

PRELIMINARY INVESTIGATION AND FEASIBILITY STUDY OF
ENVIRONMENTAL IMPACT OF ENERGY RESOURCE DEVELOPMENT
IN THE DENVER BASIN

An open-file report

By

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INTRODUCTION

Prior to the undertaking of a full-scale, three-year study of environmental impact of energy development in the Denver Basin, the Colorado Geological Survey conducted a three-month preliminary investigation and feasibility study of the longer term project. This report presents the findings of that study. Funding for the preliminary investigation was provided by the U.S. Geological Survey through U.S.G.S. Grant No. 14-08-0001-G-453.

Two primary topics were analyzed in the preliminary investigation. One, the technical feasibility of the three-year project and the other, possible coordination with local planning agencies. Factors addressed under technical feasibility are the limits of the study area, availability of information (old mine records, drill hole logs, proprietary company records, etc.), operating, licensed, and proposed mines in the study area, preliminary analysis of resource distribution, a bibliographic compilation, map availability, and determination of the best method of approaching the resource and environmental analysis during the long-term study. Coordination with local planning agencies involved inquiry into their knowledge of energy resources in their jurisdiction and analysis of their regulations or policy guidelines related to development of those resources. Also, the various agencies were asked for suggestions to improve the usefulness of our three-year study.

TECHNICAL FEASIBILITY

Delineation Of the Study Area.

In our original proposal the study area was to include only the area defined by the outcrop or subcrop of the Laramie-Fox Hills contact from Colorado Springs to near Greeley. However, after review of the resource distribution and determination of areas with considerable potential for development, the study area was expanded to include the region from Greeley north to the Wyoming-Colorado border. This area has the only active uranium mine in the Denver Basin and holds great potential for the discovery of additional deposits. Furthermore, this area contains known deposits of subbituminous coal that are currently undergoing significant leasing activity. The revised outline of the study area is shown in Figure 1.

Map Availability.

A variety of map bases at different scales cover the approximately 10,000 square mile area of interest. These include maps by the U.S. Geological Survey, Colorado Department of Highways, and Bureau of Land Management. The most useful map bases for the Denver Basin project appear to be those prepared by the U.S. Geological Survey. A 1:1,000,000 scale map base is available on which the study area is approximately $5\frac{1}{4}$ X $10\frac{1}{4}$, a size appropriate for page-sized illustrations. A 1:500,000 scale map uses the same cultural and topographic information as that on the 1:1,000,000

scale map, but is at a larger scale. At this scale the study area is about 10 1/2" X 20 1/2", a size too large for page-size illustrations and not detailed enough for use as a base for larger illustrations. The most useful map bases for plates which cover the entire study area are the 1:250,000 scale AMS 1° X 2° maps. A composite of the Greeley, Denver, Pueblo, Lamar, Limon, and Sterling sheets results in a map of approximately 21" X 41" which covers the entire study area.

Three series of more detailed maps ranging in scale from 1:24,000 to 1:100,000 are available or in preparation for most of the study area. These maps can be used when detailed topographic or cultural bases are needed for study of selected portions of the Denver Basin. These include the following map series: (1) the U.S.G.S. 7 1/2 minute quadrangles published at a scale of 1:24,000. Maps of this series cover the entire project area, but some of the quadrangle maps are not published in final form. Reproducible versions of these particular maps, however, are available from the National Cartography Information Center, U.S.G.S.; (2) a series of topographic county maps at a scale of 1:50,000 are currently being prepared by the U.S.G.S. in cooperation with the Colorado Division of Planning. Maps of this series which cover our study area are expected to be completed by June 30, 1978; and (3) the U.S.G.S. Front Range Urban Corridor Map Series at a scale of 1:100,000 cover a portion of the Denver Basin project area.

PRELIMINARY ANALYSIS OF ENERGY RESOURCES

Subbituminous coal, lignite, uranium, oil, and gas are present throughout much of the Denver Basin. Past development of these resources dates back to the late 1800's, when coal and oil were first extracted in the Denver Basin. As the demand for energy increases, so does the potential for future development of resources. The following is a brief description of the extent and past and proposed developments of these resources.

Subbituminous Coal

Subbituminous coal of the Denver Basin occurs in the Upper Cretaceous Laramie Formation. Figure 1 shows the portion within the study area that is underlain by this coal resource, as well as the area underlain by potentially strippable subbituminous coal. As shown in Figure 1, much of the study area is underlain by coal-bearing rocks, however, some of this area does not contain commercially economic coal reserves. Determination of areas which are underlain by economic coal deposits will be a prime topic of the full-scale Denver Basin project.

Historically, there has been considerable subbituminous coal produced in the Denver Basin. Most of this mining occurred in two fields, the Boulder-Weld and Colorado Springs Fields. Numerous isolated mines are scattered throughout much of the remaining area (see Fig. 1). There are two operating or licensed coal mines in

the study area, the Eagle and Lincoln Mines, both in the Boulder-Weld Field. A fairly large mine (producing up to 1 million tons per year (MTPY)) is proposed to be developed near Cedar Point in Elbert County. Some problems have been encountered during initial developmental phases, but it is quite likely that this mining operation may begin production in the next few years. A recent investigation by a firm interested in the Boulder-Weld Field has delineated three blocks of coal which will be feasible for extraction in the near future. Other areas of economic importance undoubtedly will be discovered in the near future.

Lignite And Associated Kaolin

Low-sulfur lignite deposits of Paleocene age are found in the upper portion of the Denver Formation. The known extent of these lignite deposits and areas where they are believed to be strippable are shown in Figure 1. Numerous small mines have extracted lignite for domestic use for the past several decades. An engineering firm is currently proposing development of a 12 MTPY lignite mine and a "mine-mouth" gasification plant located near Watkins, just east of Denver. A 1 MTPY lignite mine 5 miles southeast of Kiowa is proposed to aid in supplying fuel to the Watkins gasification plant.

Interbedded with the lignite deposits are thin beds and lenses of kaolin, claystone, shale, and sandstone. The primary mineral constituent of kaolin is kaolinite, a proven potential source of aluminum. It is possible to extract alumina from kaolinite through

an acid-leaching process at high temperature. This process is not yet commercially economic, but ongoing research and mineral economics may provide a breakthrough in the near future. When this extraction technique is perfected, the lignite and kaolin-bearing beds of the Denver Formation will become a viable dual-resource and extensive development most likely will result.

Uranium

Uranium is a relatively "new" resource to the Denver Basin. Numerous radioactive showings have been noted in several portions of the basin, but it wasn't until the last decade or so that the Denver Basin became an area suspected of containing economically extractable uranium deposits. There presently is one active uranium operation in the study area located near Grover in Weld County. Current production is limited to a pilot solution-mining system which extracts uranium from a marine sandstone in the Laramie Formation. The purpose of this project is to develop the most suitable process to use on the extensive, low-grade deposits found in this area. A second uranium deposit has been discovered in the north-central portion of the Denver Basin. Additional evaluation of this deposit is underway to further assess its value. Uranium exploration and active leasing are also occurring in other portions of the study area, with primary targets being the Laramie and Fox Hills Formations in Larimer and Weld Counties, and the Dawson Arkose in Douglas and Elbert Counties.

Petroleum And Natural Gas

Petroleum and natural gas have been the primary energy resource in the Denver Basin since discovery of the Boulder Field in 1892. Approximately 190 million barrels of petroleum and 450 million cubic feet of natural gas have been produced in the Basin through 1976. During the last ten years exploration for and development of these resources has greatly increased. Favorable price structures, increased demand for domestic supplies, and more effective completion technology will undoubtedly contribute to continuing resource development throughout the Denver Basin.

INFORMATION AVAILABILITY

Information concerning energy resource distribution, quality, quantity, economic feasibility, and the environmental impacts of development of these resources will be obtained from a variety of sources during the three-year study. To help accomplish this goal, a bibliography of publications relevant to study has been started with the preliminary result contained in the bibliography at the end of this report. The preliminary bibliography will be expanded during our three-year study.

Mine maps and coal production records held by the Colorado Bureau of Mines and the U.S. Bureau of Mines will furnish past histories of mining activity in the Denver Basin. Current investigations by the Colorado Geological Survey's Mineral Fuels Section

will provide up-dated information and other pertinent data. A number of energy-oriented companies who either are in production or are actively exploring for coal, uranium, petroleum, and/or natural gas have indicated that information about their activities in the study area will be available for our use. Additional sources of information are oil and gas drill hole logs held by the Colorado Oil and Gas Commission, Petroleum Information, and American Stratigraphic Company, water well logs held by the State Engineer's office and private well drillers, logs of drill holes used in seismic exploration work for oil and gas, proprietary logs from holes drilled for coal, lignite, and uranium exploration and geologic field investigation.

ENVIRONMENTAL ASPECTS

Review of our original environmental impact analysis investigation, in light of findings from our preliminary study, revealed the need for certain alterations in our proposed approach. Our original approach was to study the Basin as a whole. A more suitable approach, however, would entail detailed study of smaller areas, each of which may be developed for either subbituminous coal, lignite and kaolin, uranium, petroleum, or natural gas or for a combination of these resources. Our study could then be used by local planners to evaluate the adequacy of environmental statements and other technical documents which accompany proposed specific energy developments. It also could be

used to aid in the establishment of regulations to deal with the impact of such developments.

COORDINATION WITH PLANNING AGENCIES

All county planning agencies within the study area and several state and city planning agencies were contacted during this preliminary study. Each agency was asked questions about their knowledge of energy resources in their area and about their policy guidelines and regulations concerning development of energy resources. All agencies were asked to comment on the applicability of our study to their needs and how we could approach the study to be of maximum use to them. The results of this portion of the study are briefly summarized in Table 1.

Several local agencies had conducted studies of energy resources in their county or area. However, these reports are limited to a compilation of previously published information. All agencies agreed upon the need for additional detailed information on the distribution, quality, and quantity of energy resources, but especially the need for information on the feasibility or likelihood of commercial development. Another serious need is information about the environmental impact of development of these resources. All contacted agencies also agreed upon the rationale that the environmental impact segment of our study would be most useful if small "pilot-study" areas were selected and studied in detail, providing guidelines with

which to evaluate impact studies in their particular area or aid in the establishment of regulations on energy development.

SUMMARY

The preliminary phase of the Denver Basin project has been completed and the results of this study are summarized in this report. There is a significant potential for further development of coal, lignite, uranium, petroleum, and natural gas in this area. If any or all of these energy resources are developed, the resulting environmental impact could have a profound effect on both the urban and agricultural environments. Furthermore, past urbanization has caused the loss of extractable energy resources, a phenomenon which our energy-consuming world cannot afford to let continue. With these facts in mind, we at the Colorado Geological Survey anxiously initiate the cooperative three-year study with the U.S. Geological Survey entitled "Environmental Impact Of Energy Development In The Denver Basin."

Table 1

Summary Of Information Obtained From Coordination With Planning Agencies

Agency	Contact	Potential Energy Resources*	Status
Adams County Planning Dept. 450 S. 5th St. Brighton 80601 659-2121	Gail Seeburger	C,L,U,0	County has prepared a "Mineral Extraction and Conservation Plan" but it has not yet been adopted. A comprehensive plan for the east end of the County is being developed. It will include designated mineral resource areas in which other types of development are prohibited. Presently, proposed energy development must go through regular zoning procedure. County has had considerable involvement with the Watkins Project. A list of studies related to this project was supplied by the County. The County conducted a preliminary study of regulations concerning coal development and is anxious to establish such regulations.
Arapahoe County Planning Dept. 5334 S. Prince Littleton 80166 795-4450	Don Paul Tom Stamm	C,L,U,0	County has prepared maps and regulations for coal, oil, and gas resources. Proposed development within resource areas must submit studies identifying potential conflicts with resource development when applying for permits or zoning changes.

Potential Energy Resources*	Agency	Contact	Status
C,U,0	Boulder City Planning Dept. Municipal Building P.O. Box 791 Boulder 80302 441-3210	Jim Pendleton	Staff Geologist has prepared a report entitled "Proposed Master Plan for Mineral Extraction for the Boulder, Colorado Urban Area". The only energy resource studied in this report is coal. The City concluded that the subbituminous coal of the Laramie Formation in the City of Boulder area is not commercially extractable at this time. For this reason, coal was not included in the proposed master plan for mineral extraction. However, the city recognized that these deposits may become commercial in the future. Therefore, the Staff Geologist prepared a set of proposed land use regulations for special use review of coal extraction and a coal occurrence inventory map. The City and County of Boulder cooperatively prepared the Boulder Valley Comprehensive Plan. This plan includes information on coal resources and hazards related to coal mining (i.e. mine fires, subsidence of undetermined areas).
C,U,0	Boulder County Planning Dept. P.O. Box 471 Boulder 80302 441-3930	Tom Gray	County has studied coal resources for H.B. 1529 and reported this information in "A Report on Environmental Geology of Boulder County, Colorado." The County recently gave approval to conduct public hearings on "Environmental Geology and Land Use Policy, Boulder County, Colorado." The County located potential coal resource areas on maps included in these studies, but they do not believe any of the coal resources are economically feasible at this time. Presently, all proposed energy development must go through Special Review to obtain the necessary permits.

Agency	Contact	Potential Energy Resources*	Status
Colo. Land Use Commission 1313 Sherman (4th floor) Denver 80203 839-2778	Jim Ohi	-	The Commission is conducting a program to establish guidelines for inter-county planning of energy development.
Colo. State Div. of Planning 1313 Sherman (5th floor) Denver 80203 839-2351	Charlie Jordan	-	Div. of Planning is interested in achieving maximum utilization of the Denver Basin study by local planning agencies.
Denver Regional Council of Governments 1776 S. Jackson, Suite 100 Denver 80210 758-5166	Gail Hill	C, L, U, O	DRCOG compiled information about distribution of coal, oil, and gas on maps at scales of 1"=2 miles and 1"=2000'. DRCOG discusses their policies concerning the extraction of these energy resources in the proposed "Regional Growth and Development Plan for the Denver Region". They emphasize the need for preservation of energy resources, coordination of resource extraction with urban development, and impact analysis of extraction on existing development.
Douglas County Planning Dept. 301 Gilbert Castle Rock 80104 688-4852	Bill Noe	C, U	County developed a land use plan which included protection of energy resource areas, but the plan was not adopted.
Elbert County Planning Dept. P.O. Box 205 Kiowa 80117 621-2173	Dan Kimzey	C, L, U, O	As a result of our contact with the County, it has established a study to evaluate their energy resources.

Agency	Contact	Potential Energy Resources*	Status
El Paso Community Development Dept. 27 E. Vermejo Colorado Springs 80903 471-5742	T. M. Sundaram	C, L	County has studied energy resources and certain environmental aspects. Their "Master Plan for the Extractions of Commercial Mineral Deposits" includes policy guidelines and information on the distribution, quality, and quantity of coal. Past mining activity and historic potential subsidence hazards are the topics of "Mining Report-Colorado Springs Coal Field; A Guide for Future Land Use." Water resources in the County were studied in "Water Resources of El Paso County, Colorado." Proposed coal developments must presently go through Location Approval.
Jefferson County Planning Dept. 1700 Arapahoe Golden 80419 279-6511	Paul Gesso Paul Banks	C, U	County is currently preparing additional information on coal development which will be added to the Mineral Extractions Policy Plan. Policy regulations and maps are scheduled for completion by April, 1978. The Master Plan should be ready by December, 1978. The County has contracted work on a coal and clay resource inventory and hazard evaluation to Amuedo and Ivey, Geological Consultants and a soil survey to the U.S.D.A. Soil Conservation Service. Proposed energy extractions is reviewed through a modified form of the present Mineral Extractions Policy Plan with considerable input from the Colorado Mined Land Reclamation Board.
Larimer County Planning Dept. 200 W. Oak Fort Collins 80521 221-2100	Keith Leyden Rex Burns	C, U, O	County has not conducted studies of energy resources. It is funding a U.S. Geol. Survey groundwater investigation in the north end of the County, an area which includes a proposed coal-fired power plant site. All proposed energy development presently must go through Special Review before approval is granted.

Agency	Contact	Potential Energy Resources*	Status
Morgan County Planning Dept. P.O. Box 596 Fort Morgan 80701 867-8202	Vince Porreca	C,0	County has not studied their energy resources. Any proposed energy developments currently must obtain approval through Special Review permitting process.
Weld County Planning Dept. 915 10th St. Greeley 80631 356-4000	Roy Jost	C,U,0	County has prepared a two volume study of mineral resources, including coal, entitled "Weld County Mineral Resources." The study contains information on the distribution, quality, and quantity of coal resources, planning for extraction and reclamation, and amendments to the Weld County Zoning Resolution which involve application, operation, and reclamation requirements. Proposed coal developments must obtain a Special Use Permit before initiating mining.

* C=Coal, L=Lignite, U=Uranium, O=Oil & Gas

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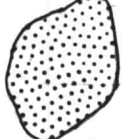
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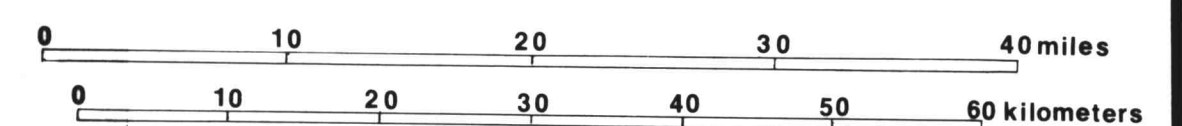
FIGURE 1

COAL AND URANIUM RESOURCES AND DEVELOPMENTS IN THE DENVER BASIN

by
R. M. Kirkham and
L. R. Ladwig

EXPLANATION

-  Outline of coal-bearing region, dashed where approximately located; based on the Laramie-Fox Hills contact
-  Strippable subbituminous coal region; depth less than 150 feet
-  Strippable lignite region; depth less than 150 feet
-  Extent of lignite deposits at a depth of 150 to 1000 feet
-  Active uranium operation
-  Underground coal mine; solid box indicates mine is active and/or licensed
-  Abandoned surface coal mine
-  Operating coal-fired or nuclear power plant



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