will be refined by incorporating data from the full-scale baghouse compartment and pilot mist eliminator demonstrations. Data pertaining to attainable mercury removal efficiencies will be correlated to other performance aspects, such as pressure drop, estimated sorbent lifetimes, and installation costs. The results obtained during the long-term performance tests, Mini-MerCAP™ regeneration tests, and post-test gold surface analyses should provide data necessary for better predicting MerCAP™ sorbent lifetime. All of the test program data will be compiled to provide an analysis of the economic merits of MerCAP™ technology for use downstream of baghouses and wet scrubbers.

Task 5.0 Program Management & Reporting

URS Group will assume overall project management responsibilities for the proposed test program including coordination of all primary program tasks. A program management team, consisting of team members from each participating organization and NETL, will be formed to provide technical guidance for the overall program. At the onset of the program, the management activities will be primarily planning activities. Throughout the program activities to disseminate the progress and results of the project, reporting and technology transfer activities will be conducted, including preparing information for COR briefings, DOE contractor review meetings, and other technical meetings.

D. Deliverables

The initial project test plan, QA/QC plan, and health & safety plan will be finalized by the project team and submitted to the NETL COR for review and acceptance. On a quarterly basis, Federal Assistance Program/Project Status Reports and Financial Status Reports will be prepared and submitted to DOE/NETL. Technical Progress Reports will be generated on a quarterly basis to summarize the results of the MerCAP™ test program. This will include a summary of all data obtained, problems encountered, and plans to the immediate future. Topical reports will be prepared, as required. A final report will be issued at the end of the program summarizing the results of testing at Sites 1 and 2 and the final economic analysis. Environmental reports will be prepared, including a Hazardous Substance Plan once the award is made and a Hazardous Waste Report at the end of the program. A property report, consisting of a Report of Termination or Completion Inventory, will also be submitted at the end of the program.

E. Briefings/Technical Presentations

Detailed briefings shall be presented to the COR at NETL's Pittsburgh facility to explain the plans, progress, and results of the project. Technical papers describing the project status and summary of results will be presented at the DOE/NETL Annual Contractor's Review Meeting.