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A REVIEW OF REGIONAL IMPACTS ASSOCIATED WITH THE DEVELOPMENT OF U.S. SYNTHETIC FUEL RESOURCES

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ABSTRACT

A comprehensive review was made of the topic of environmental impacts of synthetic fuels development. The results are discussed by resource (e.g., coal, peat, oil shale, tar sands, heavy oil), by resource region (e.g., Powder River, Fort Union, Eastern Interior, San Juan River), and by major resource provinces (e.g., Eastern Interior, Rocky Mountain, Northern Great Plains, Gulf Coast). In the West, naturally high levels of airborne particulate matter may exceed National Ambient Air Quality Standards (NAAQS). In industrialized areas in the East, non-attainment of NAAQS is a common problem, but opportunities are available for reductions in emissions from existing sources. Opportunities for such offsets are not readily available in the West, where little development has taken place. Air issues characterized by a high degree of public sensitivity include acid deposition, considered a problem in parts of the Fort Union and Texas coal regions and in high mountain lakes, and visibility deterioration, primarily with respect to the impairment of scenic vistas. Water availability is considered a limiting factor with respect to synfuel development in water-short areas, particularly the Green River Formation, comprising parts of Colorado, Utah, and Wyoming. Particularly in the West, public sensitivity concerning unique, threatened, endangered, or sensitive species (e.g., black-footed ferret, Colorado squawfish) may be a major impediment to synfuels development.

1. INTRODUCTION

In the 1850s, a U.S. oil shale boom appeared imminent but never materialized, because more economical oil supplies became available with the development of domestic oil fields. With the U.S. petroleum supplies dwindling and the price of world oil increasing, the 1970s saw a resurgence of interest in synthetic fuels from oil shale, as well as from other fossil resources. National attention focused on the potential environmental impacts of synthetic fuels development, first with proposed leasing of federal lands for oil shale development [1], and subsequently with the establishment of a U.S. synthetic fuels industry [2]. It soon became apparent that few data existed with respect to potential impacts associated with the development of synthetic fuel resources.

In 1977, the President established an interagency committee to identify health and environmental problems associated with advanced energy technologies, to review the adequacy of research programs, and to identify research needs. The committee (The Federal Interagency Committee on the Health and Environmental Effects of Energy Technologies) produced eight major reports relating to synthetic fuels, one focusing solely on research priorities relating to the health and environmental effects of synthetic fuel technologies [3].

Research conducted since the early 1970s by federal agencies, synfuel companies, and university scientists has produced a voluminous amount of data on potential impacts relating to synthetic fuels. Most of the research was funded, in some way, by the federal government. The objective of this paper is to present a summary of the salient findings of the research conducted to date. The summary is based on the senior author's involvement in many synfuel studies over the last ten years and the results of a comprehensive literature search completed January 30, 1984.

2. SCOPE OF STUDY

Several computerized literature data bases were searched for information relating to region-specific issues associated with synthetic fuels development. A master list of citations relating to environmental issues, indexed by synthetic fuel terms (e.g., coal gasification, coal liquefaction, oil shale, tar sands) was compiled, covering the period January 1970 through January 1984. The search resulted in about 1,500 citations. About 60 percent related to water quality or water availability, about 25 percent to fauna or flora, and about 15 percent to air quality. About 700 citations related to regional issues. About 300 contained detailed information. A listing of these citations is available from the authors upon request. The reader is referred to a few [4-17] of these which have been published recently and which contain an overview or comprehensive information relating to our current understanding of potential health and environmental impacts associated with synthetic fuels development.

The following is a brief review of the perceived regional impacts as presented in the relevant literature. Space constraints prevent a detailed presentation of information on production constraints posed by impact mitigation. Table 1 is an exemplary listing of the impact issues identified within major fossil-fuel resource provinces in the U.S.

3. SUMMARY OF IMPACTS OF RESOURCE DEVELOPMENT

3.1 Coal

With respect to synfuels development in coal regions, a number of studies indicated that air issues focus on the preconstruction review provisions of the Clean Air Act, especially those relating to prevention of significant deterioration (PSD). Concern centers on the likelihood of exceeding statutory increments for additional allowable emissions of sulfur dioxide (SO_2) or total suspended particulate (TSP) matter. (Generally, for PSD Class I areas, the increment is 2 percent of the National Ambient Air Quality Standard. For Class II areas, the increment is about 25 percent.) The focus of most of the literature in this area appears to be on the deterioration of air quality in the numerous national parks, wilderness areas, national monuments, Indian reservations, etc. in the West.

With respect to National Ambient Air Quality Standards (NAAQS), issues tend to focus on the problems of siting facilities in areas that do not meet the NAAQS (i.e., non-attainment) for a pollutant. In the West, naturally high levels of airborne particulate matter may result in an area being in non-attainment. In the industrialized areas in the East, non-attainment with NAAQS is a common problem. In many synfuel areas where little development has taken place, the literature suggests that currently, there is insufficient information with which to classify an area with respect to attainment.

TABLE 1. LISTING OF EXEMPLARY ISSUES

Synfuel Resource Provinces	Areas of Constraint		
	Air Quality		
	Fugitive Dust	Visibility	PSD Limits
Eastern	---	---	Class I constraints exist near NE W.VA. border
Interior	---	---	---
Rocky Mountain	Airborne dust from oil shale development	Fine particulates from coal and oil shale development, San Juan Region adversely affected	Overall Class I and possible Class II constraints from oil shale and tar sands development
Northern Great Plains	---	Theodore Roosevelt Park Impacted Vapor from coal conversion could create clouds and local ground fog	Class I and II budgets may be exceeded by emissions from coal development Theodore Roosevelt Park (Fort Union) particularly affected PSD increment already may be utilized
Gulf Coast	---	---	Class I and Class II areas may limit lignite development

	Acid Precipitation	NAAQS Limits	Metal Emissions
Eastern	---	Non-attainment areas constitute a constraint on synfuels development	---
Interior	---	Non-attainment areas constitute a constraint on synfuels development	---

TABLE 1 (Continued)

Synfuel Resource Provinces	Areas of Constraint		
		Air Quality	
	Acid Precipitation	NAAQS Limits	Metal Emissions
Rocky Mountain	Possible impact on alpine tundra and lakes	Ambient levels at or near NAAQS limits	Airborne metals could become a health problem
Northern Great Plains	Fort Union area could be severely affected by acid rain	Emissions from coal development may exceed NAAQS Particulate non-attainment areas of Powder River Region a problem Non-attainment areas constitute an overall constraint	---
Gulf Coast	Acid deposition may be a problem in northeast Texas	Non-attainment areas may limit lignite development	Airborne trace metal emissions excessive from lignite processing

	Overall Air Degradation	Complex Terrain Air Models & Impacts	Radionuclides Emissions
Eastern	---	Rough terrain would aggravate ground level concentrations	---
Interior	Ohio river towns may be impacted by emissions from coal and oil shale development	---	---
Rocky Mountain	Degradation of pristine environment, affect pronounced in San Juan Region	Existing Models not adequate to estimate oil shale or tar sands air impacts Rough terrain could aggravate ground level concentrations	---

TABLE 1 (Continued)

Synfuel Resource Provinces	Areas of Constraint		
	Air Quality		
	Overall Air Degradation	Complex Terrain Air Models & Impacts	Radionuclides Emissions
Northern Great Plains	Degradation of Fort Union region by coal conversion emissions	---	Some high radionuclides in North and South Dakota lignites
Gulf Coast	---	---	High radionuclides in Texas lignites

	Water Resources		
	Water Consumption	Acidity/Alkalinity and Metal Solubility in Runoff	Salinity
Eastern	---	Acid mine drainage from coal development	---
Interior	---	Acid mine drainage from coal development	---
Rocky Mountain	Water availability can limit shale oil production (various estimates) Area sensitive to stream-flow reduction Tar Sands areas deficient in ground-water Tar Sands areas limited in available surface water	Alkaline runoff from coal and oil shale development	Water withdrawal and saline discharges from in-situ oil shale development may impact Colorado river system
Northern Great Plains	Local streams sensitive to flow reduction	Alkaline runoff from Fort Union development	---

TABLE 1 (Continued)

Synfuel Resource Provinces	Areas of Constraint		
	Water Resources		
	Water Consumption	Acidity/Alkalinity and Metal Solubility in Runoff	Salinity
Northern Great Plains (Concluded)	(Overall regional water availability not an issue)		
Gulf Coast	Surface and subsurface water withdrawal rates can limit other water uses Aquifer disruption Impacts on groundwater quality and quantity	Acid Mine Drainage from lignite and coal development	---

	Sedimentation	Discharges
Eastern	---	Incremental pollution
Interior	---	Incremental pollution
Rocky Mountain	Erosion from oil shale development may create turbidity and sedimentation problems in the Colorado river system	Uncontrolled leachate runoff from spent shale a problem (Mostly "zero discharge") Aquifer disruption can lead to contamination of drinking water Aquifer disruption it the key water quality issue

TABLE 1 (Continued)

Synfuel Resource Provinces	Areas of Constraint	
	Water Resources	
	Sedimentation	Discharges
Northern Great Plains	---	Sensitivity to biological oxygen demand Groundwater quality threatened by Fort Union development
Gulf Coast	---	Potential Water Problems

	Wildlife	
	Habitat	Threatened, Endangered or Sensitive Species
Eastern	Reclamation of steep contours a problem	Indiana Bat and Scioto Madtom endangered by coal development
Interior	---	Indiana Bat and Scioto Madtom endangered by coal development
Rocky Mountain	Terrestrial habitat loss and disturbance Stream habitat modification Strip mining alteration and reclamation problems Metal uptake by plants Toxic metal threat to aquatic biota Acid rain impacts on vegetation	7 big game species Salmonid species affected by flow reduction Non-salmonid species affected by salinity Wild Horses Possible impacts on - black-footed ferret - peregine falcon - humpback chub - greater sandhill crane - bald eagle - whooping crane - etc. Rare prairie grasses

TABLE 1 (Concluded)

Synfuel Resource Provinces	Areas of Constraint	
	Wildlife	
	Habitat	Threatened, Endangered or Sensitive Species
Northern Great Plains	Aquatic and terrestial habitat disruption brought about by coal conversion indusry in Powder River and Fort Union Regions Stability of vegetation on reclaimed lands is improbable Metal uptake by plants (Fort Union)	Coal conversion in the Powder River Region could adversely affect certain species and unique ecosystems
Gulf Coast	Habitat disruptions	Wildlife disturbances due to lignite mining

Acid deposition has been noted as a potential problem for parts of the Fort Union and Texas Regions where soils lack buffering capacity. Airborne emissions of radionuclides have been raised as a concern for the development of localized coal and lignite deposits in the Fort Union and Texas Regions. Visibility deterioration and overall air degradation have been raised as concerns, primarily in the West, with respect to the impairment of scenic vistas.

Water issues raised in the literature in relation to coal development for synfuels production focus on a variety of problems. Issues raised in more than one region related to the potential for groundwater contamination, the need for information to estimate water quality impacts associated with runoff (non-point source discharges), an insufficiency of, or lack of adequate information on local water supplies, disruptions to surface water or aquifer flows, competition among synfuel developers and other water users for available water, and the need for multi-state coordination and consent where interstate water resource agreements are applicable.

A number of studies addressed ecological issues associated with coal development. Generally, these related to habitat disturbance and reclamation problems associated with coal mining. Concern for impacts on various threatened, endangered, or sensitive species (e.g., black-footed ferret) was a common theme in reports related to many of the coal regions.

3.2 Peat

Only one environmental issue was identified in the literature search relating to synthetic fuel production from peat. The issue related to peat processing near a wetland area in the Mid-Atlantic Peat region. The focus of the issue was that runoff from the extraction of peat and runoff from the associated reclamation for agricultural use can severely degrade the quality of water in wetland and coastal water habitats needed by marine biota.

3.3 Oil Shale

For the oil shale regions, air issues raised in the literature focus on the Piceance Creek and Uintah Basins. A number of studies have indicated that PSD requirements would likely constrain oil shale development, especially with respect to SO_2 emissions. Similar to the western coal regions, NAAQS are not being met in some locations. Acid deposition has been cited by several sources as a potential problem with respect to impacts on high mountain lakes and tundra downwind of proposed development. Complex terrain within the regions tends to cause thermal inversions and air stagnation in low lying areas. Many studies raised potential concerns with respect to air contamination from emissions of trace metals, trace organic substances, and fugitive dust from oil shale activities. Several studies indicated that reduction in the degree of visibility and overall air degradation are major issues in the regions.

The literature reviewed suggested that water availability could be a constraining factor with respect to oil shale development in the Green River Formation, which encompasses both the Piceance Creek and Utah Basins. A number of studies indicated that a point will be reached where local sources of unappropriated water become exhausted and water must be purchased from competing consumers of water, water storage projects would need to be built, shale processing plants may need to be moved closer to assured water supplies and away from the oil shale mine, and/or water would need to be transported for great distances, even from other water basins. Several studies related to the need for resolving legal and institutional uncertainties pertaining to water rights and competitive uses.

The development of eastern oil shales, in Kentucky and Tennessee, also was addressed in the literature. The problem of water quality degradation in surface waters or groundwater resulting from runoff from oil shale development was an issue raised for both states. For Kentucky, other issues suggested by the literature related to acid mine drainage and habitat disturbance.

A number of studies addressed ecological issues within the Green River Formation. Habitat disruption, reclamation, threatened/ endangered/sensitive (T/E/S) species, and pollutant uptake by plants and animals are issues common to the Piceance Creek and Uintah Basins. The literature suggested that both regions are unique in terms of the numbers and variety of T/E/S species (e.g., black-footed ferret, Colorado squawfish).

Two sources discussed potential production constraints imposed by existing policies for leasing federal lands. The Mineral Leasing Act of 1920 mandates that no individual or firm may acquire more than one lease, and limits the size of a single tract to 5,120 acres (eight square miles). The reports suggest that these restrictions will divide an oil shale resource into units too small to permit efficient mining of the resource. Efficiency is reduced further by the Federal Land Policy and Management Act of 1976, which requires that spent shale be disposed of within tract boundaries.

3.4 Tar Sands

With respect to tar sands development, the literature reviewed suggested air issues for Utah and California. For Utah, the issues relate to PSD (Class I and II) areas which may pose constraints, limits imposed by NAAQS, complex terrain problems, and overall air degradation. For California, the issues relate to only a part of the region (i.e., Kern County) where PSD Class I and II limits and overall air degradation are considered to be major problems.

Water issues raised in the literature in relation to tar sands development addressed a variety of problems, mostly associated with development in Utah. These issues focused on localized salinity problems, the quality of discharged process wastewater, runoff from site development, groundwater contamination and disruption of groundwater flow, physical water availability, and competition among tar sands developers and other water users for available water.

Ecological issues associated with tar sands development were identified for Utah. The literature suggested that tar sands development may disrupt large areas of habitat and impact several T/E/S species (e.g., black-footed ferret, Colorado squawfish).

3.5 Heavy Oil

For heavy oil development, the literature indicated issues associated with air quality in California and impacts on stream flow in Texas. For California, some of the state's heavy oil reservoirs are in areas already in violation of or near the limits of Federal and/or state ambient air quality standards. Steam generation emissions (particulates, sulfur oxides, and nitrogen oxides) from new steam-injection projects may need to be off-set by emission reductions in the surrounding area. Future projects may be limited by the availability of such tradeoffs. If adequate steam generators can be developed for use below ground level, most of the air emission problem associated with steam generators may be eliminated. One source indicated that steam boilers used in heavy oil recovery could cause overall air degradation.

The only environmental issue identified for heavy oil development in Texas related to reduced stream flow, resulting in a concentration of contaminants.

4. OVERALL STATUS OF LITERATURE

A literature search of the type conducted for this paper has several limitations. It tends to miss literature citations which may be pertinent, but are not coded into a data base by means of descriptor terms associated with synthetic fuels. For example, reports and articles relevant to environmental impacts associated with peat extraction and processing for the purposes of combustion, charcoal production, and soil conditioning may not be identified by such a literature search, unless such studies were coded with synfuels descriptors. The environmental impacts associated with extraction would be the same if the peat would be used in synfuels production. A similar situation exists with respect to the extraction and processing of coal for combustion and the recovery of heavy oil by means of enhanced oil recovery techniques from existing oil and gas wells.

Generally, synfuels related articles tend to respond to perceived problems. Many are retrospective (especially those relating to water quality). A few are prospective (i.e., deal with future development). Most issues are raised within the context of a particular site or facility development and do not address the perspective of overall synfuels development within a region.

Most environmental reports and articles dealing with geographical areas are oriented toward river basins, air sheds, and major ecological communities (e.g., biomes). They are not restricted to specific resource regions. This makes a one-to-one correlation of impacts identified in the articles to the resource regions addressed in this paper difficult.

While there is a voluminous amount of literature that addresses environmental issues in general (non-specific) terms, there are relatively few original or primary studies that explicitly identify the actual constraints to oil shale development. There are even fewer that attempt to quantitatively assess the constraints in terms of actual production numbers. Several of the studies that do make the attempt appear to be contradictory. For example, for the Green River Formation some reports indicate that there can be essentially very little oil shale development, while others predict that substantial production levels can be realized within current environmental regulations. Early estimates seemed to focus on what, at a minimum, was feasible, whereas, only recently, estimates have begun to focus on determining the maximum level of development possible due to regulatory constraints and environmental concerns.

The quality of the studies varies a great deal, ranging from those that are cursory and inadequately documented, to those which are relatively thorough and exhaustive. For all three areas (air, water, and ecology) there are significant methodological limitations which partially explain the lack of specificity in the results of the studies with respect to identifying particular constraints.

Some relevant publications are not in the open technical literature. These include private distribution of articles, brochures, fact sheets, etc. by industry and environmental organizations.

5. COMMENTARY ON IMPACT MITIGATION

Impacts should not be viewed as absolute barriers to development. Since they are anticipated, they may be overcome to a large extent by appropriate planning for synfuels development conducted at regional and site-specific levels.

An important observation made during this review of impact issues is that a compound impact on synfuels development can be anticipated when one views impacts, not individually by issue, resource, or technology, but collectively by overlaying potential impacts posed by air and water and ecological issues within a geographic area. Issues need to be viewed in light of cumulative limitations posed by planned synfuels development of all synfuels resources within a common regional area. This viewpoint is most necessary for the Green River Formation, comprising potential major synfuels development areas in Wyoming, Colorado, and Utah. A coordinated approach is needed which integrates all synfuels and other industry development plans for the area in order to minimize constraints posed by environmental issues.

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REFERENCES

1. U.S. Department of the Interior (U.S. DOE). 1973. "Final Environmental Statement for the Prototype Oil Shale Leasing Program," Vols. I-VI. Washington, D.C.

2. U.S. Energy Research and Development Administration. 1977. "Final Environmental Impact Statement: Alternative Fuels Demonstration Program." Vols. 1 and 2, ERDA-1547. Washington, D.C.

3. Brown, Richard. 1981. "Health and Environmental Effects of Synthetic Fuel Technologies: Research Priorities." April. The MITRE Corporation, McLean, VA (MTR-80W348, or available as NTIS No. PB 81-212474). "A Report to the Federal Interagency Committee on the Health and Environmental Effects of Energy Technologies."

4. Ballard, Steven C., Michael D. Devine et al. 1982. "Water and Western Energy: Impacts, Issues, and Choices." Westview Press, Boulder, CO.

5. Chartock, Michael A., Michael D. Devine, Martin R. Cines, and Steven E. Plotkin. 1982. "Environmental Issues of Liquid Transportation Fuels from Coal." Environmental Conservation, Vol. 9(2):131-139.

6. Devine, Michael D., and Gary D. Miller. 1983. "Air Quality Impacts and Issues of Energy Development in the Western United States." Energy Systems and Policy, Vol. 7(1):1-31.

7. National Research Council. 1983. "A Review of the 1982 Department of Energy Health and Environmental Effects Assessments on Coal Liquefaction and Oil Shale Technologies." National Academy Press, Washington, D.C.

8. Newton, Catherine K. 1983. "Air Quality Questions Hover over Shale Country." Shale Country, Vol. 5(3):8-11.

9. Polsgrove, Carol. 1983. "Conflict Along the Carolina Coast." Oceans, (May):65-67.

10. Rom, William N., and Jeffrey Lee. 1983. "Energy Alternatives: What are their Possible Health Effects." Environmental Science and Technology, Vol. 17(3):132A-144A.

11. Rubenson, David and Richard Pei. 1983. "Oil Shale in the Piceance Basin: An Analysis of Land Use Issues." Report No. R-3040-RC, The Rand Corporation, Santa Monica, CA.

12. Schwab, A.P., W.L. Lindsay, and P.J. Smith. 1983. "Elemental Contents of Plants Growing on Soil-Covered Retorted Shale." Journal of Environmental Quality, Vol. 12(3):301-304.

13. Turk, J.T. and D.B. Adams. 1983. "Sensitivity to Acidification of Lakes in the Flat Tops Wilderness Area, Colorado." Water Resources Research, Vol. 19(2):346-350.

14. U.S. Bureau of Land Management. 1983. "Final Supplemental Environmental Impact Statement for the Prototype Oil Shale Leasing Program." January. U.S. Department of the Interior, Billings, Mt.

15. U.S. Bureau of Land Management. 1983. "Final Fort Union Coal Regional Impact Statement." U.S. Department of the Interior, Billings, MT.

16. U.S. Bureau of Land Management. 1983. "Final Environmental Impact Statement: Utah Basin Synfuels Development." U.S. Department of the Interior, Salt Lake City, UT.

17. U.S. Environmental Protection Agency. 1983. Environmental Monitoring Reference Manual for Synthetic Fuels Facilities (EPA-600/8-83-027, or availabale as NTIS No. PB 83-251850), Office of Research and Development, Washington, D.C.