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UNDERGROUND GASIFICATION FOR STEEPLY DIPPING COAL BEDS

Phase I Report: Appendix B. Environmental Analysis

September 30, 1977—February 28, 1978

May 1978

Work Performed Under Contract No. EF-77-C-03-1472

Gulf Research and Development Company
Pittsburgh, Pennsylvania

and

TRW Energy Systems Planning Division
McLean, Virginia

MASTER

U. S. DEPARTMENT OF ENERGY

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PART I

B.1.0 EXECUTIVE SUMMARY

This environmental analysis is part of a study of the process concept and conceptual design to be used in underground gasification of steeply dipping coal beds. The study is being conducted as predecessor to a field test program at the North Knobs site near Rawlins, Wyoming. The field test program objectives include obtaining process feasibility and process economics data for use in producing the cost estimate for a pilot plant for underground gasification.

The environmental analysis provides a detailed evaluation of the impacts on the project site environment of implementation of the concept design, and it has pointed out areas where the Phase II project effort must incorporate appropriate additional environmental controls and monitoring capability. A detailed evaluation of relevant environmental regulations is also provided. Specifically, the analysis includes:

- An identification of process design and project implementation activities involving potential environmental impacts
- An estimate of the quantities of emissions or effluents most likely to result from the concept design or project implementation
- A detailed evaluation of potential environmental, health and safety, and area socioeconomic impacts related to the UCG field test program
- An identification of federal and Wyoming State statutory and regulatory constraints
- An identification of potential site-specific environmental, health and safety, or socioeconomic problem areas associated with the field test program

- An identification of potential environmental problem areas for which control measures will be developed and implemented as necessary to remain within regulatory constraints

The environmental analysis concludes that:

- The period of major environmental implications will occur during Phase III, since the test burns occur during this phase. Appropriate control measures must be implemented to avoid possible adverse impacts.
- No socioeconomic impacts of any significance to the Rawlins/ Carbon County area are expected due to the non-commercial nature of the program.
- Control measures may be required for the air pollutant emissions associated with access road construction, diesel generators operating on site, and flaring of the product gas at maximum flow.
- Appropriate measures are needed to monitor groundwater quality and thus track effects due to leaching or gasified subsurface strata
- The site surface area must be monitored to detect and track such subsidence as may occur. It is difficult to predict location, extent and character of subsidence which may take place, but such measures are necessary to determine the magnitude of any subsidence which may occur.
- Specific control measures need to be developed and evaluated during Phase II and implemented during the program as necessary to resolve the identified potential problem areas and assure that regulatory constraints are met.
- Monitoring of sub-surface aquifers and monitoring for subsidence at the test site should be continued following the burns for a minimum of one year

B.2.0 INTRODUCTION

This environmental analysis is part of a study of the concept design for underground gasification of steeply dipping coal beds. The study is being conducted for a field test program at a site in Wyoming in which steeply-dipping coal seams will be partially burned in-situ to produce a gas which could be used in certain commercial fuel applications.

B.2.1 Background

The study is being conducted under a cost-sharing contract awarded by the U.S. Department of Energy to Gulf Research and Development Company, Pittsburgh, Pennsylvania to develop a process for the underground gasification of coal seams otherwise considered inaccessible. The Energy Systems Planning Division of TRW, Inc., McLean, Virginia is a major subcontractor on the project.

The goal of the field test program is to provide data on the process feasibility and economics, including system requirements and expected gas production. These data will be used to produce a cost estimate for the design, construction and operation of a pilot plant which would be used to evaluate future commercial development of the process for underground coal gasification of steeply dipping beds.

B.2.1.1 Field Test Program Description

The field test program involves the siting, design, construction, operation and evaluation of underground coal gasification tests, which will be conducted in four phases over the next five years.

The first phase of the project, currently underway, involves site selection, preliminary environmental assessment, and technical planning and design. Following this, the second phase involves site characterization, environmental monitoring, and field development work. Plans for the third phase call for field operations and testing through 1980, followed by test site restoration. The final phase will involve the preliminary designing and costing of a pilot scale project which would be used in the future to evaluate commercial applications of the product gas.

The activities of each of these phases are further detailed in a later section of this report.

B.2.1.2 Project Location

Steeply dipping subbituminous coal fields occur primarily in the western United States that have been subject to major deformational folding. A site for the underground coal gasification field test program has been selected in the North Knobs area of Wyoming.

The test site area is located approximately eight miles west of the town of Rawlins, the county seat for Carbon County, in the south central portion of Wyoming as shown in Figure B2-1.

The site selected in this area is Section 11, T21N, R 89 W, as shown in Figure B2-2. It is along the southeastern edge of the gently rolling prairie terrain that characterizes the Great Divide basin, at an elevation of about 6,800 feet.

B.2.2 Objectives

The purpose of this environmental analysis is to provide a detailed evaluation of the impacts of the parameters contained in the concept design on the site environment and relevant environmental regulations.

The principal objectives of this analysis, therefore, are:

- To identify UCG project products/byproducts and activities involving potential environmental impacts
- To estimate the quantities of emissions or effluents most likely to result from the concept design or project implementation
- To consider UCG impacts on the Rawlins site area environmental quality, including health, safety and area socioeconomic concerns
- To identify regulatory constraints on UCG environmental impacts
- To identify potential site-specific environmental, health and safety, and/or socioeconomic problem areas associated with the UCG activities
- To recommend activities to resolve potential problem areas and remain within regulatory constraints

Figure B2-1 Index Map of North Knobs Area, Carbon County, Wyoming

B.3.0 SITE CHARACTERISTICS AND PROJECT IMPLEMENTATION ACTIVITIES

Two brief summaries are given below to describe the baseline used for the environmental analysis. These are: a short statement of the current (pre-test) environmental characteristics at the site and the surrounding area; and a concise account of the UCG project implementation activities scheduled for each phase of the program.

B.3.1 BROAD BASELINE ENVIRONMENTAL CHARACTERISTICS

The selected UCG site is located in a rural setting, generally characterized by relatively dispersed ranching and surface mining activities. The following sections briefly describe the major environmental characteristics of the North Knobs and Rawlins area, based on available data for the general area, as well as site specific data. Although minimal information was available for certain environmental parameters, particularly site-specific geology and hydrology data, broad baseline environmental quality characteristics may be projected from regional data. Activities to characterize and evaluate the geological, hydrological and coal characteristics of the site are currently underway.

B.3.1.1 Geology

The stratigraphic columns of interest in the North Knobs area, using the current nomenclature, are the Fort Union formation (Tertiary System) with an estimated thickness of 7,250 feet, the Lance formation (Cretaceous System) which is a coal bearing formation about 4,800 feet in thickness, and the Lewis Shale formation (Cretaceous System) which is about 1,350 feet thick.

The four (4) steeply dipping coal beds underlying the North Knobs area in Carbon County are listed below. The upper three beds have potential for underground coal gasification.

	<u>Range in Thickness (feet)</u>		
Wally Bed	0.0	-	13.0
Interval	155.0	-	250.0
G Bed	7.0	-	25.0
Interval	140.0	-	210.0
I Bed	5.5	-	16.0
Interval	4200.0	-	4300.0
Nebraska Bed	7.0	-	11.0

The upper three (3) coal beds are contained in the Tertiary Fort Union formation, and the Nebraska bed is in the Cretaceous Lance formation.

Strata within the study area generally strike about N 20° W and commonly dip southwesterly from 64 to 68°. An exception to this general trend is in the S/2 of Section 13, T 21 N, R 89 W, where the Fort Union Formation bends to a strike of nearly north-south and dips flatten to 17°. Dips on the North Knobs Test Site are about 64° SW.

The following table of analytical values from the various coal beds in the study area is based on reports of analytical work conducted by the Energy Development Company at their lab in Hanna, Wyoming.

Table B3-1
Representative Coal Quality
North Knobs Area
Carbon County, Wyoming

Coal Bed	As Received Basis			
	%Moisture	% Ash	% Sulfur	Btus/lb
Wally	18.6	7.4	0.45	9386
G	20.8	6.4	----	9429
I	19.5	10.8	----	8738
Nebraska	No analytical reports available			

All of the Fort Union coal beds reported above are subbituminous B rank according to ASTM classification.

The surface geology of Section 11 has been typed by an Order 3 survey, however, no published data are currently available. The site area is generally characterized by both shallow and deep alluvial soils between sandstone outcroppings and ridges. Shale is present in significant quantities. Soils are mostly coarse textured.

B.3.1.2 Hydrology

Minimal hydrological information, particularly site-specific, is available for the Section 11 site. A resistivity survey conducted by Group 7 of Golden, Colorado on the site indicates that the water table is located at

a depth of about 70 feet below the surface. No surface water bodies are located on the site, and only an intermittent stream is located in the area north of the site.

B.3.1.3 Climatology

The North Knobs site is approximately eight miles west of Rawlins and 18 miles east of the continental divide along the southeastern edge of the gently rolling prairie terrain that characterizes the Great Divide basin. The elevation is about 6,800 feet. The climate may be described as semi-arid with a mean relative humidity of 55%. The humidity seldom exceeds 30% at temperatures above 80°F.

The Rawlins airport provides the closest climatological data. These data may be representative of general climatological conditions of the area but specific site conditions, particularly wind vectors, may differ because the meteorological station is separated from the site by a ridge or hogback approximately 1,100 feet high. The hogback runs in a northwest-southeast direction and is of sufficient height to affect the local winds measured at the airport.

The average monthly temperature means vary between a low of 11°F and a high of 31°F for January to 51°F and 83°F for July. The high elevation allows average diurnal variations of 20° in the winter and 32° in the summer. High and low extremes have been 98°F and -36°F respectively.

Precipitation has averaged 7.7 inches annually with about half of the moisture occurring as rain during May to September and the remainder as snow. May is the wettest month. The average snowfall is 39 inches. On the average, precipitation greater than 0.1 inch occurs only on 27 days of the year.

Windy days are quite frequent during the winter and spring months. As an example, during January at Rawlins, about 27 days of the month have winds during the day of greater than 11.5 mph. During the summer months, the wind frequency is reduced with about 15 days having wind velocities greater than 11.5 mph during July. The nighttime winds tend to be calmer due to decreased thermal

activity. Velocity readings may vary by a factor of 2-3 between daytime and nighttime on the average. Wind directions are predominantly westerly ranging from the SW to NW quadrant. During periods of relative calm, local drainage wind may occur from the ridge to the east.

B.3.1.4 Air Quality

Air quality data for the North Knobs/Rawlins area or the site is minimal due to the rural location. Activities to characterize and evaluate baseline environmental quality, including air quality, are planned for the site. Since there is essentially no major industrial or residential development to provide contributing pollutant sources in the North Knobs area, existing levels of regulated air pollutants are expected to be relatively low. Ambient air quality levels are expected to be equivalent to background concentrations.

B.3.1.5 Water Quality

There are no surface water bodies located on or near the site, with the exception of an intermittent stream in the area north of the site. No ground water quality information is currently available for the site or the surrounding area, therefore, ground water quality could not be characterized. Activities for characterizing and evaluating baseline ground water quality on the site are planned.

B.3.2 PROJECT IMPLEMENTATION ACTIVITIES

The activities at the Rawlins site are described on a conceptual basis by program phase, as follows:

B.3.2.1 Phase I Activities

The feasibility analysis and conceptual site design work takes place during Phase I. Specific activities include the following:

- Environmental and other site characteristic data gathering and analysis
- Site selection
- Conceptual equipment design
- Preliminary environmental analysis

- Initiation of permit acquisition
- Program planning

Site activities will be limited during Phase I to occasional visits by project personnel for surveys or other non-impacting uses required to aid in the planning process.

B.3.2.2 Phase II Activities

Activities during Phase II are planned to characterize and evaluate the environmental, geological, hydrological and coal characteristics of the site. Late in Phase II site grading and preparation for test facility construction will begin. Specific Phase II activities are listed in Table B3-2.

B.3.2.3 Phase III Activities

Facility construction and equipment location will be completed during Phase III in preparation for three test burns. During the early part of Phase III, the temporary service building will be constructed along with the hardstands and parking areas for the mobile trailers and compressors. Additional work will be involved in the construction of berms for the water reservoir and fuel storage area.

The first test burn is planned for about 20 days for the purpose of evaluating the process equipment and process (i.e., test burn) controllability. Test number 2 will be used to evaluate the process parameters with a systematic variation of the controllable variables. This burn is expected to last for 80 days and will involve a module configuration of two injection wells and one production well. Burn number 3 will use a two module parallel configuration with four injection wells and two production wells. The burn will last up to 80 days to produce high quality production gas in a multi-module configuration.

The final Phase III activity is site restoration, which will take place subsequent to burn number 3. The equipment, service building, above ground foundations, footings, hardstands and such will be removed upon completion of the planned test burns. The site will be regraded to match the original terrain, and revegetated.

The specific activities that take place during Phase III are listed in Table B3-3.

Table B3-2
Phase II Project Implementation Activities

Activity	Description
Access Road Construction	1.5 miles, 22 ft. graded and gravelled all weather to Section 11. 3/8 mi. in Section 11
Site Grading	General clearing, grading and leveling of approximately 15 acres
Core Drilling	4, 4-inch nominal core holes 450' to 600' deep
Well Drilling	2, 6-inch wells for water supply approx. 120 ft. deep 12, 6-inch environmental wells 150 to 600 feet deep
Trenching	10' deep x 4' wide x 30' long along coal seam and back filled
Process Wells	1, 12" production well down the bed 1, 12" injection wells at a 45° angle into the coal bed
Coal Bed Permeability Tests	Air injected into the injection well
Hydrological Testing	Water analysis and draw down and recovery pumping tests from environmental wells
Environmental Monitoring	Monitoring trailers located at the site and/or nearby ranch locations

Table B3-3
Phase III Project Implementation Activities

Activity	Description
Construct Service Building and Pump House	40' x 120' metal building on concrete pad 10' x 20' frame pumphouse
Parking	6,000 sq. ft. gravel lot
Trailer Hardstands	4,000 sq. ft. blacktopped pad
Water System	Non-potable fire and facility water system, surface piping
Sanitary System	Septic tank and leach field trailers
Water Reservoir	50' x 50' x 4' earth bank, plastic lined
Power	2,000 kw diesel generator and 15,000 gallon fuel storage tanks with earth berm. Alternative plan requires 1.5 miles utility line with transformer bank
Gas Collection Lines and Flaring Stacks	Lines for collection, cleanup, and flaring stacks to burn produced gas
Install Major Equipment	5 personnel and instrumentation trailers 5 compressors
Test Burn 1	Approximately 20 days duration Quench by water or by sealing of both wells
Test Burn 2	Approximately 80 days duration followed by quench
Test Burn 3	Approximately 80 days duration followed by quench
Site Restoration	Remove equipment, service building, above ground foundations, footings and hardstands. Regrade and revegetate.

B.3.2.4 Phase IV Activities

The final phase consists of preliminary designing and costing of a pilot-scale facility to be used for evaluation of commercial applications. There will be no site-related activities in this phase.

B.4.0 ANALYSIS OF POTENTIAL ENVIRONMENTAL IMPACT RELATED TO THE CONCEPT DESIGN

The effects of implementing the process concept design are evaluated in the sections which follow, in terms of the potential environmental impact on air, water, and land during each phase of the program.

B.4.1 POTENTIAL AIR QUALITY IMPACT

Potential air quality impacts of the field test program are evaluated based on the known parameters related to the process concept design and project implementation activities. Estimates of air pollutant emissions are based on available emission factors and related UCG project results or observations at the LERC Hanna facilities. Pollution control measures will need to be addressed to conservative pollutant concentration estimates (i.e., the maximum level expected), and therefore unfavorable or "worst case" meteorological conditions likely to occur at the site were assumed. Actual pollutant concentrations under typical meteorological conditions will be lower than these estimates.

B.4.1.1 Phase I Impact

Minimal air quality impact is expected to result from Phase I since on-site activities are limited to periodic non-impacting survey visits by project personnel.

B.4.1.2 Phase II Impact

Inert dust generation during the construction of the five acres (total area) of access and site roads will probably be at the rate of approximately 0.4 gm/sec for dusts under 30μ . Estimated air-borne inert dust concentrations within 0.1 km downwind of the road construction activities, assuming wind speeds less than 4 mph (a "worst case" condition for the area), will be above $240 \mu\text{g}/\text{m}^3$, and most probably above $440 \mu\text{g}/\text{m}^3$, taking into account the estimated background concentrations for the area of $40 \mu\text{g}/\text{m}^3$. Suspended particulates downwind within the 0.1 km distance from road construction would

thus probably be at or above the 24-hour EPA Secondary Standard of $150 \mu\text{g}/\text{m}^3$ if no abatement techniques were used. Concentrations further downwind will decrease sharply with increasing distance.

Carbon monoxide, nitrogen oxides, non-methane hydrocarbons, SO_2 and particulate emission by the diesel powered equipment and gasoline-powered trucks used for road construction will probably have no measurable impact upon air quality. CO concentrations, for example, are expected to be less than $10 \mu\text{g}/\text{m}^3$ within 0.1 km downwind. Inert dust generated by vehicle travel on the unpaved gravel roadways is estimated as slightly under 90 g/vehicle mile, which is insufficient to cause significant area degradation of air quality (assuming normal work traffic to be about 10 vehicles at 30 miles per hour).

Site grading and preparation activities, being somewhat more concentrated in character than road construction, will cause estimated downwind dust concentrations above $500 \mu\text{g}/\text{m}^3$ and most probably above $900 \mu\text{g}/\text{m}^3$ within 0.1 km (assuming wind speeds of less than 4 mph). The downwind distance inside which site grading/preparation dust concentration 24-hour averages at or above $150 \mu\text{g}/\text{m}^3$ would probably be just over 0.2 miles.

The remaining Phase II activities will have no measurable impact on air quality in the general area of the test site.

B4.1.3 Phase III Impact

The completion of road construction activities will impact air quality in the immediate construction area similar to that projected above for this activity during Phase II. Other Phase III construction activities are not expected to impact air quality at the test site measurably.

The pollutants present after flaring the production gas will include SO_2 , NO_x , and particulates. Other pollutants such as non-methane hydrocarbons could be present. Respirable particulate emissions for Test Burn No. 1 will probably range between one pound and 40 pounds per day. The polynuclear aromatic hydrocarbon (PNA) content of the production gas is projected to be in the $\mu\text{g}/\text{m}^3$ range, based on a preliminary analysis. If there is

incomplete mixing and combustion in the flare, a large fraction of these potential carcinogens could be discharged to the air chemically intact, presenting a health problem.

The projections of air pollutants cited above assume no measurable leakage through the strata above the coal seam, as per observations at Hanna.

The estimated maximum concentrations of two major process pollutants--SO₂ and particulates--at ground level downwind from the flare stack, assuming worst conditions, are presented in Table B4-1. The values presented are based on EPA-accepted methods for calculating pollutant dispersion using Briggs plume rise equation.

TABLE B4-1

PROCESS TEST BURN NO. 1 ESTIMATED MAXIMUM DOWNWIND POLLUTANT CONCENTRATIONS (WORST CONDITIONS†)

Pollutant	Maximum Daytime Concentration ($\mu\text{g}/\text{m}^3$)	Maximum Nighttime Concentration ($\mu\text{g}/\text{m}^3$)	National & Wyoming State Ambient Air Quality Secondary Standards ($\mu\text{g}/\text{m}^3$)
SO ₂	185	164	1,300 (3-hour average)
Particulates	19	16	150 (24-hour average)

†As calculated by EPA-PTMAX Dispersion Model and not including background concentrations.

The maximum concentrations occur at distances less than 350 m during both day and night at a wind speed of 5 m/sec. Ground level concentrations at other wind speeds, slower and faster, and other stabilities classifications are less than shown in Table B4-1.

Previously reported values for ground level concentrations for pollutants emitting from the flare are an order of magnitude higher. Values for CO, NO_x, and unburned hydrocarbons were from data obtained at Hanna. Examination of the nature of the samples shows them to be not representative of flare product. They were from a partially combusted zone

in the flare stack and were calculated using Turner's centerline equation.* Zero plume rise was used in these calculations since Turner's Workbook** suggests that the plume rise as calculated by the Holland equation should not be applied within the first few hundred meters of the stack. Subsequent to the publication of the Workbook, the Briggs plume rise equation has become the standard for dispersion calculations. Turner[†] in 1973 indicated that the EPA had been using the Briggs equation in their calculations for several years. Mahoney^{††} in 1974 stated that when it is necessary to estimate plume rise within the first few hundred meters from the stack, it is suggested that the Briggs plume rise equation be used. Values in this report were obtained using this current plume rise technology.

It should be noted that process test Burn Nos. 2 and 3 are projected to have air injection rates and product gas flow rates higher than the product gas flow rate planned for process test Burn No. 1. Since pollutant concentrations downwind at ground level are a function of the rate at which product gas is flared, the resultant maximum concentrations for Burn Nos. 2 and 3 would be higher than those shown in Table B4-1.

For example, estimated maximum downwind daytime pollutant concentrations during the last 15 days of Burn No. 3 are presented in Table B4-2.

TABLE B4-2

PROCESS TEST BURN NO. 3 ESTIMATED MAXIMUM DOWNWIND POLLUTANT CONCENTRATIONS (WORST CONDITIONS[‡])

Pollutant	Maximum Daytime Concentration ($\mu\text{g}/\text{m}^3$)	National Secondary & Wyoming State Ambient Air Quality Standards ($\mu\text{g}/\text{m}^3$)
SO ₂	227	1,300 (3-hour average)
Particulates	18	150 (24-hour average)

*D. Bruce Turner, Workbook at Atmospheric Dispersion Estimates, PHS No. 999AP26, U.S. Department of HEW, NAPCA, Cincinnati, Ohio. Revised 1969, p. 6.

** ibid, pg. 31

† private communication.

†† Industrial Pollution, N.I. Sax, Van Nostrand Reinhold, N.Y., 1974. Meteorological Aspects of Air Pollution, pp. 420-421, Chapter 15.

‡ See Table B4-1.

Emission from the 2000 kW diesel generator which will start operation early in Phase III are estimated as follows for operation at 75% of load:

<u>Pollutant</u>	<u>Discharge g/sec</u>
SO ₂	0.5
CO	0.8
Non-Methane hydrocarbons	1.1
NO _x	6.6

It is therefore estimated that the diesel generator exhaust can impact significantly on test site non-methane hydrocarbon and NO_x pollution levels, even in the absence of test-burn product gas flaring. The potential problem due to flaring at the test site is compounded further by contaminants from the relatively closely-located diesel generator exhaust.

The remaining test and quench activities scheduled for Phase III have no probable air quality impact. Site restoration activities will generate a small, environmentally insignificant quantity of inert dust pollution from normal road traffic and a considerably greater quantity of inert dust particulate pollution as the result of regrading to match the terrain. Anticipated downwind dust concentrations from regrading activities will be of the same order of magnitude as those cited earlier for grading in Phases II and III (between 500 µg/m³ and 900 µg/m³ at 0.1 km for winds below 4 mph).

B.4.1.4 Post-Burn Impact

Post-burn activities will not cause measurable change in test site air quality.

B.4.2 WATER QUALITY IMPACT

There is little current knowledge regarding the sub-surface aquifer distribution and flow rates at the test site, and sub-surface water quality. The projections of potential impact on water quality which follow are based on Hanna and Hoe Creek test burn data. The actual impact at the test site may be different due to differences between the subsurface hydrology of the North Knobs area and the subsurface hydrologies of Hanna and Hoe Creek.

B.4.2.1 Phase I Impact

No measurable impact on surface or ground water quality is expected to result from Phase I on-site activities since these are limited to periodic survey visits by project personnel.

B.4.2.2 Phase II Impact

Principal effects of Phase II activities on the intermittent surface water flow present during spring snow-melt will be increased total suspended solids (TSS) in the immediate vicinity of the test site. The TSS level will drop to normal for the area within a relatively short distance downstream of the test site.

The use of adequate, properly functioning portable sanitary facilities by construction and test personnel, with contract disposal of residues off-site, will be necessary to protect intrusion by these wastes into surface and sub-surface water. Similar protection via catchment and off-site disposal will be required to guard against water contamination by lubricant and fuel oil residues from operating construction equipment.

Sub-surface water contamination arising from the process and environmental well drilling activities is projected to be minimal, since air drilling is being used and the wells are cased. In this connection, it should be noted that the plastic casings used can, through plasticizer migration, serve as a source of sample contamination. Alternatively, the plastics can absorb organic compounds from the water seeping in from sub-surface aquifers. Thus, the true composition of sub-surface water may differ from that obtained by analyses of non-flow condition samples taken from the plastic casings.

Coal bed permeability tests involving air injection may cause a temporary increase in flow of water from the coal bed into adjacent aquifers, with the potential for slight degradation of the water quality in the adjacent aquifers. The principal contaminant responsible for the temporary degradation would probably be dissolved methane.

B.4.2.3 Phase III Impact

Construction activities during Phase III would have about the same effects on water quality as those noted above in Phase II for construction activities.

The septic tank and leach field system contained in the concept design for disposal of sanitary wastes will have no impact upon the quality of intermittent surface water flow, and are projected to have no measurable impact on groundwater quality outside the test site.

The most probable source of water quality is leaching from the coal-bed char ring and ash zones resulting from the burns.

Potential groundwater pollution due to leaching from strata subjected to underground coal gasification has been the subject of a number of studies by Lawrence Livermore Laboratory (LLL). Based on these studies, and the assumption that the North Knobs test site and Hoe Creek (the LLL study site) have analogous geology, groundwater will slowly re-enter the gasifier ash zone and the surrounding char zone (far behind the "flame" front), with large increases in cyanide, iron, and phenol content, as well as increased in electrical conductivity. For example, initial values for CN of 0.01 mg/l may increase to mid-burn values of 7 mg/l. These ground water effects will be felt laterally in the coal seam at distances up to 100 feet from the burn zone. After completion of gasification, ground water continues to reinvade the gasifier, with natural flow eventually being re-established through the coal bed. Outside the burn zone, the contaminated plume in the coal bed may contain toxic materials such as phenols, cyanides, lead, barium, and boron in concentrations of 500, 300, 0.04, 1.0, and 0.5 mg/l, respectively. The phenol and cyanide concentrations cited are far in excess of the permissible concentration limits in public water supplies. However, all contaminants in ground water will decrease rapidly with distance from the burn zone, probably due to adsorption in the unreacted coal surrounding the char ring, and some (particularly phenols and cyanide) will most likely show a decrease in concentration with time. Migration of the plume of contaminated water outside the seam is estimated to be extremely slow, and will most likely take place during the following Phase IV. Discussions of the potential role and extent of pollutant migration are covered under Phase IV below.

Quenching the test burn gasification zones with water can produce a potential environmental impact in two modes: (1) sudden increase in intrusion by contaminated water into ground water, and (2) a depletion of the ground water resource due to the quantities required for the quenches. Rapid injection of water into the gasification zone can cause flow rates far in excess of those normally encountered sub-surface, with contamination of nearby aquifers in excess of that predicted based on normal rates.

Currently, alternative modes of quenching the test burns are being evaluated, including quenching with foam agents and quenching by oxygen deprivation. These alternative modes are likely to have a lesser impact on ground water quality.

The estimated water quality impact of the site restoration activities planned for Phase III is extremely low. There may be an increase in total suspended solids in the intermittent surface water flow due to sediment from building, foundation and equipment removal and regrading activities. It will be necessary to provide portable sanitary facilities and catchment devices for mobile equipment lubricant and fuel oils, with appropriate off-site disposal of residues, to prevent intrusion of these wastes into surface and ground water systems.

B.4.2.4 Post-Burn Impact

The major source for potential degradation of ground water during Phase IV will be lateral and vertical migration of leachate from the coal gasification strata. On the basis of the LLL studies cited above, lateral migration of the contaminated ground water plume is estimated to be about 17 meters downstream in ten years with a sub-surface water flow velocity of 43 inches per year. No spreading of the plume normal to the sub-surface water flow direction is projected. On this basis, if the North Knobs sub-surface water flow and geology are compatible with projections based on the LLL data, there is likely to be no measurable water quality impact beyond the boundary of the test site. A computer model study using site specific parameters is needed.

B.4.3 LAND QUALITY IMPACT

The impact of the construction activities during Phases II and III upon land quality and land use capability are relatively minor. The effects of the pre-test burn activities will be purely local disturbances, where access and site roads are constructed, and where the test facilities are erected. These local disturbances are temporary in character, and will be removed by site restoration.

The major land quality impact of concern is the possibility of ground subsidence as the result of underground coal gasification. An analysis of the ground subsidence phenomena by LLL indicates that there are four basic, distinctly different modes in which roof collapse can take place: (1) sloping or bulk subsidence; (2) chimneying; (3) bending subsidence; and (4) plug failure. Bulking subsidence involves progressive roof failure by spalling, with continued rock fall from the roof into the gasification void and a gradual approach towards the surface as the void fills. The surface subsidence may be only a fraction of the original gasification void. Bulking subsidence probably occurs when the overburden is brittle and in the presence of rock with pre-existing fractures.

"Chimneying" starts over a small area and progresses rapidly to the surface via caving subsidence which creates a rapid succession of failures or sloughs. Caves can proceed from original void to surface very rapidly (900 feet in one year is an example cited). This type of subsidence has been experienced by the Soviets when they gasified thick, steeply dipping beds. A gas leakage path extending from the gasification zone to the surface was created with extreme rapidity at Yuzhno-Abinskaya, as the flame front approached the surface. The seam gasified averaged 7 meters thickness, and subsidence craters up to 20 meters diameter and 15 meters depth were formed in the overburden. Leakage was reduced by filling the holes with mud.

Bending subsidence generally takes place when the roof material is a soft substance like clay, and involves sagging into the underground void. The depression at the surface, for steeply dipping beds, is assymetric. Maximum subsidence doesn't occur over the middle of the void, but is displaced toward an axis normal to the bed. Horizontal displacements are also assymetric, so that the resulting ground depression, in cross section, resembles a skewed

half wave. Gas leakage and water intrusion will probably be at the maximum where the lines of maximum tensile strain at the edges of the cavern open up cracks.

Plug failure, the fourth subsidence mode, involves an apparently distinctly different mechanism - sudden lowering en masse of the cover overlying an unsupported void. The volume of the surface depression created is about equal to the non-ash-occupied volume of the coal gasified. This type of failure occurs in weakly consolidated sediments or where weakly bonded rocks show some weathering on the joining planes. It is most likely to occur where the surface already shows subsidence.

The subsidence mode and extent of subsidence which may potentially occur at the site cannot be projected at this time without detailed geologic and seismic data for the area of the planned burns. This detailed data will be collected by planned activities during Phase II.

B.4.4 POTENTIAL HEALTH AND SAFETY IMPACT

The health and safety problem areas projected as the result of the environmental impacts cited above are associated almost exclusively with air emissions from the test burns. Carbon monoxide concentrations at ground level, at maximum and for worst conditions, represent the area of greatest concern since they are borderline for eight-hour exposure under OSHA regulations. Estimated levels of BaP and similar PNA materials are several orders of magnitude below OSHA limits for "coal tar pitch volatiles."

B.5.0 ANALYSIS OF SOCIOECONOMIC CONSIDERATIONS RELATED TO THE UCG PROJECT

The following section provides a brief summary of Rawlins and Carbon County area socioeconomic characteristics and evaluates the potential socioeconomic impact of the UCG project in this area. The focus of this characterization and evaluation is on population, labor force, the local economy, and housing and services.

B.5.1 RAWLINS AND CARBON COUNTY AREA SOCIOECONOMIC CHARACTERISTICS

Rawlins, the county seat in Carbon County, had a 1970 population of 7,855 (U.S. Bureau of Census), which comprised the major portion of the county's 1970 population of 13,354 (U.S. Bureau of Census). Population estimates and projections shown in Table B6-1 indicate that Rawlins will continue to contain the majority of Carbon County's population.

Table B5-1
1976 ESTIMATES AND 1985 PROJECTIONS OF POPULATION
FOR CARBON COUNTY AND RAWLINS, WYOMING

	<u>1976</u>	<u>1985</u>
Carbon County	20,886	41,987
Rawlins	11,840	24,897

SOURCE: ABT Associates, Cambridge, Massachusetts

Coal and uranium production are the major industries effecting Carbon County's population growth, overshadowing other basic industries (including agriculture) in the area. Development of these two industries in Carbon County is, therefore, expected to have the greatest industry-effect on population and socioeconomic conditions.

Carbon County had a total labor force (persons 16 years old and over) of 5,296 in 1970 (U.S. Bureau of Census) with an unemployment rate of 6.1 percent (U.S. Bureau of Census). Labor force projections for Carbon County or Rawlins were not available at this time.

Carbon County residents had a medium family income of \$8,614 in 1970 (U.S. Bureau of Census). More recent projections of family income are unavailable at this time.

B.5.2 POTENTIAL SOCIOECONOMIC IMPACT OF THE UCG PROJECT

An evaluation of the potential socioeconomic impacts related to the UCG project are briefly discussed below for the areas of major concern. Each area of concern is discussed on a phase sequenced basis.

B.5.2.1 Potential Labor Force Impact

The labor force requirements for the project are not expected to have any significant effect on the Rawlins or Carbon County area.

During Phase I, site activities will be limited to occasional visits by project personnel for surveys and other temporary activities. Phases II and III have the greatest on-site labor force requirements associated with the program, however, no significant effects on the local labor force is expected. During Phase II, construction activities will require some temporary local labor for facility construction, but most of these activities will be temporary with a duration of only a few months. On-site personnel during Phase III testing operations will probably not exceed 20 persons. Approximately half of these on-site personnel will be local hires. Only about 5 persons will be on-site for the duration of the testing operations. Phase IV will require minimal on-site personnel since the primary on-site activity will be environmental monitoring.

B.5.2.2 Potential Local Economic Impact

The UCG project is expected to have minimal impact on the local economics of either Rawlins or Carbon County. The project's limited duration and its experimental (non-commercial) nature are not expected to cause any significant effects on major economic indicators or cause potential economic impact associated with commercial coal development activities. Some positive economic benefits may be gained by use of local construction firms for Phase II and III activities, but these effects will not be of the same magnitude as experienced for commercial facilities.

B.5.2.3 Potential Impact on Housing and Services

The number of on-site personnel will vary significantly during the program phases, primarily as a function of the program activities. At most, about six personnel are likely to relocate to the Rawlins area for the duration of Phase II. For the most part, personnel will be on-site only periodically during Phase II and III and will require only temporary living accommodations such as motels/hotels. Minimal impact on housing and services is expected to result from the program at the Rawlins area site and those that may result will be temporary in duration, occurring primarily during Phases II and III of the field test program.

B.6.0 SITE-SPECIFIC ENVIRONMENTAL REGULATIONS AND CONSTRAINTS

Federal and State of Wyoming environmental regulations applicable to the field test program for underground coal gasification at the Rawlins area site are detailed below. Potential regulatory impact or constraints related to the project and/or project implementation are discussed in each of these sections. Regulatory constraints which may be imposed by pending environmental regulations are also briefly discussed.

B.6.1 FEDERAL ENVIRONMENTAL REGULATIONS

There are numerous statutory requirements which are either directly or indirectly applicable to the underground coal gasification field test program. Under such statutes, certain Federal agencies issue and implement environmental regulations with which underground coal gasification facilities must comply. Regulations applicable to the UCG field test program are listed in Table B6-1. Federal agencies, in aiding DOE are also required by Congressional mandate to conform to general national policies established in environmental legislation such as the Federal statutes listed in Table B6-2. Most of these statutes require Federal agency compliance with applicable state and local environmental laws and regulations.

Federal regulations for air quality are likely to impact and impose constraints on the UCG field test program. Estimated particulate levels generated from construction activities, particularly access road construction and grading activities of Phases II and III are likely to exceed allowable concentrations and require application of control measures.

Likewise, estimated maximum ground level concentrations of sulfur dioxide occurring during Test Burn No. 3 under "worst case" meteorological conditions may exceed Prevention of Significant Deterioration (PSD) increments as established by Federal law. Ambient Air Quality Standards for SO_2 should not be exceeded during any of the test burns.

TABLE B6-1

FEDERAL ENVIRONMENTAL REGULATIONS APPLICABLE TO THE UCG FIELD TEST PROGRAM

LEGISLATION	APPLICABILITY TO UCG ACTIVITIES
<p>Clean Air Act as amended (P.L. 91-604 as amended by P.L. 92-157, 93-15, and 93-319)</p> <p>Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500)</p> <p>Safe Drinking Water Act (P.L. 93-523)</p> <p>Toxic Substances Control Act (P.L. 94-469)</p> <p>Occupational Safety and Health Act (P.L. 91-596)</p> <p>Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (P.L. 94-580)</p>	<ul style="list-style-type: none"> ● Ambient air standards for SO₂, TSP, NO₂, CO, HC, and O_x must be complied with. ● Hazardous air pollutant standards limit mercury emissions from incineration of wastewater treatment sludge. ● National Pollutant Discharge Elimination System (NPDES) permits are required to control wastewater discharges. ● Proposed EPA guidelines regulate wastewater discharges and may involve underground leachates from UCG. ● Handling of specific toxic materials is regulated. ● Health and safety regulations limit employee exposure to certain air pollutants and ambient noise levels. ● Proposed regulations and guidelines for solid waste and solid hazardous waste management practices.

TABLE B6-2

FEDERAL ENVIRONMENTAL LEGISLATION APPLICABLE TO THE UCG FIELD TEST PROGRAM

LEGISLATION	APPLICABILITY TO UCG ACTIVITIES
National Environmental Policy Act of 1969 (NEPA) (P.L. 91-190)	<ul style="list-style-type: none"> • Environmental Impact Statements (EIS's) must be prepared for all major Federal actions significantly affecting the quality of the human environment.
Noise Control Act of 1972 (P.L. 92-574)	<ul style="list-style-type: none"> • Ambient noise levels are recommended for protection of public health and welfare.
Executive Order 11752: Prevention, Control, and Abatement of Environmental Pollution at Federal Facilities	<ul style="list-style-type: none"> • Establishes policy for Federal government agencies to comply with all applicable standards for the prevention, control, and abatement of environmental pollution.
U.S. Department of Energy Guidelines for Environmental Review (39 FR 5620, as amended by 42 FR 711)	<ul style="list-style-type: none"> • Establishes intra-agency policy and procedure for environmental review of DOE activities; sets criteria for EIA and EIS preparation.

Occupational health and safety regulations will impose constraints on program activities by requiring adequate safety procedures and personnel safeguards to ensure compliance with existing personnel exposure levels to certain air contaminants. Estimated emissions of benz- α -pyrene (BAP) and poly-nuclear aromatic hydrocarbons (PNA) are expected to be within acceptable levels of exposure with product gas flaring. Additional control measures such as increased retention and combustion time of product gases may be necessary for assurance of on-site personnel health safety.

B.6.2 WYOMING ENVIRONMENTAL REGULATIONS

Under Wyoming State statutes, certain agencies issue and administer environmental standards and regulations. Those environmental regulations applicable to the UCG field test program are listed in Table B6-4. In addition to these environmental standards or regulations, there is a body of environmental legislation which requires permits to be obtained for certain activities. Regulatory permit requirements applicable to the UCG field test program are listed in Table B6-4.

Wyoming environmental regulations are likely to have the same impact and impose the same constraints on the UCG field test program as those for Federal environmental regulations. In addition, Wyoming environmental regulations will necessitate acquisition of numerous environmental regulatory permits for UCG program activities. This will involve state agency review of essentially all major aspects of the UCG field test which may impact environmental quality.

B.6.3 POTENTIAL REGULATORY CONSTRAINTS

There are several pending Federal regulations which may potentially impose additional regulatory constraints on the UCG field test program.

One area of special concern is the recently enacted Clean Air Act Amendments which contain statutory provisions for the prevention of significant deterioration of air quality in clean air areas. Implementation of these statutes by the U.S. EPA will have a major implication with regard to control requirements for UCG facilities which are generally currently located in such clean air regions.

TABLE B6-3
WYOMING ENVIRONMENTAL REGULATIONS APPLICABLE TO THE
UCG FIELD TEST PROGRAM

LEGISLATION	APPLICABILITY TO THE UCG ACTIVITIES
<p>Wyoming Air Quality Act (Wyoming Statutes, Chapt. 186, §35-487 to 35-502, as amended)</p>	<ul style="list-style-type: none"> • Air quality standards and regulations are established for ambient air levels of TSP, SO₂, H₂S, O_x, HC, NO_x, CO, and F⁻.
<p>Water Quality Standards for Wyoming (35-502.19, 1973 Session Laws, 35-487.19)</p>	<ul style="list-style-type: none"> • Administers National Pollutant Discharge Elimination System (NPDES) permits required for control of waste-water discharges.
<p>Wyoming Occupational Health and Safety Act (Wyoming Statutes, §27-278, as amended)</p>	<ul style="list-style-type: none"> • Health and safety regulations are established which limit employee exposure to certain air contaminants, toxic materials, harmful physical agents, and ambient noise levels.

TABLE B6-4
WYOMING REGULATORY PERMITS APPLICABLE TO THE
UCG FIELD TEST PROGRAM

PERMIT	APPLICABILITY TO UCG ACTIVITIES
Land Quality Permit	<ul style="list-style-type: none"> Requires a coal mining permit involving state agency review of effects on ground water quality and land reclamation plans.
Water Quality Permit (NPDES Permit)	<ul style="list-style-type: none"> Requires both State agency and U.S. EPA review of any waste discharges and wastewater abatement procedures to be employed.
Air Quality Permit	<ul style="list-style-type: none"> Requires a review of planned facility and operations with regard to air contaminants and control measures to be employed.
Permit to Appropriate Ground Water	<ul style="list-style-type: none"> Required for utilization of ground water on site, including hydrological testing, and necessary for waste disposal wells or subsurface injection of waste materials.
Construction of a Well Permit	<ul style="list-style-type: none"> Necessary for on-site water well construction; establishes design standards.
Permit to Construct a Reservoir	<ul style="list-style-type: none"> Required for construction of a holding pond for water or wastewater on site.
Permit to Drill or Deepen a Well	<ul style="list-style-type: none"> Required for gas production and injection wells, as well as subsurface injection of wastewater or waste materials.

The Occupational Safety and Health Administration (OSHA) is shifting emphasis from regulatory standards for specific chemicals to plant and process standards. For instance, the OSHA has proposed standards for occupational exposure to carcinogens which may impact control technology requirements at UCG facilities. It is likely that OSHA will develop and promulgate other standards significantly affecting UCG operations.

B.7.0 SUMMARY

Potential environmental impact, socioeconomic impact, and regulatory constraints related to the UCG process concept design to be implemented at the North Knobs site are summarized below. Possible site-specific environmental and health and safety problem areas associated with the concept design for which control activities will be necessary to avoid adverse environmental impacts and remain within regulatory constraints are also identified.

No socioeconomic impact of significance to the Rawlins/Carbon County area is expected to occur from the field test program.

7.1 POTENTIAL ENVIRONMENTAL IMPACT AND REGULATORY CONSTRAINTS

Phase I activities are expected to have minimal environmental impact since on-site activities are limited to occasional survey visits by project personnel.

Appropriate measures must be implemented to avoid any potential adverse impacts on air quality from Phase II site preparation and access road construction activities. These would otherwise generate significant levels of suspended particulates and would thus impact local air quality. Minimal impact on air quality is expected to result from other construction equipment emissions and will be limited to the duration of construction activities.

Phase III activities are expected to have the greatest environmental implications during the field test program since activities of this phase include the UCG test burns. Control measures will be needed to minimize adverse environmental impacts. Construction activities during this phase are expected to have minimal impact on air quality. Test burn operations and product gas flaring should not produce undue environmental impact on air quality.

The test burn operations present areas where water quality monitoring will be necessary to minimize potential adverse impacts on water quality. These are needed to monitor leaching or migration of pollutants from the coal bed char ring and ash zones left by the burn. Minimal impact on land quality is expected to occur during Phase III, although subsidence effects resulting from the burn operations may have potential impact in the immediate site area.

Post-burn activities on-site are expected to have minimal environmental impact. Subsidence effects may continue to have potential impact on land quality in the immediate site area and should be monitored for an extended period following the test burns.

B.7.2 POTENTIAL PROBLEM AREAS

The following potential problem areas related to environmental and health and safety impacts requiring abatement measures have been identified from the analysis of the process concept design:

- Abatement measures must be employed to control inert dust generation during access road construction activities and to prevent concentrations above allowable levels surrounding the site area.
- Ground water pollution due to leaching from strata subjected to the test burns may result in the vicinity of the burn zones. Phenols and cyanides are of particular concern, as ground water concentrations may increase to above permissible levels in the vicinity of the site. Quench mode operations involving injection of significant quantities of water may temporarily increase ground water flows and subsequently pollutant dispersion. Frequent monitoring of ground water at the site for process-specific pollutants may be necessary to adequately determine the extent of any ground water contamination that may occur.

- Ground subsidence above the area of the burn zones may be a potential problem with the steeply dipping beds, as it is difficult to predict the extent and rapidity of occurrence. Detailed geologic and seismic data for the site will need to be collected and evaluated to project potential subsidence effects in the area and allow planning of adequate safeguards.

B.7.3 RECOMMENDATIONS

Activities and/or abatement measures necessary to resolve the potential problem areas cited above or to minimize any potentially unavoidable adverse environmental and/or health and safety impacts will need to be addressed in the Phase II program activities. Based on the results of the environmental analysis, test support and process operations will need to define and incorporate abatement measures and/or activities in certain areas of program implementation to ensure that they remain within regulatory constraints. Alternative measures to address each potential problem area should be evaluated to determine which will be the most efficient from both a technical and economical standpoint. The results of that evaluation would be a recommendation of specific activities or abatement measures for application to potential problem areas identified in the field test program implementation.

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B.B 1.0 EXECUTIVE SUMMARY

This document has been prepared to present a detailed plan for conducting an environmental monitoring program as a key portion of a project for field testing a process for gasification for steeply dipping coal beds. The project is being conducted by Gulf Research and Development Company at a site near Rawlins, Wyoming.

The purpose of this document is to provide a detailed plan for monitoring for ambient air quality, ground and surface water quality and ground subsidence at the test site. Implementation of the plan will ensure that all environmental monitoring requirements associated with the UCG test have been addressed and are satisfied. The plan provides the following specific information:

A detailed program to monitor the air and water quality parameters during Phase II (baseline monitoring) and to monitor air quality, water quality and ground subsidence during Phase III (test monitoring) of the program. Monitoring after the completion of the last test burn is also described. Monitoring will be conducted for those air and water quality parameters for which environmental quality standards or criteria have been established by the U. S. Environmental Protection Agency and the State of Wyoming Department of Environmental Quality. Monitoring will also be conducted for other, process-specific pollutants, as described below. The plan states pollutants which will be monitored, the sampling frequency, sampling and analytical procedures and equipment which will be utilized.

- A program to monitor those pollutants which are expected to be produced during the UCG test program. The environmental analysis of the concept design identified potential problem areas which are addressed in this plan. Specific monitoring which will be done to address the problem areas such as, fluorides, hydrogen sulfides, ammonia, and polynuclear aromatic hydrocarbons.
- A schedule for completing each element of the Phase II, III, and IV environmental monitoring activities.
- Recommendations for additional environmental activities that should be undertaken to provide information about the potential impacts of the UCG program. These activities consist of determining size and size distribution of particulate matter emitted during the field tests, and conducting water quality modeling.

B.B. 2.0 INTRODUCTION

This environmental monitoring plan is one element of the overall environmental activities that are being conducted as portions of a program for field testing a process for the underground gasification for steeply dipping coal beds. The other elements comprising the environmental activities in this program are:

- Environmental Analysis of Concept Design
- Environmental Permit Support
- Preparation of Environmental Impact Assessment

These environmental activities are designed to assure the preservation of environmental quality at the underground coal gasification (UCG) test site. The UCG test program is being conducted at a site at North Knobs in Wyoming. Steeply-dipping coal seams underlying the site will be partially burned in-situ to produce a gas which will have potential commercial fuel applications.

B.B.2.1 BACKGROUND

The study for which this plan has been prepared is being conducted under a cost sharing contract awarded by the U.S. Department of Energy to Gulf Research and Development Company, Pittsburgh, Pennsylvania. The purpose of the program is to develop a process for the underground gasification of coal seams which are otherwise considered inaccessible by conventional mining methods. TRW, Inc., is a major subcontractor on this project, and will conduct the environmental monitoring program at the UCG test site.

The goal of the field test program is to provide data on the process feasibility and economics, including system requirements and expected gas production. These data will be used to produce a cost estimate for the design, construction and operation of a pilot plant which would be used to

evaluate future commercial development of the process for underground coal gasification for steeply dipping beds.

The field test program will be conducted in four phases over the next five years. Phase I of the project, currently underway, involves site selection, preliminary environmental assessment, and technical planning and design. Following this, Phase II involves site characterization, baseline environmental monitoring, and field development work. Plans for Phase III call for field operations and testing through 1980, followed by test site restoration. Phase IV will involve the preliminary designing and costing of a pilot scale project to evaluate future commercial development of the process.

B.B. 2.2 OBJECTIVES OF THE ENVIRONMENTAL MONITORING PLAN

The purpose of this document is to provide a detailed plan for monitoring environmental conditions, including ambient air quality, ground and surface water quality, and ground subsidence, at the North Knobs test site. Implementation of this plan will assure that the environmental requirements of the UCG program are satisfied. The principal objectives of the environmental activities described in the plan are as follows:

- To monitor environmental conditions at the test site prior to the test burns (baseline environmental quality), during the three test burns, and for a period of time following the test burns.
- To produce baseline environmental data which can be used in preparation of an Environmental Impact Assessment (EIA).
- To enable any significant changes from baseline environmental quality to be detected and mitigating measures to be developed, in a timely manner.

To assure appropriate regulatory agencies and local citizens that preservation of environmental quality is an integral part of the UCG test program.

B.B.2.3 ENVIRONMENTAL PLAN DESCRIPTION AND APPROACH

This environmental monitoring plan details the activities which will be implemented during the remaining three phases of the program to satisfy the environmental monitoring requirements. The plan describes an environmental monitoring program which addresses current regulatory requirements and the findings of the environmental analysis of the concept design, which identified areas where the program must provide measures to assure that the effect on the environment is minimal and within the government regulations. The plan describes each of the environmental activities in the format of the Work Breakdown Structure (WBS) which will be described later in this section.

B.B.2.3.1 Federal and State Environmental Requirements

There are several statutory requirements which apply either directly or indirectly to the UCG test program. The U.S. Environmental Protection Agency (EPA), under the mandate of the 1970 Clean Air Act and the 1972 Federal Water Pollution Control Act, has established environmental quality standards for the protection of the nation's air and water quality. Other Federal agencies, including DOE, are also required to conform to national policies established by environmental legislation. In addition to Federal requirements, states have established environmental regulations which are at least as stringent and in many cases more stringent than Federal requirements.

The EPA has established National Ambient Air Quality Standards (NAAQS) for six air pollutants. These pollutants are: sulfur dioxide (SO₂); nitrogen dioxide (NO₂); carbon monoxide (CO); photochemical oxidants as ozone (O₃); non-methane hydrocarbons (NMHC); and total suspended particulates (TSP). Water quality standards and criteria have been established for

several parameters. These parameters may vary depending upon whether the water is used for public drinking water supply, agricultural use, industrial water supply, recreation and/or aesthetics, and for supporting either freshwater or marine aquatic life and wildlife. In addition to Federal regulations, the State of Wyoming has also established environmental standards for air and water quality.

The environmental monitoring plan is designed to provide environmental monitoring for those air and water quality parameters for which environmental standards or criteria currently exist. This monitoring will be conducted prior to the three test burns in order to establish baseline environmental quality, and also during and after the test burns. In addition to monitoring for regulated pollutants, additional monitoring will be conducted for those pollutants specific to the underground gasification of coal.

B.B.2.3.2 Environmental Monitoring Plan Organization

There are two major environmental monitoring activities which will be conducted during the UCG test program. These activities are Baseline Monitoring which will be conducted during Phase II, and Test Monitoring which will be conducted during Phase III. All of the activities in this program are divided into work elements which comprise the overall Work (WBS) for the entire UCG program. The program is divided into functional

groups from level 1 through level 5. Figure B.B.2-1 depicts the Work Breakdown Structure for this program down to level 4. As seen from this figure, the Baseline Monitoring program is assigned WBS No. 3.3.1, and the Test Monitoring program is assigned WBS No. 3.3.2

The Baseline Monitoring program which will be conducted during Phase II involves the characterization of the existing air and water quality at the test site. This data will be input to the Environmental Impact Assessment (EIA) and will be used as a basis for comparison with the environmental data collected during the test burn period. This Baseline Monitoring program, WBS No. 3.3.1, is further divided into five separate elements which are at level 5 in the WBS structure. These elements are described in detail in Section 3.0 of this plan and are as follows:

WBS No. 3.3.1.1 Mobilize Monitoring Equipment

WBS No. 3.3.1.2 Monitoring of Meteorological Parameters

WBS No. 3.3.1.3 Monitoring Atmospheric Concentrations
of Criteria Pollutants

WBS No. 3.3.1.4 Measurement of Process Specific
Pollutants

WBS No. 3.3.1.5 Monitoring Water Quality Parameters

The environmental monitoring activities which will be conducted during the UCG test period (Phase III) will aid in detecting any significant changes in environmental conditions or the release of contaminants directly attributable to the burn phase of the program. The data obtained will be compared against baseline environmental quality data to make this assessment, and to ensure that adequate environmental safeguards are initiated. This Test Monitoring program, WBS No. 3.3.2, is further divided into six separate elements which are at level 5 in the WBS structure. These elements are described in detail in Section B.B.4.0 of this plan and are as follows:

FIGURE B.B.2-1

WORK BREAKDOWN STRUCTURE (WBS) FOR UNDERGROUND COAL GASIFICATION

- WBS No. 3.3.2.1 Mobilize Monitoring Equipment
- WBS No. 3.3.2.2 Monitoring of Meteorological Parameters
- WBS No. 3.3.2.3 Monitoring Atmospheric Concentrations of Criteria Pollutants
- WBS No. 3.3.2.4 Measurement of Process Specific Pollutants
- WBS No. 3.3.2.5 Monitoring Water Quality Parameters
- WBS No. 3.3.2.6 Subsidence Monitoring

Following the three test burns the environmental monitoring activities in Phase IV will provide data for determining the nature and magnitude of any changes in environmental conditions from baseline conditions at the site. In addition, it is anticipated that some pollution of the subsurface waters near the site may result from the underground gasification test depending on the rate of flow and movement of these groundwaters through the burn area. Post-burn environmental activities will provide adequate monitoring of these groundwater resources and permit evaluation of the appropriateness of safeguards taken.

B.B. 3.0 PHASE II-ENVIRONMENTAL ACTIVITIES

During this task, baseline environmental quality data will be collected at the North Knobs test site. This task consists of preparing the monitoring equipment, and collecting data on meteorological parameters, criteria air pollutants, trace elements, process specific air pollutants, and water quality parameters. All of the monitoring and data analysis activities will be conducted by the TRW Environmental Engineering Division. A schedule of the activities is presented in Figure B.B.3-1.

FIGURE B.B.3-1

SCHEDULE OF PHASE II ENVIRONMENTAL ACTIVITIES

KEY: ▲ - TASK COMPLETION
 Δ - SAMPLE COLLECTION DATES

B.B.3-2

B.B.3.1 WBS NO. 3.3.1.1 MOBILIZE MONITORING EQUIPMENT

B.B.3.1.1 WBS Element Description

During this task, all of the environmental monitoring equipment which will be used during the baseline monitoring period will be prepared for field use. The preparation of the equipment includes a thorough check-out of all circuitry, calibration using reference gases, and operation for a 48-hour period to assure that equipment is functioning properly.

After preparation, all of the instrumentation and the instrument trailer will be transported to the test site and installed during mid to late April, 1978. After installation and calibration, the instruments will be operated for a period of three to four days to assure that the instruments have stabilized and are operating according to specifications. Collection of baseline air quality data will begin on May 1, 1978.

B.B.3.1.2 Deliverables

Once the equipment preparation has commenced, a status report will be prepared detailing the progress of equipment procurement, refurbishment, and calibration. This report will be submitted to the TRW project manager at the end of the month in which this work has begun (March, 1978). Any major problems which may have an impact on placing the equipment in the field at the desired time will be conveyed to the TRW project manager at once.

B.B.3.1.3 Long Lead Items

The major items which will have to be purchased are the on-site electric generators if power from the utility company is not available. The lead time required for purchase of the generators is 90-120 days.

A second item to be purchased is a portable carbon monoxide monitor. This instrument will be used to conduct spot checks of ambient carbon monoxide levels at the test site.

Other long lead items involve the hiring of an on-site instrument technician. It is imperative that this effort be started as soon as possible so that the technician would be available on-site by April, 1978. Approximately 2-3 months will be required locating and bringing the individual on board.

B.B.3.1.4 Schedule Items Needed

- A. The start date of this task is March 1, 1978.
- B. Projected end date is May 1, 1978.
- C. All equipment will be prepared, calibrated and ready for shipment to the site by April 7, 1978.
- D. The task which impacts on this activity is the preparation of the access road to the UCG test site to facilitate transporting the instrument trailer to the site. The road(s) should be accessible for a technician to visit the instrumentation trailer daily, and for fuel deliveries at 2-3 week intervals. A determination has to be made as to whether the site will be accessible during the winter months. If access cannot be assured, then the air monitoring instruments will be demobilized during this period.

Provisions will be made to protect the instrumentation trailer and generator from vandalism and theft.

- E. This task is a necessary predecessor to the remaining WBS elements in Task 3.3.1.

B.B.3.2 WBS NO. 3.3.1.2 MONITORING OF METEOROLOGICAL PARAMETERS

B.B.3.2.1 WBS Element Description

During the baseline monitoring period, wind speed and direction will be monitored at the North Knobs site with a portable meteorological tower. The purpose of this monitoring is to determine on-site wind speed and direction so that during the test burns, the air monitoring instruments can be located such that they will detect any pollutants released by the tests. In addition, the data will assist in locating the instruments upwind from the portable electric generators since they may emit various air pollutants. In cases where shifting winds have caused the emissions from the generator to be directed toward the air monitoring instruments, the air quality data from that period must be corrected before being included as part of the baseline data. Any air pollution diffusion modeling studies conducted later in the program can be used to perform the necessary corrections. The data from the meteorological tower are recorded on strip charts which will be analyzed at the TRW laboratory in Vienna, Virginia.

B.B.3.2.2 Deliverables

A summary of on-site wind speed and direction data will be provided in the baseline environmental report. The data will be used in correlating wind direction and speed with air quality data. It will also be used to locate the air monitoring instrument trailer where it will not be impacted by on-site construction activity. Temperatures and general weather conditions will also be recorded.

B.B.3.2.3 Long Lead Time

There are no longer lead items required for this task.

B.B.3.2.4 Schedule Items Needed

- A. This task will commence at the start of the baseline monitoring period which is scheduled for May 1, 1978.
- B. Projected end date is the end of the baseline period, April 30, 1979.
- C. There are no interim milestones in this task.
- D. WBS No. 3.3.1.1 must be completed before this task can commence.
- E. The data from this task will be used in the preparation of the EIA, WBS 1.1.3.

B.B. 3.3 - WBS NO. 3.3.1.3 MONITORING ATMOSPHERIC CONCENTRATIONS OF CRITERIA POLLUTANTS

B.B. 3.3.1 WBS Element Description

Ambient air monitoring of six criteria air pollutants will be conducted at the UCG test site during the baseline monitoring program. The pollutants which will be monitored are sulfur dioxide, nitrogen dioxide, carbon monoxide, non-methane hydrocarbons, ozone and total suspended particulates. National Ambient Air Quality Standards (NAAQS) have been established for these pollutants by the EPA.

All of the gaseous pollutants with the exception of carbon monoxide will be monitored continuously using automatic analyzers. The carbon monoxide monitor is a portable unit which will be used to spot check background carbon monoxide levels. Total suspended particulates will be monitored on a six-day frequency in accordance with the National Air Surveillance Network (NASN) schedule. A list of the monitoring equipment which will be used at the UCG test site is listed in Table B.B.3-1. This equipment meets the requirements of the EPA reference methods specified in the Federal Register, December 1, 1976 with the exception of the carbon monoxide analyzer. At this time, there is no reference method for portable units. All of the instruments will be housed in an 8' x 16' trailer designed for air pollution monitoring. The air quality data will be analyzed and interpreted by the TRW Environmental Engineering Division.

Upon completion of the baseline monitoring program, all of the instruments will be demobilized and shipped to the TRW laboratory in Vienna, Virginia. It is anticipated that the trailer will be left on-site during the period between the baseline monitoring period and test monitoring period.

TABLE B.B.3-1

AIR POLLUTION MONITORING EQUIPMENT AND SAMPLING FREQUENCY

<u>POLLUTANT</u>	<u>SAMPLING AND ANALYTICAL EQUIPMENT</u>	<u>SAMPLING FREQUENCY</u>
SULFUR DIOXIDE	PHILIPS MODEL PW 9720 CONDUCTIVITY ANALYZER	CONTINUOUS 24-HOUR
NITROGEN DIOXIDE	BECKMAN MODEL 952 CHEMILUMINESCENT NO/NO _x /NO ₂ ANALYZER	CONTINUOUS 24-HOUR
TOTAL HYDROCARBONS AND METHANE	BENDIX MODEL 8201 REACTIVE HYDRO-CARBON ANALYZER	CONTINUOUS 24-HOUR
OZONE	McMILLAN 1100 OZONE ANALYZER	CONTINUOUS 24-HOUR
CARBON MONOXIDE	ENERGETICS-SCIENCE ECOLYZER	SPOT CHECKS
TOTAL SUSPENDED PARTICULATES	GENERAL METAL WORKS HIGH-VOLUME SAMPLER	SIX-DAY INTERVAL
TRACE ELEMENTS	FILTERS FROM HIGH-VOLUME SAMPLER ANALYZED BY ATOMIC ADSORPTION SPECTROPHOTOMETRY	ONE SAMPLE PER QUARTER
HYDROGEN SULFIDE AND CARBONYL SULFIDE	MYLAR BAGS	TWICE DURING BURN PERIOD

B.B.3-9

B.B. 3.3.2 Deliverables

A summary of the ambient air concentrations of the six criteria pollutants will be included in the environmental baseline report. It is anticipated that this report will be completed in July, 1979.

B.B.3.3.3 Long Lead Items

Long lead items required for this task are the same as those discussed in WBS 3.3.1.1, Mobilize Monitoring Equipment.

B.B.3.3.4 Schedule Items Needed

- A. This task will commence at the start of the baseline monitoring period which is scheduled to begin May 1, 1978.
- B. Projected end date is the end of the baseline period, April 30, 1979.
- C. There are no interim milestones in this task.
- D. WBS No. 3.3.1.1 must be completed before this task can commence.
- E. The data from this task will be used in the preparation of the EIA, WBS 1.1.3.

B.B.3.4 WBS NO. B.B.3.3.1.4 MEASUREMENT OF PROCESS SPECIFIC AIR POLLUTANTS

B.B.3.4.1 WBS Element Description

In addition to criteria air pollutants, ambient concentrations of trace elements will be sampled and analyzed. The total suspended particulate (TSP) filter samples will be analyzed by atomic absorption spectrophotometry at the TRW laboratory at Redondo Beach, California. The trace element concentrations which will be analyzed are listed on Table B.B.3-2. An analysis of the fluoride content of the ambient air will also be conducted. Additional pollutants which will be monitored are hydrogen sulfide, carbonyl sulfide, and ammonia. Ambient air samples will be taken in evacuated Mylar bags and shipped to the laboratory at Redondo Beach for analysis. Trace element samples will be analyzed four times during the baseline period, while hydrogen sulfide, carbonyl sulfide, and ammonia will be analyzed twice during the baseline period.

B.B.3.4.2 Deliverables

A summary of the concentrations of these pollutants will be included in the baseline environmental report.

B.B.3.4.3 Long Lead Items

There are no long lead items required in this task.

B. B.3.4.4 Schedule Items Needed

- A. The samples will be taken in June, August and October, 1978, and April 1979.
- B. The projected end date is April, 1979.
- C. There are no interim milestones in this task.

TABLE B.B.3-2

TRACE ELEMENTS WHICH WILL BE ANALYZED IN AMBIENT AIR

ALUMINUM
ANTIMONY
ARSENIC
BERYLLIUM
BISMUTH
BORON
CADMIUM
CALCIUM
CHROMIUM
COPPER
GERMANIUM
IRON
LEAD
MAGNESIUM
MERCURY
MOLYBDENUM
NICKEL
SELENIUM
SILICON
TIN
TITANIUM
VANADIUM
ZINC

- D. WBS No. 3.3.1.1 must be completed before this task can commence.
- E. The data from this task will be used in the preparation of the EIA, WBS No. 1.1.3.

B.B. 3.5 WBS NO. 3.3.1.5 BASELINE WATER QUALITY MONITORING

B.B. 3.5.1 WBS Element Description

The purpose of the baseline water quality monitoring program is to perform determinations of physical characteristics, metals, inorganic nonmetallic constituents and organic constituents, and an examination of radioactivity in the coal seam aquifer and in adjacent underlying and overlying aquifers before the SDB-UCG experiments. The data obtained from baseline monitoring will be compared with data obtained from subsequent phases to determine the nature of possible changes in the selected parameters.

B.B. 3.5.1.1 Monitoring Wells

The number, location, and construction of monitoring wells are themselves variables that can significantly influence the results obtained. Presented below are the requirements for water quality monitoring wells. In some cases the recommendations are not specific because information is not available. For example, data on rate and direction of groundwater flow at the North Knobs site is not yet available. In these cases, guidelines have been prepared which can be easily applied to the data as soon as it is available.

Number: Samples should be taken from a sufficient number of monitoring wells to demonstrate the variations in concentration of selected parameters that occur in the vicinity of the SDB-UCG experiments. Four monitoring wells will be sampled in Phase II; this should be an adequate number for determining the variation in water quality occurring in the SDB-UCG testing area. Adjacent underlying and overlying aquifers (if present) will also be sampled to serve as baselines on checks for contamination as a result of SDB-UCG and on the demonstration to the State of Wyoming that there is no contamination of these aquifers.

The number of wells selected for groundwater quality monitoring is a more important factor in Phase III, during-burn, and Phase IV, post-burn, water quality monitoring activities than in Phase II, baseline water quality monitoring. Therefore, the monitoring needs of Phases III and IV were considered in determining the number of strategically located monitoring wells which should be constructed. Because of low rates of groundwater flow and the plume migration characteristics of pollutants in groundwater, each of the three burn sites will have to be monitored individually. One strategically placed monitoring well on the down gradient side of each burn site should adequately indicate changes in groundwater quality during and following test burns. Additional wells placed down-gradient, but farther away from the burn site will indicate rates of pollutant migration, and will indicate the extent of pollutant resorption by the coal seam. The minimum number of wells needed to monitor changes in water quality during Phases III and IV is four. With four wells, two burn sites would be monitored with one well and one site would use two wells.

Location: The location of the monitoring wells is a critical factor for determining contaminant plume direction, extent, duration, and quality, during burn and post-burn monitoring. Adequate baseline data can be obtained from wells located to serve the requirements of burn and post-burn monitoring. General recommendations for dual purpose monitoring well locations are given below to reflect the needs of Phase III, burn monitoring, and Phase II, baseline water quality monitoring.

General recommendations for the monitoring wells are given here because, at this time, sufficient information is not available to permit identification of specific locations for monitoring wells. For example, the rate and direction of groundwater flow are not known, and the actual configuration of the wells has not been determined. The rate and direction of groundwater flow will be determined by GR&DC during the first part of Phase II.

An important recommendation is that burn #3 be located between burns #1 and #2, and that burn #2 be located on the down gradient side of the test area as shown in Figure B.B.3-2. By locating burn site #2 on the down gradient side of the test area, possible alterations of groundwater flow due to activities at other burn sites will be on only one side of and up gradient from burn site #2. Therefore, at burn site #2 there would be no down gradient perturbations due to other UCG activities, and any observed changes in parameters may be related directly to the burn #2 site. This will increase the ability to obtain useful data from burn #2.

The monitoring wells should be located in the down gradient direction of flow from the UCG burn areas and within the average expected distance of annual groundwater flow. Specifically, two distances equivalent to 0.3 and 0.9 of the distance of annual groundwater flow from the burn edge have been chosen for the monitoring wells. These distances were chosen because of an interest in assessing the magnitude of pollutant migration from the burn sites, over time, in the groundwater. Locating monitoring wells at distances closer to the sites than 0.3 annual groundwater flow may tend to measure the more immediate changes at the site and provide less information on long term migration. Locating the wells at distances greater than 0.9 annual groundwater flow would tend to reduce the amounts of useful data obtained due to time constraints on monitoring.

Figure B.B.3-2 shows possible sites for the monitoring wells. In determining the locations we have assumed a groundwater flow rate of 100 ft./yr. and a direction of flow that is parallel to the coal outcrop. Wells used for monitoring the steeply dipping bed (SDB) aquifer will also be used to monitor underlying and overlying aquifers. Monitoring wells #1 and #3 may be too close to other burn areas; the three burns should probably be farther apart.

In distributing four wells among the three sites, we have chosen to locate two wells at burn #2 and one each at burns #1 and #3. The advantage

⊗ Ground water monitoring wells

Scale: 1" = 100'

Assumptions: Groundwater movement is parallel to the coal outcrop. Groundwater flow rate is 100 ft/yr.

FIGURE B.B.3-2

POSSIBLE SITES FOR GROUNDWATER QUALITY MONITORING WELLS

of locating more than one well at a site is that changes in selected parameters can be observed in the migrating plume as functions of time and distance. Although burn #1 will be conducted first and, hence, Phase III monitoring will be the longest, burn #2 is significantly larger and also early enough in Phase III to allow almost a full year of post-burn data collection. Burn #3, the largest burn, would be the one to emphasize, but since it is scheduled very late in Phase III, only about nine months of post-burn data is likely to be collected by the end of the project.

Construction: The State of Wyoming has set minimum standards for the construction of monitoring wells. All wells used in the UCG program for monitoring water quality will be constructed in compliance with State of Wyoming Guidelines for Baseline, Mining, and Post-Mining Water Quality Monitoring Program (State of Wyoming, Department of Environmental Quality, March, 1977). Slight modifications will be made to allow sampling of multiple aquifers from the monitoring wells. Wyoming requirements for well construction are as follows:

"Wells shall conform to the following minimum design and construction standards:

- A continuous string of suitable casing from the surface to the production zone.
- The annular space between the casing and the well bore shall be cemented from the production zone to the surface.
- Cement shall be emplaced by displacement through the casing. A sufficient volume of cement shall be emplaced to provide circulation to surface. Pump and plug displacement methods are recommended.

- A minimum of three (3) centralizers shall be installed on the casing; one at or immediately above the production zone, the second midway between the production zone and the surface, and the third in the first competent formation below the surface."

Additional requirements for monitoring wells are as follows:

- To allow sampling of multiple aquifers from the monitoring wells, gravel and cement will be used alternately to fill the annular space between the casing and the well bore. Gravel will be used where aquifers are encountered; cement will be used between aquifers. Holes will be blown in the casing at each aquifer to allow for sampling.
- The type of gravel used will be quartzite, which is primarily inert SiO_2 . The quartzite will be prerinsed before emplacement in the well. Most other types of gravel (e.g., lime/limestone, graphite) will cause high dissolved solids levels in water samples.
- A potential problem exists if the use of plastic piping is used in monitoring wells. Plastic is known to cause contamination of water samples by leaching plasticisers into the water. An additional problem of adsorption of organic compounds from water samples onto the walls of plastic tubing has also been suggested. Pumping of the wells prior to water sampling is expected to minimize the effects of PVC.

B.B.3.5.1.2 Parameters to be Measured

Table B.B.3-3 summarizes the parameters to be measured in each sample collected. The list of parameters shown in Table B.B.3-3 is intended to be comprehensive in that any parameter measured in Phase III will have been measured in Phase II, so as to provide a baseline for later comparison. Other parameters such as bromide, antimony, bismuth, germanium, silicon, tin, titanium, etc., will be measured if the method used to dispose of product waters warrants it.

B.B.3.5.1.3 Sampling Frequency

One set of samples will be collected from each monitoring well in the coal seam and from two underlying and one overlying aquifer during baseline monitoring. These samples will be collected shortly after the monitoring wells have been constructed. The preferred time of sample collection is near the midpoint of Phase II. This would allow sufficient time for sample analysis and data assessment prior to Phase III.

B.B.3.5.1.4 Sampling Procedures

In preparing plans for sampling, consideration was given to the types of analyses to be performed and possible methods for analysis. Table B.B.3-4 presents a summary of preservation and handling requirements for each of the parameters to be investigated. Variations in sample preservation and handling include acidification with H_2SO_4 , or HNO_3 , glass vs plastic containers. To ensure that sample collection, handling, and transportation will allow valid analyses, the following procedures will be undertaken:

- At each sampling point, a set of ten (10), 1-liter sample containers will be collected. These ten containers will constitute one "sample;" each container will constitute one "subsample." Table B.B.3-5 shows the type of containers and preservatives to be used.

TABLE B.B.3-3

SELECTED PARAMETERS FOR BASELINE WATER QUALITY MONITORING

PHYSICAL CHARACTERISTICS:

CONDUCTIVITY

TEMPERATURE

TOTAL DISSOLVED SOLIDS (TDS)

TOTAL SUSPENDED SOLIDS (TSS)

INORGANIC NONMETALLIC CONSTITUENTS

AMMONIA (NH_3)

BICARBONATE

CARBONATE

CHLORIDE (Cl^-)

CYANIDE (CN^-)

FLUORIDE (F^-)

NITRATE-NITRITE (NO_3^- - NO_2^-)

ORGANIC NITROGEN

pH

SULFATE ($\text{SO}_4^{=}$)

SULFIDE ($\text{S}^{=}$)

TOTAL

ARSENIC (As)

BORON (B)

SILICON (Si)

TABLE B.B.3-3 (continued)

RADIOACTIVITY:

GROSS ALPHA AND BETA ACTIVITY OF FILTRATE

METALS:

ALUMINUM (Al)
BARIUM (Ba)
CADMIUM (Cd)
CALCIUM (Ca)
CHROMIUM (Cr)
COPPER (Cu)
IRON (Fe)
LEAD (Pb)
MAGNESIUM (Mg)
MANGANESE
MERCURY (Hg)
MOLYBDENUM (Mo)
NICKEL (Ni)
POTASSIUM (K)
SELENIUM (Se)
SODIUM
URANIUM
VANADIUM (V)
ZINC (Zn)

TABLE B.B.3-3 (continued)

ORGANIC CONSTITUENTS:

CHARACTERIZATION OF SPECIFIC ORGANICS

CHEMICAL OXYGEN DEMAND (COD)

PHENOLS

TOTAL ORGANIC CARBON (TOC)

MISCELLANEOUS:

AS NEEDED

TABLE B.B.3-4

SUMMARY OF HANDLING REQUIREMENTS FOR SELECTED PARAMETERS

PARAMETER	PROBABLE ¹ ANALYTICAL PROCEDURE	VOLUME REQUIRED FOR ANALYSIS	PRESERVATIVES REQUIRED	MAXIMUM HOLDING TIME BEFORE COMPLETING ANALYSIS	TEMPERATURE FOR SHIPMENT	TYPE OF CONTAINER	PLACE FOR ANALYSIS
CONDUCTIVITY	205	100 ml	----	NONE	N/A	C	ON-SITE
TEMPERATURE	212	100 ml	----	NONE	N/A	C ²	ON-SITE
TDS	208B	100 ml	----	7 DAYS	4°C	C	GRDC
TSS	208D	100 ml	----	7 DAYS	4°C	C	GRDC
ALKALINITY	403	100 ml	----	24 HOURS	4°C	C	GRDC
AMMONIA	418	400 ml	2 ml H ₂ SO ₄	24 HOURS	4°C	C	GRDC
BROMIDE	406	100 ml	----	24 HOURS	4°C	C	GRDC
CHLORIDE	408C	50 ml	----	7 DAYS	AMBIENT	C	GRDC
CYANIDE	413C	500 ml	NaOH TO pH $\geq$ 12	24 HOURS	4°C	C	GRDC
FLUORIDE	414	300 ml	----	7 DAYS	4°C	C	GRDC
NO ₃ -NO ₂	419,420	100 ml	2 ml H ₂ SO ₄	7 DAYS	4°C	C	GRDC
ORGANIC N	421	500 ml	2 ml H ₂ SO ₄	7 DAYS	4°C	C	GRDC
pH	424	100 ml	----	NONE	N/A	C	ON-SITE
SULFATE	427	50 ml	----	7 DAYS	4°C	C	GRDC
SULFIDE	428	500 ml	2 ml ZINC ACETATE	24 HOURS	AMBIENT	C	GRDC
NONMETALLIC ELEMENTS & METALS	EMISSION SPECTROSCOPY	250 ml	----	24 HOURS	4°C	C	GRDC
As	424	100 ml	5 ml HNO ₃	6 MONTHS	AMBIENT	C	GRDC
Hg (TOTAL)	315	100 ml	5 ml HNO ₃	13 DAYS	AMBIENT	C	GRDC
SPECIFIC ORGANICS	HIGH PRESSURE LIQUID CHROMA- TOGRAPHY OF VOLATILE, ACID, BASE, NEUTRAL FRACTIONS	1,000 ml	----	24 HOURS	4°C	G	GRDC

TABLE B.B.3-4 (CONCLUDED)

PARAMETER	PROBABLE ¹ ANALYTICAL PROCEDURE	VOLUME REQUIRED FOR ANALYSIS	PRESERVATIVES REQUIRED	MAXIMUM HOLDING TIME BEFORE COMPLETING ANALYSIS	TEMPERATURE FOR SHIPMENT	TYPE OF CONTAINER	PLAGE FOR ANALYSIS
COD	508	50 ml	2 ml H ₂ SO ₄	7 DAYS	AMBIENT	C	GRDC
OILS & GREASE	502	1,000 ml	2 ml H ₂ SO ₄	24 HOURS	4°C	G	GRDC
PHENOLS	510	500 ml	H ₃ PO ₄ TO pH <4 1.0g CuSO ₄ /l	24 HOURS	4°C	G	GRDC
TCC	505	50 ml	H ₃ PO ₄	7 DAYS	4°C	G ³	GRDC
RADIOACTIVITY	703	10 ml	----		4°C	C	GRDC

¹BASED ON STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 1975.

²C = PLASTIC CUBITAINER

³G = GLASS BOTTLE

TABLE B.B.3-5

CONTAINERS AND PRESERVATIVES USED WITH GROUNDWATER SAMPLES

<u>SAMPLE CONTAINER AND PRESERVATIVE</u>	<u>PARAMETERS TO BE ANALYZED</u>
1. CUBITAINER, NOT TREATED	TEMPERATURE, CONDUCTIVITY, pH (ON-SITE)
2. CUBITAINER, NOT TREATED	TDS, TSS, SULFATE, TRACE ELEMENTS, BROMIDE, CHLORIDE, FLUORIDE, RADIOACTIVITY, ALKALINITY
3. CUBITAINER, WITH H_2SO_4	NH_3 , NO_3-NO_2 , ORGANIC N, COD
4. CUBITAINER, WITH NaOH	CYANIDE
5. CUBITAINER, WITH HNO_3	Hg, As
6. CUBITAINER, WITH ZINC ACETATE	SULFIDE
7. GLASS BOTTLE, NOT TREATED	SPECIFIC ORGANICS
8. GLASS BOTTLE, WITH H_3PO_4	TOC
9. GLASS BOTTLE, WITH H_2SO_4	OILS AND GREASE
10. GLASS BOTTLE, WITH H_3PO_4 AND $CuSO_4$	PHENOLS

- Except for subsamples analyzed on-site, all other containers will be packed, on ice or blue ice, in coolers and air shipped to GR&DC labs (in Pittsburgh, PA) immediately, so that elemental analysis, organic analysis, and so forth may begin within 24 hours of sample collection.
- Sample collection and other appropriate procedures are as described in "Standard Methods for the Examination of Water and Wastewater," 14th edition, American Water Works Association (AWWA) or "Methods for the Chemical Analyses of Water and Wastes," Environmental Protection Agency (EPA).

The State of Wyoming has recommended the procedures shown below for the collection of groundwater samples for baseline monitoring (Guidelines for Baseline, Mining, and Post-Mining, Water Quality Monitoring, Wyoming Department of Environmental Quality, 1977). These procedures will be followed in this activity.

- "Each well should be pumped until the electrical conductivity of the water produced is essentially constant.
- At least one casing volume of water shall be extracted prior to sample collection."

B.B.3.5.2 Deliverables

TRW will collect the baseline water samples and deliver them to GR&DC. After the results of water analyses have been received from GR&DC, the results will be included in the baseline monitoring report.

B.B.3.5.3 Long Lead Items

A local well driller will be subcontracted to pump the wells in order to collect the water samples if the monitoring wells are not equipped with pumps.

B.B.3.5.4 Schedule Items Needed

- A. The water quality samples will be taken in October, 1978.
- B. The projected end date is October, 1978.
- C. There are no interim milestones in this task.
- D. There are several tasks which input into the water quality monitoring subtask (WBS 3.3.1.5) and which must be completed before this subtask can be started. Before groundwater sampling can begin, hydrology studies must be conducted (WBS 1.2.5) to determine the locations and depths of aquifers, the rates and direction of groundwater flow, sites for monitoring wells must be selected (WBS 1.4.8), and monitoring well construction must have been completed (WBS 3.1.4). The technical discussion above presents the needs of water quality monitoring (WBS 3.3.1.5) with regard to monitoring well location and construction.

The arrangement of the three burn areas will have an effect on the results of groundwater monitoring. In order for the best monitoring data to be obtained, burn #2 should be located on the down-gradient side of the test area, with respect to groundwater flow.

The current plan is based upon the standard procedures for analysis shown in Table B.B.3-4.

- E. Input from the baseline monitoring activity is required for WBS 3.3.2, Test Monitoring (Phase III), and the EIA, WBS 1.1.3.

B.B.4.0 PHASE III-ENVIRONMENTAL ACTIVITIES

During Phase III, environmental quality data will be collected during the burn and post burn periods. This task consists of preparing the monitoring equipment, and collecting data for meteorological parameters, criteria air pollutants, trace elements, process specific air pollutants, and water quality parameters. Monitoring for ground subsidence will also be conducted during this task. All of the monitoring and data analysis activities will be conducted by the TRW Environmental Engineering Division (EED), with the exception of subsidence monitoring which will be conducted by a surveyor licensed in the State of Wyoming, and water quality analysis which will be conducted at the Gulf Research and Development Company laboratory. A schedule of the activities during the burn period is presented in Figure B.B. 4-1.

FIGURE B.B.4-1

SCHEDULE OF PHASE III ENVIRONMENTAL ACTIVITIES

B.B.4-2

KEY: ▲ - TASK COMPLETION

△ - SAMPLE COLLECTION DATE

■ - TERMINATION OF MONITORING AT END OF BURN NO. 2

B.B.4.1 WBS NO. 3.3.2.1 MOBILIZE MONITORING EQUIPMENT

B.B.4.1.1 WBS Element Description

Work performed under this task will be similar to that performed for the baseline testing, WBS 3.3.1.1. The preparation of the equipment will include a thorough check-out of all circuitry, calibration using reference gases, and operation for a 48-hour period to assure that equipment is functioning properly. It is anticipated that this work will begin in March, 1980. All of the instrumentation will be shipped to the test site and installed in the instrument trailer during April, 1980. After installation and calibration, the instruments will be operated for 3-4 days to assure that all instruments have stabilized and are operating according to specifications. At that time, the instruments will be in operation for monitoring during burn test period (May, 1980).

B.B.4.1.2 Deliverables

Once the equipment preparation has commenced, a status report will be prepared detailing the progress of equipment procurement, refurbishment, and calibration. This report will be submitted to the TRW project manager at the end of the month in which this work has begun (March, 1980). Any major problems which may have an impact on placing the equipment in the field at the desired time will be conveyed to the TRW project manager at once.

B.B.4.1.3 Long Lead Items

No long lead items are anticipated at this time. Monitoring equipment that was used during Phase II will be refurbished during this task in preparation for Phase III.

B.B.4.1.4 Schedule Items Needed

- A. The start date of this task is March 1, 1980.
- B. Projected end date is April 30, 1980.
- C. All equipment will be prepared, calibrated and ready for shipment to the site by April, 1980.
- D. There are no tasks which input into this activity.
- E. This task must be completed before the remaining level 5 WBS elements can be started.

B.B.4.2 WBS NO. 3.3.2.2 MONITORING OF METEOROLOGICAL PARAMETERS

B.B.4.2.1 WBS Element Description

During the Phase III monitoring period, wind speed and direction will be monitored with a portable meteorological tower. The purpose of this monitoring is to determine on-site wind speed and direction so that during the test burns, the air monitoring instruments can be located downwind from the potential sources of emissions from the UCG tests.

All of the meteorological data can also be used if any air pollution diffusion modeling studies are conducted later in the program. The data from the meteorological tower are recorded on strip charts which will be analyzed at the TRW laboratory in Vienna, Virginia.

B.B.4.2.2 Deliverables

A summary of local wind speed and direction data will be provided in the final environmental report.

B.B.4.2.3 Long Lead Items

There are no long lead items required for this task.

B.B.4.2.4 Schedule Items Needed

- A. This task will commence May 1, 1980, prior to the start of the burn test period. Monitoring will continue until after Burn 2, (November, 1980). The monitoring will be discontinued until May, 1981, prior to the start of Burn No. 3. It will continue until December 1981.

- B. Projected end date is December 1, 1981.
- C. There are no interim milestones in this task.
- D. There are no tasks which input into this activity.
- E. This task does not input to other activities.

B.B.4.3 WBS NO. 3.3.2.3 MONITORING ATMOSPHERIC CONCENTRATIONS OF CRITERIA POLLUTANTS

B.B.4.3.1 WBS Element Description

Ambient air monitoring of six criteria air pollutants will be conducted at the UCG test site during the three UCG test burns. The pollutants which will be monitored are sulfur dioxide, nitrogen dioxide, carbon monoxide, non-methane hydrocarbons, ozone and total suspended particulates. National Ambient Air Quality Standards (NAAQS) have been established for these pollutants by the EPA.

All of the gaseous pollutants will be monitored continuously using automatic analyzers. Total suspended particulate will be monitored on a six-day frequency in accordance with the National Air Surveillance Network (NASN) schedule. Unlike the baseline monitoring program, carbon monoxide (CO) will be monitored using a continuous monitor meeting EPA specifications instead of the portable CO monitor. Because of the potential for increased CO levels at the test site continuous monitoring rather than spot checks will be necessary. All of the instruments will be housed in an 8' x 16' trailer designed for air pollution monitoring. An air quality diffusion model will be utilized to determine the location of the maximum pollutant concentrations as a result of the UCG tests. The instrumentation trailer will be located at the site determined by the model. Additional hi-volume air samplers for total suspended particulates will be utilized in order to collect samples during changing wind directions.

Ambient air monitoring will begin in June 1980, prior to the start of Burn No. 1 and continue until January, 1981, after the completion of Burn No. 2. The air monitoring equipment will be decommissioned until August 1981, one month prior to the start of Burn No. 3. Monitoring will continue until January, 1982 after the completion of Burn No. 3.

B.B.4.3.2 Deliverables

A summary of ambient air concentrations of the six criteria pollutants will be included in the final environmental report.

B.B.4.3.3 Long Lead Items

There are no long lead items anticipated for this task.

B.B.4.3.4 Schedule Items Needed

- A. This task will start in July 1980.
- B. The projected end date is January 1982.
- C. There are no interim milestones in this task.
- D. There are no tasks which input into this activity.
- E. This task does not input to other activities.

B.B.4.4 WBS NO. 3.3.2.4 MEASUREMENT OF PROCESS SPECIFIC AIR POLLUTANTS

B.B.4.4.1 WBS Element Description

In addition to criteria air pollutants, ambient concentrations of trace elements will be sampled and analyzed. The total suspended particulate (TSP) filter samples will be analyzed by atomic absorption spectrophotometry by the TRW laboratory at Redondo Beach, California. The trace element concentrations which will be determined are listed on Table B.B.3-2. An analysis of the fluoride and polynuclear aromatic hydrocarbon (PNA) content of the ambient air will be conducted from the filter samples. Additional pollutants which will be monitored are hydrogen sulfide, carbonyl sulfide, and ammonia. Ambient air samples will be taken in evacuated Mylar bags and shipped to the laboratory at Redondo Beach for analysis. Trace element samples will be analyzed once during the burn period and twice during Burn Numbers 2 and 3. Hydrogen sulfide, carbonyl sulfide, and ammonia will be sampled at the same frequency.

B.B.4.4.2 Deliverables

A summary of the concentrations of these pollutants will be included in the baseline environmental report.

B.B.4.4.3 Long Lead Items

There are no long lead items required in this task.

B.B.4.4.4 Schedule Items Needed

- A. The samples will be taken in June, September, and October 1980 and September and October 1981.
- B. The projected end date is October 1981.
- C. There are no interim milestones in this task.

- D. There are no tasks which input into this activity.
- E. This task does not input to other activities.

B.B.4.5 WBS 3.3.2.5 MONITORING WATER QUALITY PARAMETERS

B.B.4.5.1 WBS Element Description

The purpose of the during-burn and post-burn water quality monitoring program will be to determine if burn activities are resulting in any significant changes in groundwater quality. During the burn period (Phase III) data on physical characteristics, metals, inorganic nonmetallic constituents, organic constituents, and radioactivity will be obtained from the coal seam aquifer and from underlying and overlying aquifers and compared with data obtained during pre-burn monitoring. Water quality monitoring will continue for nine months following the termination of Burn No. 3.

B.B.4.5.1.1

The wells used for pre-burn water quality monitoring will be used for during-burn water quality monitoring. The rationale for the number of wells and their location and construction is presented in WBS 3.3.1.5, Baseline Water Quality Monitoring. As in the baseline monitoring program, four monitoring wells will be utilized for during-burn monitoring. A probable arrangement for these wells is shown in Figure B.B.3-2

B.B.4.5.1.2 Parameters to be Measured

This section (B.B.4.5.1.2) and sections B.B.4.5.1.3 and B.B.4.5.1.4 present the plan for Phase III water quality sampling. This plan will be followed until significant water quality changes are detected. Section B.B.4.5.1.5 presents a contingency sampling schedule which will be followed in the event significant changes in water quality are detected.

Part A of Table B.B.4-1 lists the parameters which will be measured in water samples from the coal seam aquifer. These parameters were selected

TABLE B.B.4-1

PARAMETERS TO BE MONITORED DURING PHASE III, DURING-BURN MONITORING

A. SDB AQUIFER:

PHYSICAL CHARACTERISTICS:

CONDUCTIVITY
TEMPERATURE
TOTAL DISSOLVED SOLIDS (TDS)
SUSPENDED SOLIDS (TSS)

INORGANIC NONMETALLIC CONSTITUENTS:

AMMONIA (NH_3)
BICARBONATE
CHLORIDE (Cl^-)
CYANIDE (CN^-)
FLUORIDE (F^-)
NITRATE-NITRITE (NO_3^- - NO_2^-)
ORGANIC NITROGEN
pH
SULFATE
ARSENIC (As)
BORON (B)
SILICON (Si)

TABLE B.B.4-1 (continued)

RADIOACTIVITY:

GROSS ALPHA AND BETA ACTIVITY OF FILTRATE

METALS:

ALUMINUM (Al)
BARIUM (Ba)
CADMIUM (Cd)
CALCIUM (Ca)
CHROMIUM (Cr)
COPPER (Cu)
IRON (Fe)
LEAD (Pb)
MAGNESIUM (Mg)
MERCURY (Hg)
MOLYBDENUM (Mo)
NICKEL (Ni)
POTASSIUM (K)
SELENIUM (Se)
VANADIUM (V)
ZINC (Zn)
URANIUM
SODIUM
MANGANESE

TABLE B.B.4-1 (continued)

ORGANIC CONSTITUENTS:

CHARACTERIZATION OF SPECIFIC ORGANICS

CHEMICAL OXYGEN DEMAND (COD)

OILS AND GREASE

TOTAL ORGANIC CARBON (TOC)

MISCELLANEOUS:

AS NEEDED

B. UNDERLYING/OVERLYING AQUIFERS:

AMMONIA (NH_3)

CYANIDE (CN^-)

IRON (Fe)

NITRATE - NITRITE (NO_3^- - NO_2^-)

SULFIDE (S^-)

TOTAL DISSOLVED SOLIDS (TDS)

TOTAL ORGANIC CARBON (TOC)

PHENOLS

because previous studies (such as those by Mead et al 1977) have shown that these parameters are likely to be altered by SDB-UCG activities in the vicinity.

The four monitoring wells will also be used to monitor any changes in quality of underlying and overlying aquifers. This is planned to monitor for adjacent aquifer contamination. Although periodic checks of adjacent aquifers are important, neither the frequency of sampling nor the number of parameters monitored needs to be as great as for the SDB aquifer; therefore, samples of underlying and overlying aquifers will be collected on a quarterly basis and analyzed for the parameters shown in part B of Table B.B.4-1.

B.B.4.5.1.3. Sampling Frequency

In pre-burn monitoring activities, collecting one set of samples from each monitoring well will be sufficient to indicate overall water quality in a slow-moving aquifer. In during-burn monitoring, some changes to water quality may occur, and sampling frequency has been increased to biweekly and quarterly intervals to detect any changes in selected parameters and to monitor fluctuations in these parameters during and following the burn periods. Table B.B.4-2 shows frequencies of water sample collection planned for each of the four monitoring wells. The time that monitoring at each well begins will be when the burn begins that each is intended to monitor. Organic contaminant characterization, which will be conducted once for each monitoring well and adjacent aquifers, will be performed three months after monitoring begins at each well.

Table B.B.4-3 shows the scheduled dates that sampling of the SDB aquifer, and underlying and overlying aquifers begins in each well.

TABLE B.B.4-2

SAMPLING FREQUENCIES FOR SELECTED PARAMETERS DURING PHASE III,
DURING-BURN MONITORING

<u>PARAMETER</u>	<u>FREQUENCY</u>		
	<u>BIWEEKLY</u>	<u>QUARTERLY</u>	<u>ONCE ONLY</u>
SDB AQUIFER			
ALKALINITY	X		
AMMONIA	X		
CHEMICAL OXYGEN DEMAND (COD)	X		
CONDUCTIVITY	X		
NITRATE-NITRITE NITROGEN	X		
ORGANIC NITROGEN	X		
pH	X		
SULFIDES	X		
TEMPERATURE	X		
TOTAL DISSOLVED SOLIDS (TDS)	X		
TOTAL ORGANIC CARBON (TOC)	X		
TOTAL SUSPENDED SOLIDS (TSS)	X		
PHENOLS	X		
CHLORIDE	X		
CYANIDE	X		
FLUORIDE		X	
OILS AND GREASE		X	
RADIOACTIVITY		X	
TRACE ELEMENTS: ALUMINUM, ARSENIC,		X	
BARIUM, BISMUTH, BERYLLIUM,			
CADMIUM, CALCIUM, CHROMIUM,			
COPPER, GERMANIUM, IRON, LEAD,			
LITHIUM, MAGNESIUM, MERCURY,			
MOLYBDENUM, NICKEL, POTASSIUM,			
SELENIUM, SILICON, TIN, TITANIUM,			
VANDIUM, ZINC, URANIUM, SODIUM,			
MANGANESE, ANTIMONY			

TABLE B.B.4-2 (continued)

<u>PARAMETER</u>	<u>FREQUENCY</u>		
	<u>BIWEEKLY</u>	<u>QUARTERLY</u>	<u>ONCE ONLY</u>
SDB AQUIFER		X ←———— X	
CHARACTERIZATION OF SPECIFIC ORGANICS		X ←———— X	
MISCELLANEOUS ANALYSES (AS NEEDED)			
UNDERLYING/OVERLYING AQUIFERS			
AMMONIA		X	
CYANIDE		X	
IRON		X	
NITRATE-NITRITE		X	
SULFIDE		X	
TOTAL DISSOLVED SOLIDS		X	
TOTAL ORGANIC CARBON		X	
PHENOLS		X	

B.B.4.5.1.4 Sampling Procedures

In preparing plans for water sampling, consideration was given to the types of analyses to be performed and possible methods for analysis. Table B.B.4-4 presents a summary of preservation and handling requirements for each of the parameters to be investigated. Variations in sample preservation and handling include acidification with H_2SO_4 or HNO_3 , and glass vs. plastic containers. To ensure that sample collection, handling, and transportation will allow valid analyses, the following procedures will be undertaken:

- At each sampling point, a set of ten (10), 1-liter sample containers will be collected. These nine containers will constitute one "sample;" each container will constitute one "subsample." Table B.B. 4-5 shows the types of containers and preservatives to be used.
- Except for on-site subsamples, all other container will be packed, on ice or "blue ice," in coolers and air shipped to GR&DC labs (in Pittsburgh, Pennsylvania) immediately, so that the emission spectroscopy and specific organic analysis may begin within 24-hours of sample collection.
- Sample collection and other appropriate procedures will be as described in "Standard Methods for the Examination of Water and Wastewater," 14th edition, American Water Works Association (AWWA) or "Methods for the Chemical Analyses of Water and Wastes," Environmental Protection Agency (EPA).

The State of Wyoming has recommended the procedures shown below for the collection of groundwater samples for baseline monitoring which are

TABLE B.B.4-3
SCHEDULED BEGINNING FOR SAMPLING AT
EACH MONITORING WELL

<u>WELL NO.</u>	<u>DATE</u>
1	JULY 1980
2	SEPTEMBER 1980
3	SEPTEMBER 1981
4	SEPTEMBER 1980

TABLE B.B.4-4

SUMMARY OF HANDLING REQUIREMENTS FOR SELECTED PARAMETERS

PARAMETER	PROBABLE [†] ANALYTICAL PROCEDURE	VOLUME REQUIRED FOR ANALYSIS	PRESERVATIVES REQUIRED	MAXIMUM HOLDING TIME BEFORE COMPLETING ANALYSIS	TEMPERATURE FOR SHIPMENT	TYPE OF CONTAINER	PLACE FOR ANALYSIS
CONDUCTIVITY	205	100 ml	----	NONE	N/A	C	ON-SITE
TEMPERATURE	212	100 ml	----	NONE	N/A	C ²	ON-SITE
TDS	208B	100 ml	----	7 DAYS	4°C	C	GRDC
TSS	208D	100 ml	----	7 DAYS	4°C	C	GRDC
ALKALINITY	403	100 ml	----	24 HOURS	4°C	C	GRDC
AMMONIA	418	400 ml	2 ml H ₂ SO ₄	24 HOURS	4°C	C	GRDC
CHLORIDE	403C	50 ml	----	7 DAYS	AMBIENT	C	GRDC
CYANIDE	413C	500 ml	NaOH TO pH $\geq$ 12	24 HOURS	4°C	C	GRDC
FLUORIDE	411	300 ml	----	7 DAYS	4°C	C	GRDC
NO ₃ -NO ₂	419,420	100 ml	2 ml H ₂ SO ₄	7 DAYS	4°C	C	GRDC
ORGANIC N	421	500 ml	2 ml H ₂ SO ₄	7 DAYS	4°C	C	GRDC
pH	421	100 ml	----	NONE	N/A	C	ON-SITE
SULFIDE	425	500 ml	2 ml ZINC ACETATE	24 HOURS	AMBIENT	C	GRDC
NONMETALLIC ELEMENTS & METALS	EMISSION SPECTROSCOPY	250 ml	----	24 HOURS	4°C	C	GRDC
As	404	100 ml	5 ml HNO ₃	6 MONTHS	AMBIENT	C	GRDC
Hg (TOTAL)	315	100 ml	5 ml HNO ₃	13 DAYS	AMBIENT	C	GRDC
SPECIFIC ORGANICS	HIGH PRESSURE LIQUID CHROMA- TOGRAPHY OF VOLATILE, ACID, BASE, NEUTRAL FRACTIONS	1,000 ml	----	24 HOURS	4°C	G	GRDC

TABLE B.B.4-4 (continued)

PARAMETER	PROBABLE ANALYTICAL PROCEDURE	VOLUME REQUIRED FOR ANALYSIS	PRESERVATIVES REQUIRED	MAXIMUM HOLDING TIME BEFORE COMPLETING ANALYSIS	TEMPERATURE FOR SHIPMENT	TYPE OF CONTAINER	PLACE FOR ANALYSIS
COD	508	50 ml	2 ml H_2SO_4	7 DAYS	AMBIENT	C	GRDC
OILS & GREASE	502	1,000 ml	2 ml H_2SO_4	24 HOURS	4°C	G	GRDC
TOC	505	50 ml	H_3PO_4	7 DAYS	4°C	G ³	GRDC
RADIOACTIVITY	703	10 ml	----		4°C	C	GRDC

¹BASED ON STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 1975.

²C = PLASTIC CUBITAINER

³G = GLASS BOTTLE

TABLE B.B.4-5
CONTAINERS AND PRESERVATIVES USED WITH GROUNDWATER SAMPLES

<u>SAMPLE CONTAINER AND PRESERVATIVE *</u>	<u>PARAMETERS TO BE ANALYZED</u>
1. CUBITAINER, NOT TREATED	TEMPERATURE, CONDUCTIVITY, pH (ON-SITE)
2. CUBITAINER, NOT TREATED	TDS, TSS, ALKALINITY, NONMETALLIC ELEMENTS AND METALS, CHLORIDE, FLUORIDE, RADIOACTIVITY
3. CUBITAINER, WITH H_2SO_4	NH_3 , NO_3-NO_2 , ORGANIC N, COD
4. CUBITAINER, WITH NaOH	CYANIDE
5. CUBITAINER, WITH HNO_3	Hg, As
6. CUBITAINER, WITH ZINC ACETATE	SULFIDE
7. GLASS BOTTLE, NOT TREATED	SPECIFIC ORGANICS
8. GLASS BOTTLE, WITH H_3PO_4	TOC
9. GLASS BOTTLE, WITH H_2SO_4	OILS AND GREASE
10. GLASS BOTTLE, WITH H_3PO_4 AND $CuSO_4$	PHENOLS

* ALL TEN CONTAINERS WILL BE SHIPPED TO GR&DC FOR ANALYSIS.

found in "Guidelines for Baseline, Mining, and Post-Mining Water Quality Monitoring Program" (State of Wyoming, Department of Environmental Quality, March, 1977). These procedures will be followed in this activity.

- "Each well should be pumped until the electrical conductivity of the water produced is essentially constant.
- At least one casing volume of water shall be extracted prior to sample collection."

A potential problem exists related to the use of plastic casings in monitoring wells. Plastic is known to cause contamination of water samples by leaching plasticisers into the water. An additional problem of adsorption of organic compounds from water samples onto the walls of plastic tubing has also been suggested. More study is needed to assess the extent of these problems and the need for choosing alternate materials. Pumping on the wells prior to sampling should minimize the effects of PVC.

B.B.4.5.1.5 Contingency Sampling Schedule

Some data available on the effects of UCG on groundwater quality indicate the monitoring frequency may have to be increased for certain parameters. Data recently presented by Mead, Campbell and Stephens at the 3rd Annual Underground Coal Conversion Symposium, June, 1977, demonstrated that a variety of inorganic materials have migrated from UCG burn areas and that high levels of organics appear to be concentrated in a thin shell that is peripheral to the burn zone. These concentrated organics slowly migrate from the site as a plume. This process is illustrated in Figure B.B.4-2. Mead, et al., (1977) analysis of specific organic compounds in groundwater down-gradient from the burn area shows many organic compounds also found in coal tar. Figure B.B.4-3 presents a gas chromatograph/mass spectrometer (GC/MS) chromatogram of organics in groundwater down-gradient from a UCG test, which Mead, et al., (1977) have presented.

Initial distribution of Contaminant Sources

Ground-water flow leads to plume development

SOURCE: Mead; Campbell and Stephens, 1977.

Figure B.B.4-2

SUGGESTED MECHANISM FOR MIGRATION OF ORGANIC AND INORGANIC MATERIALS FROM UCG BURN AREA

SOURCE: Mead, Campbell, and Stephens, 1977.

FIGURE B.B.4-3

CHROMATOGRAMS OF VOLATILE ORGANICS FOUND IN PRODUCT TAR AND IN WATER, TAKEN 5 FT. AND 45 FT. FROM THE BURN ZONE

Table B.B.4-6 lists several parameters from the Mead, et al., (1977) study which showed significant increases after UCG experiments. Of these parameters, cyanide (CN), ammonia (NH₄), lead (Pb), TOC, and the trace elements are included in our selected parameters for analysis. These will be used as key parameters for indicating significant changes in water quality. When significant changes are noted in these parameters, sampling frequency will be increased to biweekly for all parameters, except specific organics. Specific organic characterization will be performed monthly. Additional parameters will also be analyzed on a biweekly basis; these include phenols and sulfate.

Table B.B.4-7 presents the contingency sampling schedule, and parameters to be analyzed. If a significant increase in concentrations of selected parameters occurs in either the underlying or overlying aquifers, all parameters shown in Table B.B.4-7 will be analyzed at the frequency indicated for underlying and/or overlying aquifer samples.

The contingency sampling schedule will be followed until parameters return to baseline levels, or until the end of Phase III. Some attempts to model the migrating plume of organic and inorganic constituents (Campbell 1976) have led to suggestions that many of the organic pollutants are eventually resorbed by the coal.

B.B.4.5.2 Deliverables

TRW will collect the water samples and ship them to GR&DC. The results of water quality monitoring, as received from GR&DC, will be included in the Phase III summary report.

B.B.4.5.3 Long Lead Items

A local well driller will be subcontracted to pump the wells in order to collect the water samples, if the monitoring wells are not equipped with pumps.

TABLE B.B.4-6
A SIMPLIFIED SUMMARY OF DATA FOR CONTAMINANTS THAT SHOWED
A LARGE INCREASE FOLLOWING GASIFICATION

Species	Pre-gasification value (mg/l)	Inside burn zone		Outside burn zone	
		Concentration (mg/l)	Increase	Concentration (mg/l)	Increase
Phenols	0.001	0.1	100 ×	500	5 × 10 ⁵ ×
CN ⁻	0.01	0.4	40 ×	300	3 × 10 ⁴ ×
NH ₄ ⁺	0.5	20	40 ×	70	100 ×
DOC	6	4	—	200	40 ×
Br ⁻	0.1	1.0	10 ×	4	40 ×
Pb ⁺²	0.001	0.001	—	0.04	40 ×
Ba ⁺²	0.1	—	—	1.0	10 ×
K ⁺	5	60	10 ×	45	8 ×
Li ⁺¹	0.03	0.3	10 ×	0.2	6 ×
Mg ⁺²	10	50	5 ×	60	6 ×
SO ₄ ⁻²	200	2000	10 ×	1000	5 ×
Ca ⁺²	40	600	20 ×	200	5 ×
B ⁺³	0.1	0.7	7 ×	0.5	5 ×

SOURCE: Mead, Campbell, Stephens.

TABLE B.B.4-7

CONTINGENCY SAMPLING SCHEDULE FOR SDB AQUIFERS AND
OVERLYING/UNDERLYING AQUIFERS

<u>PARAMETER</u>	<u>BIWEEKLY</u>	<u>MONTHLY</u>
CONDUCTIVITY	X	
TEMPERATURE	X	
TDS	X	
TSS	X	
ALKALINITY	X	
AMMONIA	X	
CHLORIDE	X	
CYANIDE	X	
FLUORIDE	X	
NO ₃ -NO ₂	X	
ORGANIC N	X	
pH	X	
SULFIDE	X	
NONMETALLIC ELEMENTS AND METALS	X	
SPECIFIC ORGANICS CHARACTERIZATION		X
COD	X	
OILS AND GREASE	X	
TOC	X	
RADIOACTIVITY	X	
SULFATES	X	

B.B.4.5.4 Schedule Items Needed

- A. The water quality monitoring will begin in July, 1980.
- B. The projected end date is December 31, 1981.
- C. There are no interim milestones in this task.
- D. There are several tasks which input into the water quality monitoring subtask (WBS 3.3.2.5) and which must be complete before this subtask can be started. Before groundwater sampling can begin, hydrology studies must be conducted (WBS 1.2.5) to determine the locations and depths of aquifers, the rates and direction of groundwater flow; sites for monitoring wells must be selected (WBS 1.4.8), and monitoring well construction must have been completed (WBS 3.1.4). The technical discussion above presents the needs of water quality monitoring (WBS 3.3.2.5) with regard to monitoring well location and construction.

The arrangement of the three burn areas will have an effect on the results of groundwater monitoring. In order for the best monitoring data to be obtained, burn #2 should be located on the down-gradient side of the test area, with respect to groundwater flow.

The current plan is based upon the standard procedures for analysis shown in table B.B.4-4.

The during-burn water quality monitoring subtask (WBS 3.3.2.5) can not be completed until the results of water analysis have been received from GR&DC labs.

- E. This task inputs to WBS 3.3.2, Environmental Lab Support.

B.B.4.6 WBS NO. 3.3.2.6 SUBSIDENCE MONITORING

B.B.4.6.1 WBS Element Description

The purpose of this task is to determine the extent of ground subsidence resulting from the underground gasification tests. Prior to the start of Burn No. 1, locations of the subsidence monuments will be determined. The monuments will be placed in the predetermined locations by a local surveyor, licensed in the State of Wyoming, who will be subcontracted to perform this work. During the test burns, the monuments will be surveyed at a frequency specified by the mining engineer.

B.B.4.6.2 Deliverable

The extent of the ground subsidence will be documented in the final environmental report.

B.B.4.6.3 Long Lead Items

A subcontract to a local surveyor should be initiated and signed by May, 1980.

B.B.4.6.4 Schedule Items Needed

- A. The start date of this task is June, 1980.
- B. The projected end date is September, 1982.
- C. There are no interim milestones in this task.
- D. There are no tasks which feed into this activity.
- E. This task does not input to other activities.

B.B. 5.0 RECOMMENDATIONS

Although the environmental monitoring activities which will be conducted during the three remaining phases of the UCG test program are extensive, there are additional activities that are recommended to provide additional information about the environmental aspects of underground coal gasification for steeply dipping coal beds. The recommended programs are as follows.

B.B.5.1 PARTICLE SIZE AND SIZE DISTRIBUTION ANALYSIS

Sampling and analyses to determine the size and size distribution of airborne particulate material in the ambient air at the test site is recommended. The environmental analysis of the concept design indicated that respirable particulate emissions would range from one pound to 40 pounds per day. In order to determine the potential hazard from respirable dust emissions, it is advisable to determine the sizes of the particles emitted. Particle sizing can be determined using a cascade impactor. In addition to the particle sizes, it is also necessary to determine distribution of the particle sizes from 0.5 microns to 15 microns which includes the size range of respirable particulates.

B.B.5.2 WATER QUALITY MODELING

The groundwater contaminant plume model developed by Campbell (1976) should be utilized in conjunction with site specific hydrology data, to assess the extent of pollutant migration in the groundwater. The possibility exists that pollutants will be discharged into the groundwater as a result of underground coal gasification for steeply dipping beds. The concentrations of the pollutants and the rates of migration will be measured during Phase III. Through the application of these data to existing models, such as the one developed by Campbell (1976) the magnitude of the groundwater

contamination may be assessed. These models would estimate the extent of pollutant resorption by the coal beds over extended periods of time. The modeling effort will apply the Phase III data to the above mentioned model or to a more appropriate model which may be developed by 1982.