RESOURCE AND ENVIRONMENTAL CONSTRAINTS

OF SYNFUELS DEVELOPMENT

FINAL REPORT

WATER PURIFICATION ASSOCIATES

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by

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ABSTRACT

Resource and environmental constraints of synthetic fuels production are reviewed. The major resource constraint is water availability in the semi-arid regions where much of our western coal and oil shale reserves lie. Applicable air, water and solid waste regulations are summarized and potential constraints are identified. Generic solutions to overcoming each of the potential resource and regulatory constraints for synfuels production are presented and possible intermedia impacts are identified. Almost every generic solution for constraints in one media affects at least one constraint in another media.

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RESOURCE AND ENVIRONMENTAL CONSTRAINTS OF SYNFUELS DEVELOPMENT

Purpose and Authority

The objective of this report is to identify resource and environmental limitations of synfuels development for use by authors of Pollution Control Guidance Documents (PCGD's). These documents are being prepared for the EPA in response to the President's program to expedite development and commercialization of synthetic fuels conversion technologies. The technologies addressed in this report are: oil shale, direct coal liquefaction, medium BTU gas and indirect coal liquefaction. Resource constraints considered are the availability of water and the location of known deposits of coal and oil shale. Environmental constraints addressed relate current and future waste discharge and disposal regulations to wastes generated by each technology. Finally, generic solutions and their potential effects are addressed as intermedia constraints.

Resource Constraints

The major resource constraint for synfuels development is the availability of sufficient water. Primary water uses in synfuels production include: (1) hydrogenation, (2) cooling and other process uses, (3) mining and residuals disposal. Water is consumed in hydrogenation to improve the hydrogen to carbon ratio of the product fuel. Cooling is often the major consumptive water use in synfuels production. Various degrees of dry (or air) cooling may be employed to reduce this consumption at a higher initial cost. Dust control in mining and crushing operations can consume significant quantities of water, particularly in surface mining. Revegetation may also require significant amounts of water as may the compaction of spent shale. Other water uses include service, sanitary and potable consumption. The net water consumed will depend on many factors, including the composition of the feed coal or oil shale, the process type and the climate.

The rich oil shale deposits of the Green River Basin and much of the western coal reserves are located in some of the most arid regions of our country. Much of the limited water supply is currently utilized for agricultural production and other purposes such as municipal and power generation. Surface water supplies are characterized by poor quality and are subject to highly variable flows. Major use of the region's groundwater (which is often of poor quality) to augment surface supplies could ultimately affect the hydrologic cycle, resulting in a possible depletion of groundwater reservoirs and/or a reduction in surface water flows. Only a detailed regional hydrologic investigation can project the ultimate effects of synfuels production. The development of a significant fossil fuel industry in such a water limited environment requires techniques beyond what would be dictated in a water sufficient region. For example, greater incentives for water recycle/reuse, dry or wet/dry cooling and attainment of zero discharge exist. Also, acquisition of water rights or development of additional reservoirs may be justified. Other options include the exportation of the fossil fuel resource and/or the importation of water to alleviate water limited situations.

In other areas such as the eastern coal regions (Appalachian and Illinois coal regions) water availability is less likely to be a major constraint to synfuels development. In such cases water conservation and reuse would not be economically justified to the degree warranted by a water limited situation. Rather, effluent discharge regulations may dictate the degree of water conservation, recycle and reuse.

However, away from the major rivers in the East, surface water supplies are much less reliable, and water may be a limiting factor in these regions. The same incentives for minimum water usage would apply here as would apply in the West.

In certain locations an excess of water may be generated. This could result, particularly for the case of modified-in situ oil shale conversion, from excessive mine drainage. Here the problem becomes disposing of the excess water in an environmentally acceptable manner, and the incentive for water conservation and recycle/reuse is diminished. Disposal options might include subsurface injection, land application, discharge to receiving waters or storage in reservoirs for future use after appropriate treatment.

Possible intermedia constraints resulting from the solution of specific water resource constraints will be discussed in the final section of this report.

Environmental Constraints

Introduction

During the past decade Congress has enacted strong pieces of legislation to control air, water and solid waste discharges. Among those laws which could constrain the development of a synthetic fuels industry are provisions of the Clean Air Act, Clean Water Act, Safe Drinking Water Act and Resource Conservation and Recovery Act. In addition, state laws sometimes exceed the discharge requirements of Federal regulations.

Federal and state standards affecting air, water and solid waste discharges are listed in this section together with the major coal and oil shale resource regions in an attempt to show where and how a synfuels industry could be constrained. Specific pollutants which may be present in synfuel waste streams are then related to regulated pollutants.

It should be noted that additional environmental legislation exists which could affect synfuels development, but which does not pertain directly to controlling waste discharges. Such legislation includes the Toxic Substances Control Act (which could affect the transportation of syncrude), the Occupational Safety and Health Act, the Endangered Species Act, the Surface Mining Control and Reclamation Act and the National Environmental Policy Act. We will limit this analysis to regulatory constraints relating directly to the control of waste streams.

Air Emission Constraints

The Clean Air Act of 1970 and the Clean Air Act Amendment of 1977 provide the basis for air emission regulatory authority. Major provisions include: (1) promulgation by the EPA of National Ambient Air Quality Standards (NAAQS) for six major pollutants, CO, HC, O_x, NO_x, SO_2 and particulates; (2) establishment by the EPA of National Emission Standards for hazardous pollutants and standards of performance for new sources; (3) prevention of significant deterioration where air quality is better than NAAQS through establishing the permissible incremental increase in ambient concentrations from new sources.

Two sets of ambient quality standards are required; primary standards for health considerations and secondary standards for environmental considerations. Primary standards become effective 12/31/82, while secondary standards are to be achieved as soon as possible thereafter. Areas which exceed the primary standards are designated as "non-attainment" areas. To obtain permission to locate in a non-attainment area, a new source must show that the total emissions in the area will not be increased. In other words, he may be required to finance air emission improvements to other facilities to offset his emissions.

A hazardous pollutant is one for which no NAAQS is applicable and which, in the judgment of the EPA, causes or contributes to air pollution resulting in an increase of mortality or incapacitating illness. The EPA is authorized to set emission standards for these substances. To date standards have been promulgated for asbestos, beryllium, mercury, vinyl chloride, radionuclides and benzene. Other hazardous substances under consideration for emission standards are arsenic and polycyclic organic matter (POM).

In addition, the EPA may establish standards of performance for sources emitting noncriteria and nonhazardous pollutants which in its judgment contribute to the endangerment of public health or welfare. Such designated pollutants which might affect the synfuels industry include NH_3, H_2S, COS, HCN, mercaptans and $Ni(CO)_4$. The designation of additional pollutant discharge limitations may affect PCGD documents and permitting requirements and is, therefore, addressed herein.

Table 1 lists the major regulations, status and current limits authorized by the Clean Air Act which could impact the synfuels industry. Many state ambient standards are more stringent than federal standards in one or more pollutants. Figure 1 compares state standards with coal resources. Notably the states of Kentucky, West Virginia and Virginia in the Eastern Coal Region are not more stringent than Federal ambient air quality standards. Table 2 presents a summary of states which are more stringent than Federal ambient air quality standards by pollutant.

The richest oil shale deposits in the United States are located in the Green River Basin of Colorado, Utah and Wyoming. Figure 2 shows eight designated Class I air quality areas in the region. Note that the eight areas approximately encircle the Piceance Creek portion of the Basin, where most of the oil shale is located.

On September 5, 1979 the EPA proposed comprehensive amendments to the PSD portion of the Clean Air Act[7]. The proposals include guidelines for minimum emission rates in tons per year and corresponding minimum ambient air quality concentrations for 17 pollutants. These values, termed de minimus values, reflect emissions well below that considered harmful, and are intended to provide a systematic means of exempting insignificant sources from PSD requirements. The proposed de minimus emission rates and corresponding ambient concentrations are presented in Table 3.

TABLE 1. FEDERAL AIR QUALITY REGULATIONS

Provision of Clean Air Act	Status
New Source Performance Standards (NSPS)	No NSPS set for synfuels. Fossil fuel powered electric utility NSPS would apply to boilers, as shown.

Current Limits

SO_2 lb/10^6 Btu	SO_2 Min. % Removal	Particulates lb/10^6 Btu	NOx lb/10^6 Btu
1.20	90 (initial demo.plants -80)	0.03	0.50

Provision of Clean Air Act	Status
Prevention of Significant Deterioration (PSD)	Air quality increments for SO_2 and particulates are established to date

Area*	SO_2 ($\mu g/m^3$) Annual	SO_2 24 hr/max	SO_2 3 hr/max	Particulates ($\mu g/m^3$) 24 hr	Particulates Annual
Class I	2	5	25	10	5
Class II	20	91	512	37	19
Class III	700	182	40	75	37

Provision of Clean Air Act	Status
Non Attainment (NA) Areas	Sources locating in areas exceeding Nat'l. Ambient Air Qual. Standards must utilize lowest achievable emission rate technology & offset emissions by cleaning up existing sources.

National Ambient Air Quality Standards ($\mu g/m^3$)

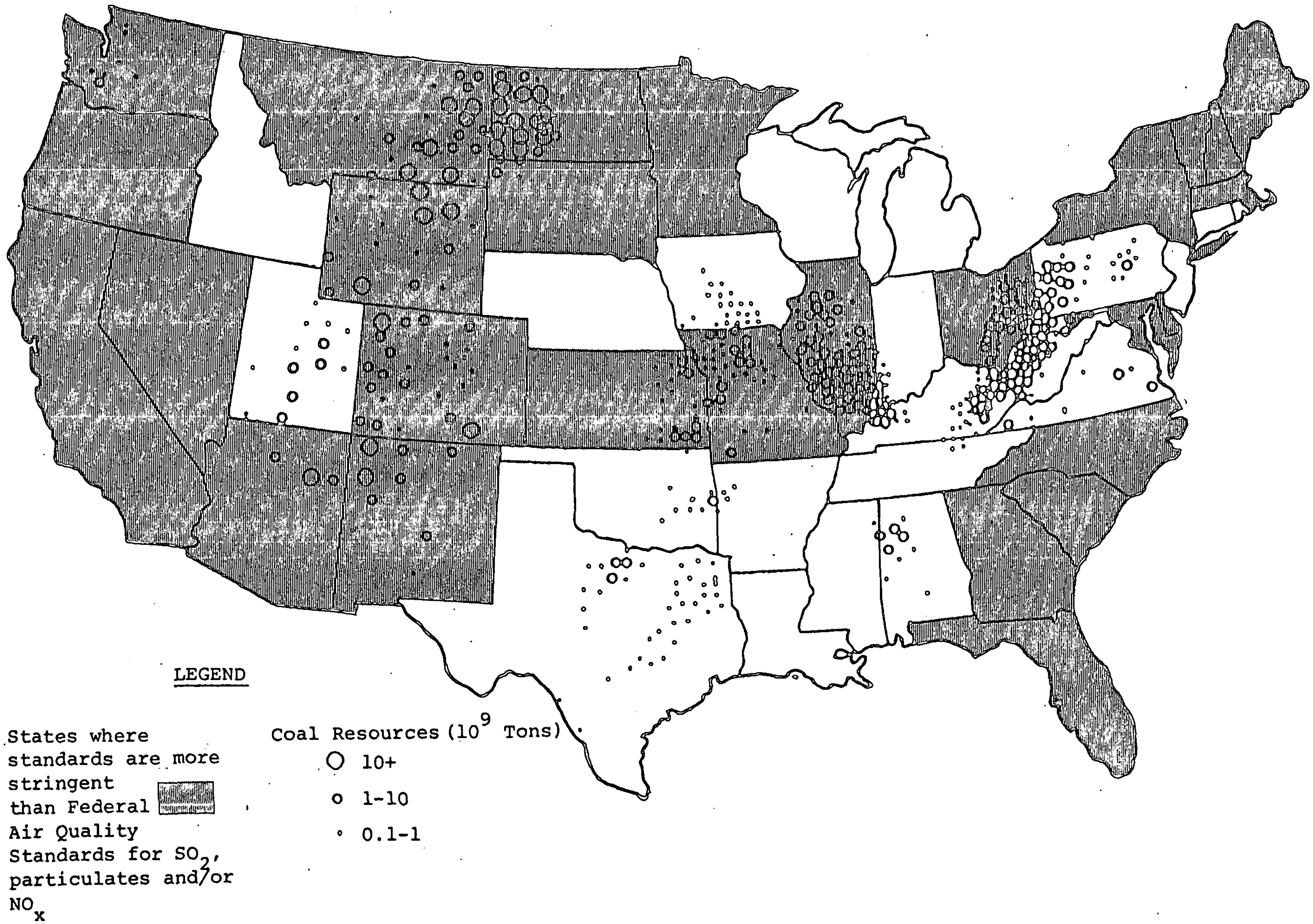
Classification	SO_2 3 hr/ Max	SO_2 24 hr/ Max	SO_2 Annual Mean	Particulates 24 hr/ Max	Particulates Annual Mean
Primary (Eff.12/31/82)	-	365	80	260	75
Secondary (Eff. asap after 12/31/82)	1300	365	80	150	60

Provision of Clean Air Act	Status	Current Limits
Visibility	Sources affecting a Class I area's visibility may be req. to implement controls exceeding BACT, even though source may not be located in Class I area.	To be decided on a case by case basis.

Provision of Clean Air Act	Status
Hazardous Pollutant Emission Standards	No hazardous pollutant emission standards for synfuel facilities have been developed. Hazardous pollutants regulated which could relate to synfuels include beryllium and mercury.

Hazardous Pollutant	Industries	Emission Standard (24 hrs)	Ambient Standard ($\mu g/m^3$)
Beryllium	Ore and Battery	10 gm	0.01
Mercury	Extraction, Mach. Shop, & Ceramics	2300	None
Mercury	Sludge Incineration	3200	None

*Class I includes most national parks, national wilderness areas, national memorial parks and international parks; currently there are no Class III areas, so all areas not designated Class I are Class II.



LOCATION OF COAL RESOURCES WITH RESPECT TO AMBIENT AIR QUALITY STANDARDS

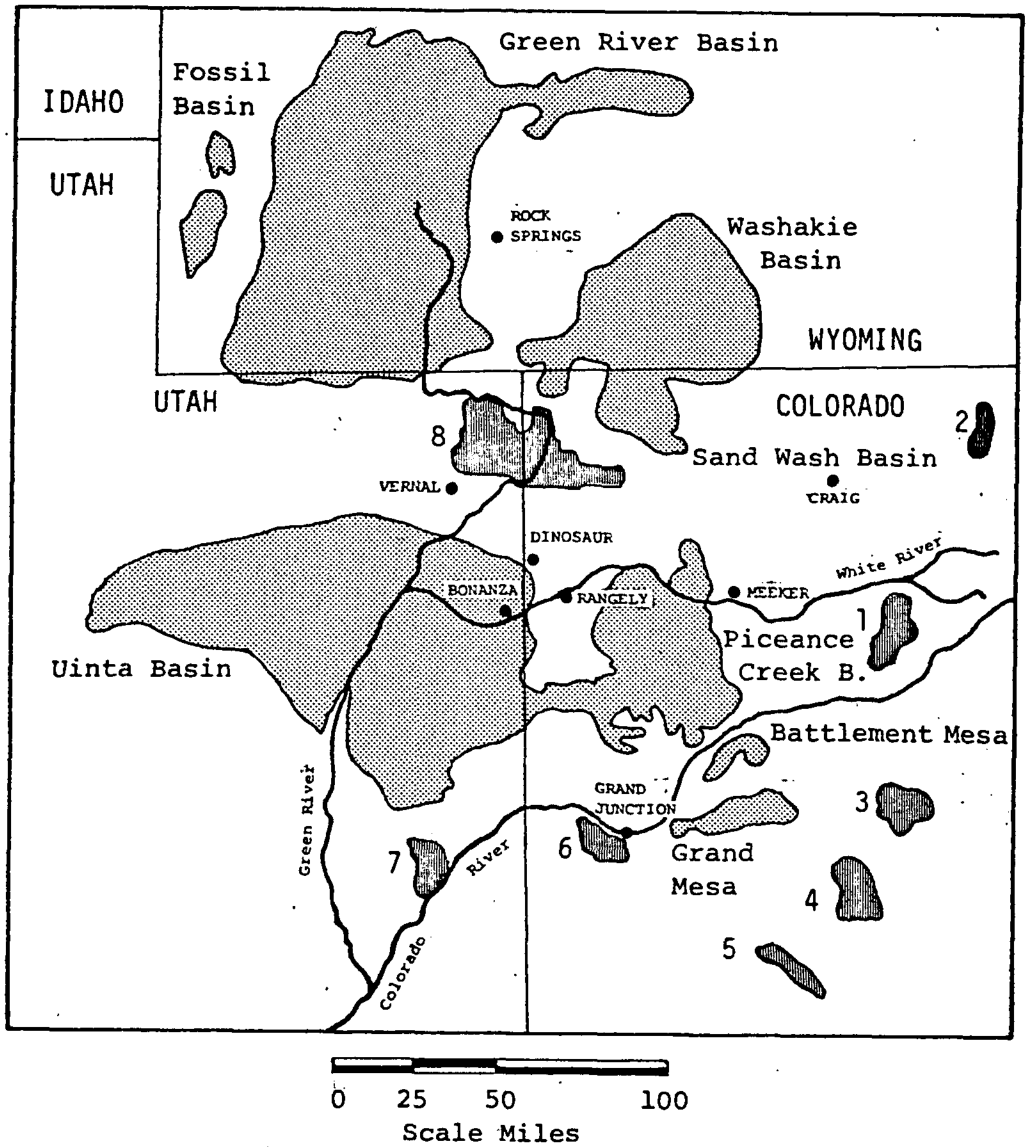
FIGURE 1

TABLE 2

STATES WHERE AMBIENT AIR QUALITY STANDARDS EXCEED FEDERAL STANDARDS

STATE	POLLUTANT		
	SO_2	Particulates	NO_x
Alabama			
Alaska		x	
Arizona		x	
Arkansas			
California	x	x	
Colorado	x	x	x
Connecticut			
Delaware	x	x	
Florida	x	x	
Georgia	x	x	
Hawaii	x	x	x
Idaho			
Illinois	x		x
Indiana			
Iowa			
Kansas	x	x	x
Kentucky			
Louisiana			
Maine	x	x	
Maryland			
Massachusetts	x		x
Michigan			
Minnesota	x		x
Mississippi			
Missouri	x	x	
Montana	x	x	
Nebraska			
Nevada	x	x	
New Hampshire	x	x	
New Jersey			
New Mexico	x	x	
New York	x	x	x
North Carolina		x	x
North Dakota	x	x	
Ohio	x	x	
Oklahoma			
Oregon	x	x	
Pennsylvania			
Rhode Island			
South Carolina		x	
South Dakota		x	
Tennessee			
Texas			
Utah			
Vermont	x	x	
Virginia			
Washington	x	x	
West Virginia			
Wisconsin			
Wyoming	x	x	
TOTAL	24	25	8

Base data source: 1979 Yearbook and Product Reference Guide. Pollution Engineering 10(12), Technical Publishing Co., Greenwich, Conn.



Areas of oil shale deposits

Designated Class I areas

1 Flat Tops Wilderness

2 Mount Zirkel Wilderness

3 Maroon-Bells-Snowmass Wilderness

4 West Elk Wilderness

5 Black Canyon of the Gunnison Wilderness

6 Colorado National Monument

7 Arches National Park

8 Dinosaur National Monument

RELATIONSHIP OF OIL SHALE RESOURCE AREAS TO CLASS I AIR QUALITY AREAS

FIGURE 2

TABLE 3. PROPOSED DE MINIMUS VALUES

Pollutant	Emission Rate (Tons per Year)	Correspondng Ambient Impact (mg/m^3)	Average Time Use for Ambient Impact Determination
Carbon Monoxide	100	500	8 hour
Nitrogen Dioxide	10	1	Annual
Total Suspended Particulates	10	5	24 hour
Sulfur Dioxide	10	5	24 hour
Ozone	*	*	*
Lead	1	0.03	3 month
Mercury	0.2	0.1	24 hour
Beryllium	0.004	0.005	1 hour
Asbestos	1	1	24 hour
Fluorides	0.02	0.01	24 hour
Sulfuric Acid Mist	1	1	Maximum value
Vinyl Chloride	1	1	1 hour
Hydrogen Sulfide	1	1	1 hour
Methyl Mercaptan	1	0.05	1 hour
Dimethyl Disulfide	1	2	1 hour
Carbon Disulfide	10	200	1 hour
Carbonyl Sulfide	10	200	1 hour

* Although no specific de minimus values are proposed for ozone, an emission of 100 tons per year of total volatile organics subject to PSD would require an impact analysis including ozone.

The specific pollutants emitted in any of the basic processes considered herein will depend upon many factors including resource characteristics, process design, equipment selection and emission controls. Only detailed mass balance calculations can predict stream characteristics. For purposes of identifying possible constraints we have tabulated the regulated and potentially regulated pollutants with respect to air emissions for each of the technologies considered. This information is shown in Table 4.

Wastewater Discharge Constraints

Provisions of the Federal Water Pollution Control Act of 1972 and the Clean Water Act of 1977 include the National Pollutant Discharge Elimination System (NPDES), the establishment of instream water quality criteria, and the development of of Best Management Practices (BMP).

Under NPDES, the EPA is authorized to set effluent limitations and standards by specific industrial category. In addition a court settlement between the EPA and several environmental groups requires the EPA to set standards for specific toxic pollutants. NPDES discharge criteria may vary for existing sources, new sources (NSPS) or sources discharging to publically owned treatment works (POTW's).

Effluent guidelines for synthetic fuels facilities do not yet exist. Effluent guidlines for coal conversion systems are in the early planning stages, with promulgation expected to be staggered between late 1981 and 1984[6] Aqueous discharges from these facilities, however, are subject to provisions of NPDES. As such, applications from synfuel plants must be reviewed by state regulatory personnel. Criteria on which such reviews may be based are summarized herein.

Existing effluent guidelines address conventional pollutants and are based upon best practicable control technologies (BPT). Conventional water quality pollutants include: biological oxygen demand (BOD), biochemical oxygen demand (COD), oil and grease, total suspended solids (TSS), fecal coliform, total phosphorus and pH. Future effluent limitations for these parameters effective 7/1/84 will be based on best conventional pollutant control technology (BCT).

Limitations for toxic pollutants effective 7/1/84 will be based on the more stringent best available technology economically achievable (BAT). There are currently 129 pollutants listed as toxic by the EPA.

TABLE 4. SUMMARY OF SELECTED POTENTIAL AIR EMISSION CONSTRAINTS

	LEGAL AUTHORITY			
Constraint	NAAQS/PSD	Hazardous	Non-Hazardous Non-Criteria	De Minimus
SO_2	X			X
Particulates	X			X
NO_x	X			X
Asbestos		X		X
Beryllium		X		X
Mercury		X		X
Vinyl Chloride		X		X
Radio Nuclides		X		
Benzene		X		
POM		X		
Ammonia			X	
Hydrogen Sulfide			X	
COS			X	
HCN			X	
Mercaptans			X	X
$NiCO_4$			X	
CO				X
Ozone				X
Lead		X		X
Fluorides				X
SO_2 Mist				X
H_2S				X
Dimethyl Sulfide				X
Carbon Disulfide				X
Carbonyl Sulfide				X

Pollutants such as color which are not specifically identified as conventional or toxic are classified as non-conventional. These must also be considered by the EPA in establishing NPDES limitations.

Although there are no effluent guidelines established for synthetic fuels production, standards exist for similar industries as presented in Table 5.

In 1976 the EPA established instream water quality criteria to attain the goal of fishable, swimmable waterways. Most states have since adopted these criteria, and in some instances have set more stringent standards. Among the latter are salinity standards for western rivers, particularly for the Colorado River.

Stream segments may be designated as "water quality limited" by states. Industries discharging to segments so designated are subject to more stringent NPDES permitting requirements. Although dissolved oxygen is the primary consideration, currently there is no uniform procedure by which states designate segments as water quality limited[3]. As a result the same stream may be water quality limited on the upstream side of a state border but not on the downstream side. Also, many states have not yet acquired sufficient data to designate stream segments as water quality limited. For example, no streams in the oil shale rich Green River Basin have yet been designated as water quality limited by Colorado, but a final determination on this matter is still under investigation by the state.

Four key fossil fuel states which have made water quality limited designations are Pennsylvania, West Virginia, Kentucky and Utah. River basins with water quality limited segments in these four states are listed below[4]:

State	Basin with Water Quality Limited Segments
Pennsylvania	Delaware R., Susquehanna R., Ohio R., Lake Erie
West Virginia	Kanawa R., Monongahela R., Ohio R., Little Kanawa R.
Kentucky	Big Sandy R., Cumberland R., Green R., Kentucky R., Licking R., Mississippi R., Ohio R., Tradewater R., Salt R., Tenneco R.
Utah	Great Salt Lake, Lower Colorado R., Green R.

Figure 3 illustrates the geographic relationship of these basins to coal resources. The effect of a water quality limited designation, however,

TABLE 5. CURRENT EPA EFFLUENT STANDARDS FOR SOURCES SIMILAR TO SYNTHETIC FOSSIL FUELS PLANTS

Category	Subcategory	Basis	Pollutant or Effluent Characteristics	Maximum Day	Maximum 30-day Average
Coal Mining (Expressed in mg/l except pH)	Coal preparation plants and mine	BPT	Total Fe	7.0	3.5
			Total Na	4.0	2.0
			TSS	70.0	35.0
			pH	6.0 - 9.0	acidic stream only
		BAT	As in BPT except for Fe	6.0	3.0
Iron and Steel Manufacturing (Expressed in kg/kkg of product, except pH)	Byproduct Coking	BPT	NH_3	0.2736	0.0912
			Cyanide	0.0657	0.0219
			Oil/grease	0.0327	0.0109
			Phenol	0.0045	0.0015
			TSS	0.1095	0.0345
			pH	6.0 - 9.0	
		BAT, USPS	Cyanide amenable to Chlorination	0.0003	0.0001
			Oil/Grease	0.0124	0.0042
			Phenol	0.0006	0.0002
			Ammonia	0.0126	0.0042
			Sulfide	0.0003	0.0001
			TSS	0.0312	0.0104
			pH	6.0 - 9.0	
Petroleum Refining For Typical lube refining (expressed in mg/l)	Topping (for discharge other than runoff or ballast)	BAT	BOD_5	2.3	2.0
			TSS	2.4	2.0
			COD	10.0	8.0
			Oil/grease	0.5	0.4
			Phenolic compounds	0.012	0.0060
			Ammonia (as N)	0.68	0.51
			Sulfide	0.055	0.035
			Total Chromium	0.126	0.105
Organic Chemical Manufacturing	Processes with process water contact as steam diluent or absorbent	BAT,NSPS	COD	7.8	4.2
			BOD_5	0.37	0.27
			TSS	0.94	0.50
			pH	6.0 - 9.0	
Steam Electric Power Generating (Expressed in mg/l except pH)	Generating Unit	BPT	pH	6.0 - 9.0	
			Polychlorinated Biphenyl Compounds	No discharge	
			TSS	100.0	30.0
			Oil/Grease	20.0	15.0
			Total copper from metal cleaning or boiler blowdown	1.0	1.0
			Total iron from metal cleaning or boiler blowdown	1.0	1.0
			Free available chlorine from cooling tower blowdown	0.5	0.2
		BAT	From cooling tower blowdown	Same as BPT except as shown below	
			Zinc	1.0	1.0
			Chromium	0.2	0.2
			Phosphorus	5.0	5.0
			Free available chlorine from cooling tower blowdown	0.0 except for 2 hr period/day	
			Materials added for corrosion inhibition in cooling tower blowdown	Limits to be established on a case-by-case basis	
			Heat from main condensers	None except under special circumstances	

Source: Bureau of National Affairs, Inc.
Environmental Reporter, Washington, D.C.
(as updated through 2/1/80)

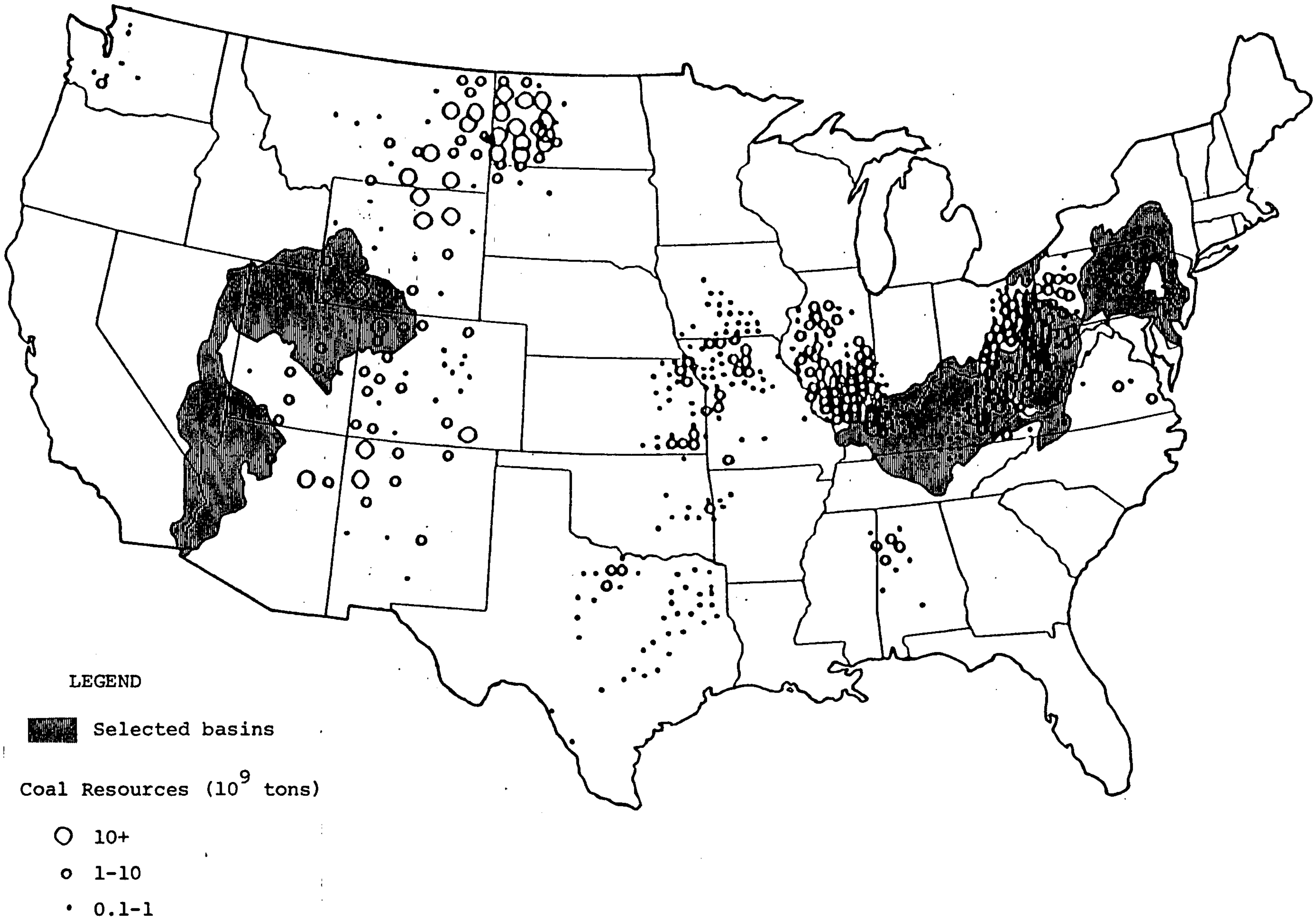


FIGURE 3. SELECTED DRAINAGE BASINS WITH WATER QUALITY LIMITED SEGMENTS NEAR MAJOR COAL REGIONS

is specific to that river segment. It is, therefore, of particular significance that the entire oil shale rich Uinta Basin and the lower Green River in Utah (Figure 2) are designated as water quality limited[4].

The USEPA in cooperation with the various states is currently acquiring and assessing instream water quality data. Efforts to date indicate that some water quality problems exist in portions of most basins in the United States. This is evidenced by compilations of data for suspended solids and toxics as shown in Figure 4 and 5 respectively[5]. As further data is acquired and assimilated, the potential constraints to fossil fuel conversion systems should become more apparent.

As with gaseous emissions effluent stream characteristics depend upon many variables. A detailed mass balance for a particular site and plant are required to accurately predict pollutants and flows. We have prepared Table 6 for the purpose of illustrating potential regulatory constraints on synfuels effluent discharges.

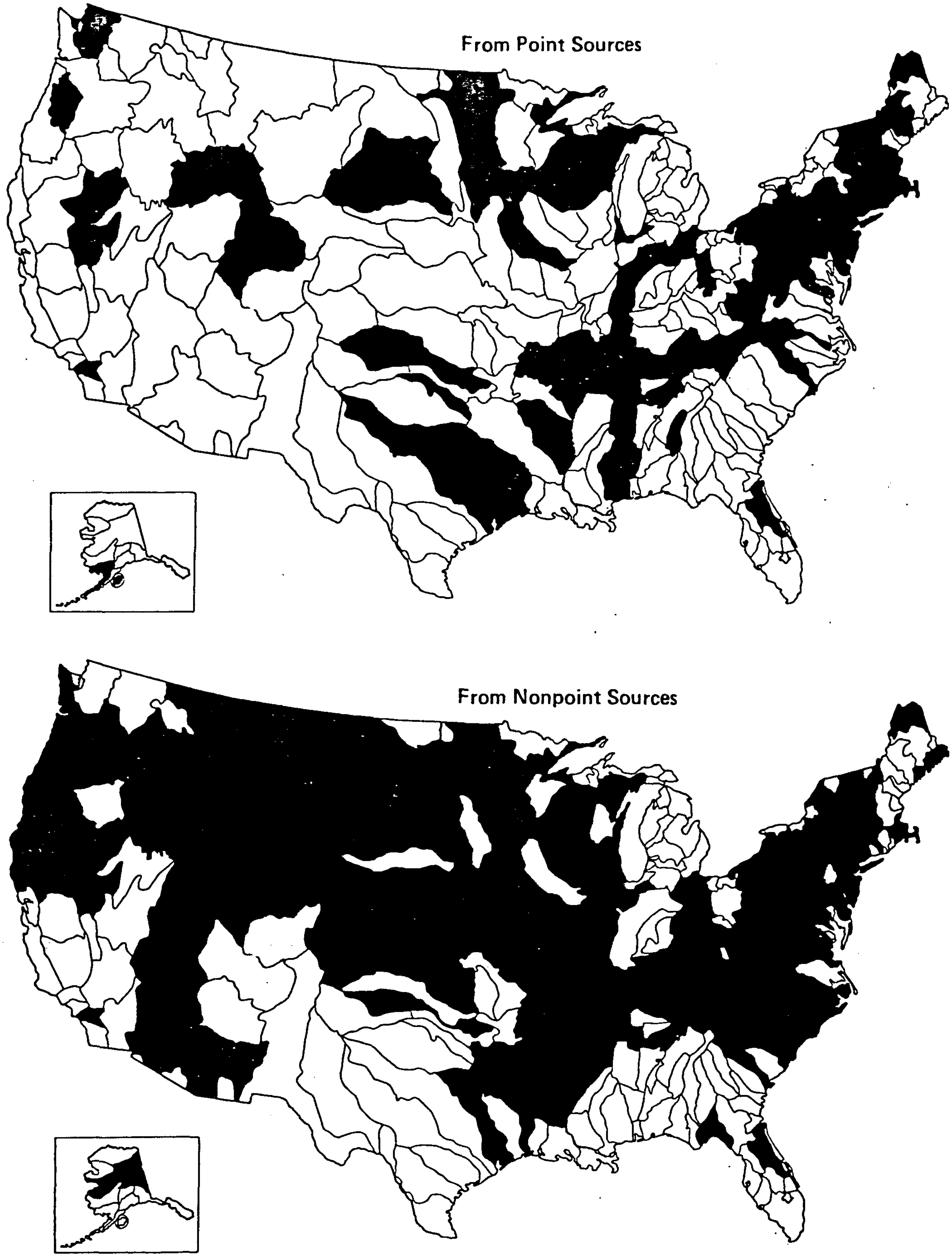
It is noteworthy that some pollutants with known toxic effects such as C_3-alkylphenol, dihydrobenzene and phthalates have been reported in coal gasification condensate[8], but are not currently listed as priority pollutants. Such pollutants are subject to consideration as future additions to the priority list.

Underground Injection Constraints

The Safe Drinking Water Act provides for underground injection guidelines to be developed for wastewater discharges. Currently specific technical and operational requirements have not been proposed. The EPA has recently required that states submit regulatory requirements for underground injection to the EPA within 270 days from July 24, 1980. Until such regulations are approved, underground injection of hazardous wastes is to be controlled under the Hazardous Waste Management Program.

The underground injection guidelines will apply to all underground sources of drinking water which are not designated as sole source aquifers. An underground source of drinking water means an aquifer which (1) supplies drinking water for human consumption or contains fewer than 10,000 mg/l dissolved solids and (2) is not an "exempted aquifer".

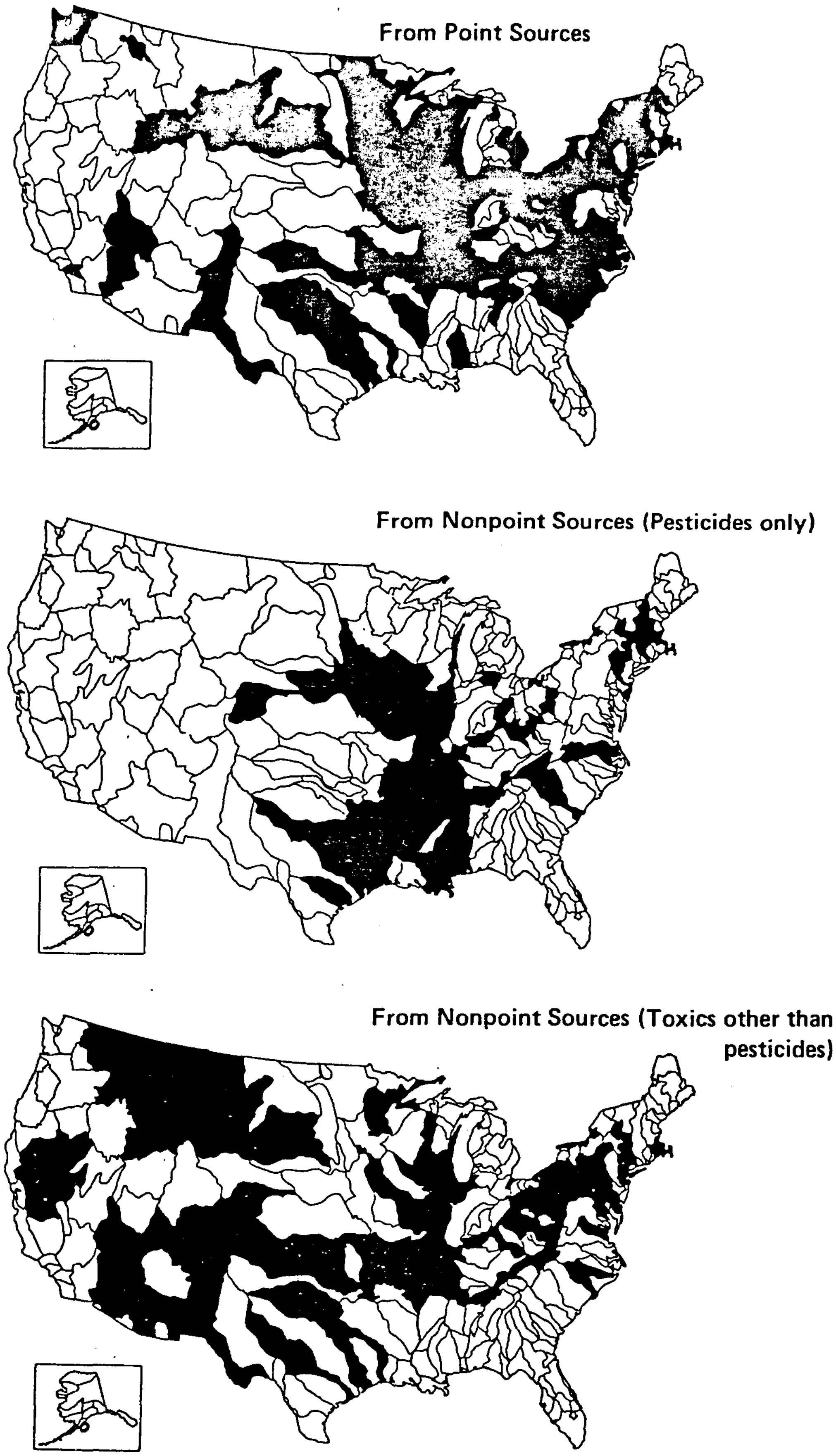
The Safe Drinking Water Act authorizes the designation of certain aquifers as sole or principal drinking water sources. Underground injection of wastes is prohibited in aquifers so designated. Currently there



* In whole or in part

Note: Affected basins are shaded

FIGURE 4. BASINS AFFECTED* BY EXCESS SUSPENDED SOLIDS
Source: USEPA, National Water Quality Inventory, EPA-440/4-78-001, October 1978.



* In whole or in part

Note: Affected basins are shaded

FIGURE 5. BASINS AFFECTED* BY TOXIC POLLUTANTS
Source: USEPA, National Water Quality Inventory, EPA-440/4-78-001 Oct. 1978.

TABLE 6. SELECTED POTENTIAL WASTEWATER DISCHARGE CONSTRAINTS

Parameter	Legal Authority			
	Conventional	Priority	Non-Conventional	In-Stream
BOD	X			
COD	X			
TSS	X			
Fecal Coliform	X			
Phosphorus	X			
Oil and Grease	X			X
Arsenic		X		
Beryllium		X		
Cadmium		X		
Copper		X		
Cyanide		X		
Lead		X		
Mercury		X		
Nickel		X		
Selenium		X		
Silver		X		
Thallium		X		
Zinc		X		
Phthalates		X		
C_2-Alkyl Phenol		X		
C_3-Alkyl Phenol			X	
Napthalene		X		
Cresol			X	
Dihydrobenzene			X	
Acenaphthalene		X		
Benzoperylene		X		
Phenol			X	
POM			X	
Arsene			X	
Metal Carbonyls			X	
Ammonia			X	X
COS			X	
Alcohols			X	
Dissolved Gases			X	
Trace Organics			X	
Alkalinity				
Iron				
Manganese				
TDS				X
Sulfides				X
pH				X
Temperature				X

are seven sole source aquifers in the United States: (1) San Antonio, Texas, (2) Spokane/Rathdrum Valley, Washington, (3) Fresno County, California, (4) Biscayne Aquifer, Florida, (5) Buried Valley, New Jersey, (6) Ten Mile Creek, Maryland and (7) Nassau/Suffolk Counties, New Jersey. None of these sole source aquifers are located in the vicinity of major coal or oil shale resources.

An aquifer may be exempted if it does not currently and cannot in the future serve as a source of drinking water because (1) it is mineral, hydrocarbon or geothermal producing, (2) water recovery for drinking purposes is economically or technologically impractical, (3) contamination has made it impractical to render its water fit for human consumption or, (4) it is subject to subsidence or catastrophic collapse. To date no aquifers have been determined to be exempt.

The EPA is currently raising the attention given groundwater protection due in part to recent catastrophies such as Love Canal. As a result, the EPA is holding a series of groundwater quality workshops in order to formulate future policy alternatives. Depending on ultimate policy directives, regulatory constraints on groundwater injection of synfuel wastes may be increased.

Solid Waste Constraints

The primary Federal law governing solid waste disposal is the Resource Conservation and Recovery Act of 1976 (RCRA). Although RCRA is aimed at proper disposal of all solid waste, its major emphasis and intent is the control of hazardous materials. Criteria for identifying a waste as hazardous are shown below:

Hazardous Nature	Criteria
Ignitability	Flash point $< 140°F$ ($60°C$)
Corrosivity	$2.0 \geqslant pH \geqslant 12.5$
Reactivity	Explosive
Toxicity	24 hr leaching test in pH = 5.0 solution. Leachate must not exceed 100 times drinking water standards. (Extraction Procedure, EP)

The toxicity EP test is of most significance for synfuels solid wastes. The pollutants and maximum allowable concentrations in the EP test are shown in Table 7. It is probable that the EPA will expand this pollutant list in the future. Also of significance is that the EP dilution factor may be reduced from 100 to 10. For wastes not identified as being hazardous by the EPA, the burden is on the generator to test and report his wastes.

The EPA has listed certain solid wastes as hazardous. Unless proven non-hazardous from an individual facility, generators must comply with strict identification, transportation and disposal procedures. Currently no synthetic fuels wastes are listed as hazardous; however, the following petroleum refinery wastes are listed.

Petroleum Refinery Wastes Listed as Hazardous

Dissolved Air Flotation (DAF) Float
Slop Emulsion Solids
Heat Exchanger Bundle Cleaning Sludge
API Separator Sludge
Tank Bottoms (leaded)

TABLE 7. MAXIMUM CONCENTRATION OF CONTAMINANTS FOR CHARACTERISTIC OF EXTRACTION PROCEDURE TOXICITY

Pollutant	Max. Concentration
Arsenic	5.0 mg/l
Barium	100.0
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0
Endrin	0.02
Lindane	0.4
Methoxychlor	10.0
Toxaphene	0.5
Dichlorpheroxyacetic acid	10.0
2-4-5 TP Silvex	1.0

There is little or no available data concerning the toxicity of solid wastes from fossil fuel conversion systems. It is anticipated that the larger volume wastes such as spent shale and ash will pass the EP toxicity test while spent catalysts will probably not pass due to their high heavy metal content. It is possible that wastes which pass all the hazardous testing criteria may still be listed by EPA. Spent shale is a candidate for such a waste for the following reasons: (1) possibility of carcinogens, (2) trace metals, (3) concern over carbonized shale and (4) thermal characteristics. The requirements for disposal in this case could be less stringent than those for hazardous wastes not passing the testing criteria. For example disposal requirements might include quenching, compaction and separate disposal sites. Non hazardous solid wastes will still be subject to disposal requirements, though less stringent.

Certain exclusions contained in RCRA affect synthetic fuels production. These are listed below:

Selected Exclusions Contained in RCRA

Excluded Waste	Remarks
Overburden intended for return to mine site	Except for uranium and phosphate mining, overburden has been specifically excluded as a hazardous waste
In situ mining wastes	Materials which are not removed from the ground are specifically excluded under RCRA
All hazardous wastes generated at less than 1000 kg/mo	EPA plans to extend coverage to 100 kg/mo within 2-5 yrs
Hazardous solids entrained in air or wastewater streams	Such materials are specifically excluded since they are covered by other laws.

Certain other items contained in RCRA and EPA's interpretation of them are of significance to the synthetic fuels industry. These are listed below:

Other Signficant Items of RCRA

Item	Significance
Recycle/Reuse	Hazardous waste recovery and/or reuse is considered a management technique, and does not exempt the waste from RCRA regulations
Economic Impact	RCRA makes no mention of cost or economic impact. EPA's interpretation is: 1. Cost is not a basis for lessening standards to protect health or the environment. 2. Cost/effectiveness may be used in choosing among alternatives meeting RCRA requirements.

The volume and nature of solid wastes generated will vary from site to site. Information in Table 8 is presented to identify the relative quantity of each solid waste generated and its likelihood of being subject to hazardous waste regulations under RCRA.

Intermedia Constraints

Introduction

In the previous sections we have discussed specific potential resource and environmental constraints for fossil fuel conversion systems. We will now present alternative general solutions to each of the identified constraints and their potential impact on constraints in other media or other consequences. By this approach a desirable balance of resource, environmental or other impacts and the optimum level of production can be determined. Each alternative presented will require evaluation on a case by case basis for a specific course of action to be recommended.

Discussion

A summary of identified constraints, generic solutions and associated intermedia impacts and other aspects is presented in Table 9. In the following commentary selected items in the table are expanded and applied to specific cases.

TABLE 8. POTENTIAL SOLID WASTE DISPOSAL CONSTRAINTS

	Indirect Liquefaction				Direct Liquefaction			MED, BTU Gas				Oil Shale					
	Gasifier Ash	Water Trtmt Sludge	Spent Catalysts	Wastewater Trtmt Sludge	Fly Ash Sludge	Slag Sludge	Treatment Sludge	Utility Boiler Ash	Limestone Wet Scrubber Sludge	Spent Catalyst	Gasifier Ash	Spent Shale	Spent Catalysts	Water & Air Sludges	Oil Removal Sludge	Coke	Fines from Crush-ing Operation (Paraho only)
Relative Quality*	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2
Likelihood of Hazardous Classification*	2	3	1	2	2	2	2	3	3	1	2	3	1	2	2	3	2

*Key: Relative Quantity: 1, major; 2, minor.
Likelihood of being classified as hazardous: 1, high; 2, medium; 3, low

TABLE 9. INTERMEDIA CONSTRAINTS

Resource/Environmental Constraint	Generic Solution	Potential Intermedia Impact	Other Aspects
Limited Water Supply	Import water across basin boundaries	Additional air, water & solid wastes from increased production	Possible legal constraints; reduction of water supply in source basin; economic & environmental costs associated with water transport
	Off site processing	Potential air, water & solid wastes constraints at ultimate processing site	Economic & environmental impacts associated with fuel transport
	Acquire local water rights	Additional air, water & solids wastes from increased production	Constraint on water availability for other uses such as agriculture
	Develop additional surface supplies	Additional air, water & solid wastes from increased production	Costs & environmental impact associated with reservoir development
	Develop groundwater supplies	Additional air, water & solid wastes from increased production	Possible aquifer depletion & reduced surface water flow
	Alteration of climate or vegetation	Additional air, water & solid wastes from increased production	Environmental alterations, limited chance of success
	Implement dry(air) cooling processes	Reduced water requirements & wastewater flow	Higher capital costs
	Apply water recycle/reuse technology	Reduced water requirements & wastewater flow	Higher capital costs
	Use treated sewage for cooling or other uses	Possible release of viruses or other contaminants from treated sewage into the atmosphere; reduced fresh water requirements; pretreatment sludge	Pretreatment of sewage
	Use saline cooling towers	Reduced fresh water requirements	New technology
Excessive Water	Dispose of excess water with spent fuel for compaction/cementation	Increased leaching	Longer disposal site life
	Treat & discharge excess water	Increased wastewater discharge and treatment sludge	Economic costs
	Subsurface injection	Aquifer contamination	Practice could be affected by sole source or exempted aquifer designation and/or injection guidelines
	Evaporation (solar or induced)	Reduced effluent discharge; solids residual, leaching	High land and/or energy requirements
New Source Air Emission Performance Standards	Install BAT technology to meet standards	Additional sludge generation & water generation	Less impact on ambient air quality resulting in more production prior to reaching NAAQS
	Selective development of low sulfur deposits	Concentrated development may cause localized air, water or solid waste constraints	Reduced total production

TABLE 9. (Continued)

Resource/Environmental Constraint	Generic Solution	Potential Intermedia Impact	Other Aspects
Prevention of Significant Deterioration	Install more efficient emission controls Install higher stacks Selective development of resources away from Class I areas Off site processing	Increased sludge and/or water requirements None Concentrated development may cause increased local resource/environmental constraints Decentralization could lessen local resource/environmental constraints	Increased capital & operating costs More pollutants emitted Reduced total production Costs & environmental impact associated with fuel transportation
Non Attainment	Exceed BAT technology (i.e. LAER)	Additional sludge production & water consumption	Reduced development due to increased costs
Visibility (Class I Areas)	Use dry cooling to reduce evaporation Improve emission control efficiency Off site processing	Reduced water consumption & blowdown Increased sludge &/or water requirements Decentralization could lessen localized resource & environmental constraints	Increased total cost Economic cost Costs & environmental impact for raw fuel transport
Hazardous Pollutant Emission Standards	Apply necessary technology Selective resource development	Increased sludge production and/or water consumption Centralization could increase local resource/environmental constraints	Economic costs Reduced overall production
NPDES Permit (Conventional Pollutants)	Apply BCT technology and/or best management practices (BMP) Apply wastewater to spent shale or ash Attain zero discharge	Additional sludge production Possible groundwater contamination Reduced water requirements	Economic cost Cementation may seal landfill More feasible in dry climates
NPDES (Priority or Non-conventional Pollutants)	Apply BAT technology and/or BMP Attain zero discharge	Additional sludge, spent carbon or other solid wastes Reduced water requirements Possible air & groundwater impacts	Economic cost More feasible in dry climates
Instream Water Quality Criteria and/or Water Quality Limited Designation	Apply appropriate treatment Zero discharge	Additional sludge production Reduced water requirements Possible air & groundwater impacts	Increased economic cost Increased economic cost; More feasible in dry climates
Hazardous Listing of Low Volume Waste such as Spent Catalysts	Implement RCRA requirements Recover catalysts for reuse Treat waste so as to render it non-hazardous (encapsulation, fixation)	Reduced groundwater impact None Reduced groundwater impact	Economic costs Economic costs Economic costs
Hazardous Listing of High Volume Waste such as Spent Shale	Implement RCRA requirements Insitu oil shale retorting to reduce waste volume	Reduced groundwater impact. Possible air emissions & land use impacts Reduced water requirements; aquifer contamination by residual organics. Possible air emissions	Economic costs Developing technology
Non-hazardous Classification of Wastes	Implement non-hazardous waste disposal requirements	Reduced groundwater impact. Possible air emissions and land use impacts	Reduced economic cost over that required for hazardous classification

As discussed previously, the primary resource related constraint is water supply. Numerous imaginative approaches or combinations can resolve this constraint. Some of these are listed in the table. The specific approach selected will depend in part upon whether the Riparian or Appropriation Doctrine of water rights applies, the availability and competition for existing and potential fresh water supplies or the proximity to a significant supply of salt water or of treated sewage. Humm[1] has prepared a detailed summary of eight specific limited water supply situations and resolutions of energy developers. These approaches include:

1. Contracting directly with Indian tribes to obtain access to a superior water supply which was independent of the appropriative rights governing most supplies in the state,

2. Aquisition of existing irrigation water rights.

3. Negotiating mutually beneficial arrangements to augment or fully utilize existing supplies,

4. Utilizing saline cooling towers, and

5. Using sewage effluent as a water source.

The latter two approaches are particularly attractive in that areawide fresh water requirements are not increased.

Although it has received only limited use in the United States, treated sewage is often used for cooling in other countries, including South Africa and England. A major constraint to the practice is calcium phosphate scale formation resulting from high sewage phosphorus concentrations. However, various physical, chemical or biological means are available for phosphorus removal[2]. Such treatments usually result in additional sludge production which may impact solid waste constraints. The potential release of viral or bacterial organisms in drift could be a problem. This possibility is minimized, however, by chlorination and biological activity in the cooling tower as well as exposure to sunlight. In some cases it may be desirable to transport treated sewage or raw fossil fuel some distance to take advantage of this potential water supply.

An inherent potential impact of resolving or improving a limited water supply constraint is that the increased allowable fossil fuel production will produce proportionately more air, water and solid wastes, which could accentuate the environmental constraints in any or all of these areas.

Other areas of concern with development or acquisition of additional water supplies (either in appropriation or Riparian states) is the potential injury to other users and/or the potential development of other water dependent industries. Such factors must be considered in determining the desired balance of impacts resulting from synfuels development.

Certain air emission control technologies such as scrubbers and wet electrostatic precipitators generate sludge and/or consume water, which may impact solid waste disposal or water resource constraints. Other technologies such as the use of dry cooling equipment may improve emissions without imposing constraints, but at a higher capital cost.

Plant siting options including off site processing and selective development of coal deposits may improve air emissions and permit development away from environmentally sensitive or non-attainment areas. Again economic, social and other aspects must also be considered in recommending a balanced resolution.

Wastewater treatment technologies may produce potentially hazardous wastes such as sludge, spent carbon or ion exchange resin and may consume water. Therefore, solid waste or water resource related constraints may be impacted. Zero discharge may be required by regulations, or may be the most cost effective means of achieving discharge requirements. If zero discharge is attained by recycle/reuse options, pretreatment could produce solid wastes and/or consume water as just mentioned. If evaporation is accomplished by ponding, groundwater quality may be impacted and a solids residual produced. Induced evaporation could consume large amounts of energy and would also produce a solids residual.

Disposal of solid wastes by landfill or deep well injection could ultimately affect groundwater quality. Detailed reporting and disposal requirements for hazardous and non-hazardous wastes should minimize this impact. Although insitu retorting of shale may exempt the inplace spent shale from regulation under RCRA, the potential exists for groundwater contamination by residual organics. This is especially true if groundwater is in direct contact with the spent shale after the operation is abandoned. Groundwater monitoring would minimize the risk of unchecked contamination in this case.

The potential of groundwater contamination may be increased by the disposal of wastewater on ash or spent shale piles. However, the addition of wastewater will suppress dust at the disposal site, allow for greater compaction and longer site life and may cause a cementation reaction to occur which could effectively seal the landfill. The adverse and beneficial effects of this practice must be determined on a case by case basis.

Conclusions

This discussion illustrates that almost all of the solutions to the identified resource and environmental constraints impact at least one other area of constraint. In some cases the impact may be sufficient to significantly increase the magnitude of the impacted area of constraint. Therefore, each of the identified generic solutions and intermedia constraints should be carefully considered for each site to achieve the desired balance of impacts.

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