ENVIRONMENTAL IMPACT OF OIL AND GAS EXPLORATION AND PRODUCTION
COMPLEMENTARY PROGRAM PROJECT ABSTRACTS

Task 1: Evaluation of Subsurface Drip Irrigation (SDI)

Subsurface drip irrigation (SDI) is a potential low-cost means to dispose of produced water that may increase CBNG production in the PRB, increase crop yield, and foster better relationships between gas companies and landowners/ranchers.

Traditional irrigation with CBNG produced water can destroy soil productivity because the high sodium content of the water reduces infiltration rates. In theory, SDI can avoid the deleterious effects of surface application by introducing CBNG produced water at the base of the root zone using buried, perforated pipe (emitters). At this depth, there is sufficient calcium and magnesium present in the soil to offset the adverse effect of the high-sodium CBNG produced water. Further, vigorous root penetration from the crop (most commonly alfalfa) will maintain vertical infiltration pathways.

Many questions exist concerning the long-term effects of SDI on soil productivity, salt mobilization, and the displacement of high-TDS native groundwater into surface streams. This task will establish long-term phreatic and vadose zone monitoring at an SDI site being constructed for Anadarko Petroleum to provide unbiased answers to these questions (Fig. 1). Prior to the installation of the SDI, NETL will use electromagnetic surveys to identify areas containing clay layers, salt layers, and high-TDS groundwater so that these areas can be avoided when the SDI is installed. During SDI operation, electromagnetic and resistivity surveys will monitor groundwater movement.

In a letter addressed to the NETL Director, the Wyoming Department of Environmental Quality requested that NETL conduct research pertaining to management of CBNG produced water in the Powder River Basin. A long-term evaluation of subsurface drip irrigation was given first priority.

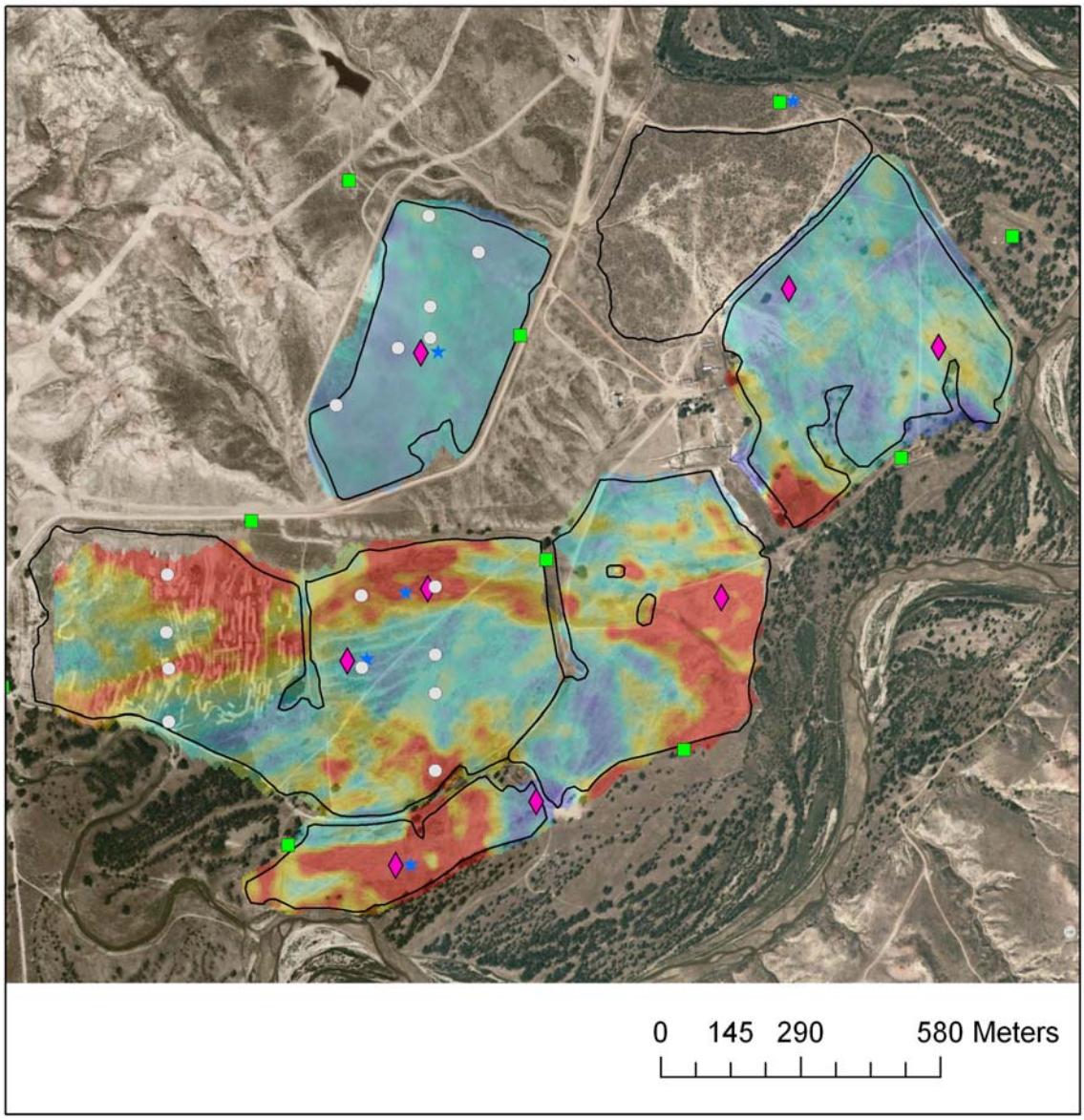

Figure 1. Location of monitoring sites at Headgate Draw

Task 2: Better Assessment of Watersheds; Wyoming Section 20 Discharges

This task seeks to develop better methods for determining permissible effluent limits for CBNG produced water discharges under provisions of Wyoming's Agricultural Use Protection Policy (Section 20) tier 2. Currently, effluent water quality limits are based on background water quality which is determined by the analysis of "semi-random" soil samples collected from sub-irrigated portions of floodplains (vegetated areas along streams as determined from satellite infrared imagery). The minimum number of soil samples is three samples for 0-5 acre areas, five samples for 5-10 acre areas, and 7 samples for areas comprising more than 10 acres. Soil sample locations must be more than 50 ft apart. At each location, soil samples are collected in one-foot intervals to a minimum depth of 4 feet. If the area is planted with alfalfa, soil samples are collected at one-foot intervals to a depth of 6 feet. The samples are analyzed (either separately or "composited") for EC. To be permitted, the EC of CBNG produced water discharges must be less than the background EC determined from soil samples.

This task will develop and evaluate new methods for determining effluent limits under Wyoming's Agricultural Use Protection Policy. The new methods will be evaluated in the Beaver Creek Watershed, a tributary to the Powder River in Wyoming that already has been evaluated for Section 20 discharge permits. Specifically, sub-irrigated areas will be delineated using high-resolution (sub-meter) hyperspectral imagery that is spatially more accurate than the satellite imagery currently used. Further, hyperspectral data has the ability to determine vegetation type and the mineralogy of exposed soils (including efflorescent salts), important for determining the areal extent of sub-irrigated areas. The background EC will be calculated from the apparent conductivity of a near surface layer as determined by helicopter electromagnetic surveys. Background water quality values obtained using the new methods will be compared with the background water quality derived from the analysis of soil samples. The new techniques have the potential to provide more accurate values for background water quality because the determination is based on results from the entire area, not just a few soil sample locations. Because these techniques are aircraft-based, very large areas could be quickly evaluated; thereby making hundreds of miles of drainages available for CBNG produced water discharge.

Task 3: Impact of Oil and Gas Activities on Local and Regional Air Quality

Visibility impairment from regional haze is a significant problem in many areas of the U.S. Reduction of visibility is due to absorption and scattering of light by both particles and gases. Oil and gas production activities emit a variety of air pollutants such as $PM_{2.5}$, NO_x, SO_2, VOCs and air toxics from multiple sources that include volatiles that escape from the wellhead during the drilling and production operations, production site product separation processing steps, combustion-based energy conversion point sources, etc.

Estimates of the impact of oil and gas exploration and production activities on regional air quality are generally based on air quality models that treat these activities in a given state as a single point source at worst, and at best, a series of generic point source pollution emitters.

These inaccurate assumptions result in a very different air quality impact than would result from modeling the many small, widely dispersed sources that actually exist.

The impact of small-scale oil and gas production activities on local and regional air quality will be established through a combination of source-receptor modeling based on historic emissions literature, selected site air quality studies, and university partner based laboratory studies. Objectives for this task include identifying information gaps necessary to assess the impact of air emissions from oil and natural gas production activities and conducting assessment studies needed to develop models of the impacts on local and regional ambient air quality. Work this quarter has focused on evaluating air quality models such as PMF and CALPUFF for eventual modeling of visibility impacts and initial planning for conducting targeted on-site measurements of emissions from oil and gas production activities.

Task 4: Environmental Assessment of Oil Shale Technologies

This task will use publicly available information to conduct an environmental assessment of next generation oil shale retort technologies. The objective of this work is to anticipate potential environmental problems so that avoidance/mitigation strategies for each retorting technology can be developed prior to commercialization. For the various oil shale retorting technologies, this task will:

A. Determine process water requirements, regional water availability, and impacts on surface and subsurface water availability;
B. Determine the potential for contamination of surface and groundwater resources;
C. Develop models for contaminant generation, transport, and deposition;
D. Evaluate air contamination potential; and
E. Evaluate the anaerobic biotreatment of liquid effluents.

Task 5: Incorporate EPAct EI Data into Knowledge Management Database

This task will transform geospatial data developed by EPAct 999 Environmental Initiative (EI) projects into data structures and file protocol that can easily be assimilated into the EPAct 999 Knowledge Management Database (KMS). The goal of this project is to ensure an orderly flow of data products into KMS. Further, personnel assigned to this task will work with KMS developers to build on-line, interactive tools that will make EPAct EI data more useful to stakeholders. All data products will be reviewed to meet federal geospatial data standards (FGDC).

Task 6: Ecological Impact of Oil and Gas Activities

This task will provide an unbiased, science-based assessment of the impacts that oil and gas activities have on indigenous flora and fauna. Opinions regarding the adequacy of regulations intended to protect indigenous species are widely varied. Oil and gas interests see many of these regulations as overly protective, unnecessary, and preventing access to energy resources that the

nation needs. Environmental groups feel that regulations cannot be too protective. This task will use well-accepted scientific methods to evaluate the actual impact of oil and gas activities on the local ecology. Specifically, one subtask will determine the impact of oil and gas access roads on local hydrology, flora and fauna in the Allegheny National Forest, an area currently undergoing intense gas development. The US Forest Service will be an active partner for this subtask. The second subtask will evaluate the effect that oil and gas activities are having on songbirds and raptors in the central Appalachians of West Virginia.

Task 7: Environmental Barriers to Oil and Gas Development

This task seeks to catalogue (identify, compile, and compare) environmental barriers/issues/best practices (Federal, state, or local) that affect on-shore oil and gas development.

Subtask 1 will be to prepare a report on the various environmental barriers limiting on-shore domestic oil and gas production. The report will identify the issues, and describe the relative magnitude of the impact in terms of lost or foregone production. The report will include both regulatory and technical issues. The report also will provide a discussion of the steps that would be needed to address each issue as well as the relative costs and timeframes required for such solutions and the likelihood of success.

Subtask 2 will be accomplished by arranging three regional meetings (Appalachian Region, Gulf Coast Region and Rocky Mountain Region) to gather input from stakeholders (industry, regulators, landowners, and NGOs) pertaining to environmental barriers that they have encountered. At each meeting, participants will be asked to identify environmental barriers to domestic on-shore production. "Environmental Barriers" will be broadly defined to include issues such as the need to reduce impacts as well as environmental regulations or permitting issues that impose unnecessary restrictions or costs. The results of these meetings will be compiled and analyzed in a report to NETL. The report will be structured to provide NETL with the information needed to prioritize its research activities.

Subtask 3 will be to move the web-based produced water management information system (PWMIS) developed by Argonne National Laboratory (ANL) from the ANL server to the NETL website. Arrangements have been made to maintain and update PWMIS.

Task 8: Interactive Model to Predict Erosion or Flooding Caused by Produced Water Discharges

This task will develop an interactive model for estimating the amount of produced water that can be discharged to an ephemeral stream before significant flooding or erosion problems occur. The model also will determine the areas most likely to be affected by flooding and/or erosion and suggest alternative discharge locations and rates to avoid impacting these areas. The model will be based on high accuracy stream topography obtained using airborne, high-resolution lidar. In its fullest development, the model will be available on the web where it will provide regulators with information needed when permitting new produced water discharges.