

Legal, Institutional, and Political Uncertainties

Surface Water - Direct Diversions. Legal and institutional constraints significantly affect water availability for synfuel development. In the Upper Colorado Basin, these constraints include the:

Colorado Constitution (pure appropriation doctrine),
Colorado Water Right Determination and Administration Act, and other
state water laws,
Colorado River Compact of 1922,
Boulder Canyon Project Act of 1928,
Upper Colorado River Basin Compact of 1948,
Mexican Water Treaty of 1944-45,
Colorado River Storage Project Act of 1956, and
Colorado River Basin Project Act of 1968.

A good summary of these compacts and Colorado water law appears in the June 1980, OTA report, Assessment of Oil Shale Technologies and the Section 13(a) Assessment. As a consequence, this background information is not repeated herein. In the future, as the water rights in the entire Colorado Basin become fully developed, the legal framework and its interpretation will become an even more critical factor in assessing water availability than at present. Because full development has not been reached, some provisions of the law and compacts have not been exercised or tested. For example, the Upper Basin states have not fully developed their rights to Colorado River water, and there has been no need to date for limiting Upper Basin diversions. As a result, considerable uncertainty exists about procedures and priorities which will be used in the Upper Basin to call Upper Basin out-of-priority diversions when Colorado River Basin Compact requirements cannot otherwise be met. The legal uncertainties which exist are generally not fully recognized, or emphasized, in the Section 13(a) or other assessments of water availability for shale oil development.

The obligation of Colorado and other Upper Basin states under the Colorado River Compact is to deliver 75 million acre-feet at Lees Ferry "for any period of ten consecutive years." For planning purposes, this commitment is assumed to be 7.5 million acre-feet annually. However, there is a dispute

regarding whether the Upper Basin states will be required to supply 50 percent of the 1.5 million acre-feet annual commitment to Mexico under the Mexican Water Treaty of 1944-45.

Furthermore, Colorado has not determined how it will internally administer the state's water rights to meet its commitments under the Colorado River Basin Compact, the Mexican Treaty, and other legal constraints. As the basin becomes fully developed, other basin states will exercise their rights, and a demand will be placed upon Colorado to deliver required flows to the state line. There are at least two scenarios that could be used to administer the compacts within Colorado; but since no planning has been undertaken to date, prediction of a likely option is not possible. The first plan would follow the Appropriation Doctrine and curtail the most junior rights to meet the calls, irrespective of the sub-basin in which they were located. A second administrative scenario would allocate a percentage of the demand to each sub-basin. For example, the Colorado River mainstem at the state line could be required to deliver a certain percentage of Colorado's commitment to the compacts, and similar allocations would be undertaken for the White, Dolores, Yampa, and San Juan Rivers. If the first scenario were used, some basins would require more reservoir storage than if the second plan were implemented. The second scenario would allow the state to "manage" the available water supply to mitigate against unequal impacts caused by Colorado's obligation. Political and legal influences will play major roles in determining any solution to this highly controversial matter.

Therefore, the various compacts and treaties add considerable uncertainty to the projected availability of water supply for synfuel development because many of their provisions and conditions are not definite or have not been tested. Further uncertainty is added to water availability because state implementation procedures to meet various conditions and requirements of these treaties and compacts have not been developed. This uncertainty provides a significant cloud on the availability of water for synfuel development.

Federal Reservoirs. The Colorado Department of Natural Resources assessment predicated its conclusion of water availability on the assumption that water could be obtained from existing reservoirs or new reservoirs. While federal reservoirs, such as Ruedi and Green Mountain Reservoirs in Colorado, provide an attractive option to water supply for oil shale, the amount of water available is uncertain.

- o Ruedi Reservoir. The total amount of firm yield that could be made available for sale from Ruedi Reservoir ranges from zero to 67,500 acre-feet--or the water needs of about 11 unit-sized (50,000 bbl/d) shale oil plants. While Ruedi Reservoir, located on the Fryingpan River near Aspen, Colorado, appears to be a logical and convenient source of water for oil shale development in the near-term, potential sales of water from Ruedi Reservoir to industry are subject to controversy and uncertainty.

The primary purposes of Ruedi Reservoir, according to its authorizing statute, are to: (1) satisfy depletions caused by transmountain diversions to the Arkansas Basin in eastern Colorado, and (2) provide water for future users in western Colorado, in particular the municipal and industrial water needs associated with the shale oil industry. However, to date, no long term contracts have been entered into for water sales, even though water has been available since 1969. The impediments to sales appear to be:

- (a) Uncertainty as to the amount required for replacement of eastern slope diversions: While 28,000 acre-feet has been set aside for make-up water for out-of-priority diversions to the eastern slope, WPRS has estimated that less than 10,000 acre-feet is needed for that purpose. Hydrological operation studies show that the 28,000 acre-feet requirement could be reduced to 10,000 acre-feet; however, these studies will need to be confirmed and agreed to by the parties of interest in the reservoir before the 18,000 acre-feet saving could be used on the western slope. This amount could satisfy another two or three shale oil facilities.

- (b) Uncertainty about the firm yield of the reservoir: Controversy exists among the Southeastern Water Conservancy District, the Colorado River Water Conservancy District, the State of Colorado, and the Water and Power Resources Service regarding firm yield of the reservoir. As a result, no general agreement exists concerning the total amount of water ultimately available.
- (c) Uncertainty about the contract terms in water sales: WPRS has not decided whether it will market a firm yield to lessees or contract for a percentage of the annual reservoir yield. Additionally, a price structure has not been determined. These uncertainties may have to be resolved in individual contract negotiations on a case-by-case basis.
- (d) Controversy regarding the principal purpose of the reservoir: A coalition of interests (including the towns of Aspen, Snowmass, Basalt, Carbondale, Glenwood Springs, and Pitkin County) is seeking to gain control of the marketing of Ruedi water, or severely restrict the amount of water which can be marketed from Ruedi Reservoir, so that the reservoir level can be maintained at a high and consistent level for recreation. Should the coalition be successful, all or most of the marketable water (estimated at 49,500 acre-feet) would be pre-empted for recreation. This would be an extreme outcome and it is assumed that a compromise might be a more realistic resolution.
- (e) Uncertainty about the marketing agency: The above-named coalition of municipalities, the Colorado River Water Conservation Board, and the State of Colorado have been seeking to become the marketing agent for the sale of water from Ruedi. Each entity would have different management purposes, which would affect conditions placed on water available for sale. For example, the coalition of municipalities would restrict

sales in order to maintain recreational values. The Colorado River Water Conservation District would manage Ruedi as part of a series of reservoirs (to be constructed or acquired) in a basinwide storage management plan. The State of Colorado would manage the reservoir sales in coordination with state-wide water resource considerations (eastern slope and western slope). These entities would impose different restrictions on the type of sales and pattern of releases.

If Water and Power Resources, which is currently in negotiations regarding an application for lease of water to one oil company, grants the lease, some of the issues may be resolved and precedents established. However, if and as more and more contracts are let, the issues of a reserve for recreation and the firm yield of the reservoir will become more important impediments.

- o Green Mountain Reservoir. Green Mountain Reservoir, located on the Blue River, was constructed in 1942 as a replacement reservoir for transmountain diversions to northeastern Colorado by the Colorado Big Thompson project. Of the 153,639 acre-feet total storage volume, 52,000 acre-feet is set aside for replacement of transmountain depletions and 7,000 acre-feet is dead storage.

While the operating principles are defined in Senate Document 80, there has been a continuous dispute since the completion of the reservoir between Water and Power Resources Service and prospective users about who is entitled to use the water from Green Mountain Reservoir. The reservoir has been mainly operated to meet power plant requirements. This has meant that storage in Green Mountain Reservoir has been maintained at a minimum of 41,000 acre-feet to maximize power generation efficiency. Other uses-- except for Colorado Big Thompson Project replacement needs-- have been subordinated. Such an operating criterion reduces the dependability of supplies from Green Mountain Reservoir for meeting oil shale industry requirements.

Firm yield of Green Mountain Reservoir (as noted in the 13(a) Assessment, p. 6-11) is further limited because of potential landslide problems. The Water and Power Resources Service believes that if the reservoir were

to be lowered below about 41,000 acre-feet, the potential exists for a major landslide. These limitations reduce the effective capacity of the reservoir by 34,000 acre-feet, or the equivalent of the annual requirements of about 5 or 6 unit-sized oil shale plants.

This detailed discussion of water availability from Ruedi and Green Mountain Reservoirs is presented to demonstrate that water availability for synfuel development is uncertain even in the case of existing Federal reservoirs. Institutional and legal constraints, however, are creating delay and uncertainty concerning the availability of this water for synfuel development. This uncertainty and potential for delay reduce the attractiveness of this water supply to energy companies seeking a water supply for a shale oil plant.

Alternatives. Legal, institutional, and political factors can be major constraints against implementation of alternative means of water supply for synfuel development.

The Upper Colorado River Basin report provides a good discussion of alternatives for synfuel water supply. In addition to discussing traditional sources of supply (e.g., development of surface supplies through use of original appropriation, construction of new reservoir storage, or water contracts from existing U.S. Water and Power Resources Service reservoirs), the report provides detailed discussion of: (1) purchase of surface water rights from existing irrigated agriculture, (2) development of groundwater, (3) improvements in use efficiency by irrigated agriculture and municipalities, and (4) weather modifications.

While the Section 13(a) report adequately presents these alternatives, it does not fully discuss the legal and institutional constraints which would hinder implementation of alternatives such as reducing exports from the basin.

- o Agricultural Water Rights. The Section 13(a) Assessment states:

Purchases of water from irrigated agriculture could more than satisfy the water requirements of postulated levels of EET (Emerging Energy Technology) development in this basin. Furthermore, if sufficiently senior rights were obtained, it would be possible to develop the necessary water supply through direct diversions alone without any reservoir storage facilities (Department of Natural Resources, 1979, p. 7-28).

The statement does not accurately reflect the limitations placed upon transfers of use under Colorado water law. A water right transferred from agriculture to industrial use in Colorado must be transferred by court decree and is limited to the historic consumptive use of that agriculture water right (evapotranspiration, plant absorption, etc.). The historic use applies not only to the quantity but also to the historic period of use and the location of diversion. Thus, a converted agricultural right could only be used during the irrigation season. If diversions are to be available from these transferred rights for oil shale development throughout the year, storage facilities would also have to be acquired or built to store flows during the irrigation season for replacement release during the non-irrigation season.

Energy companies have been acquiring irrigation water rights in the basin for many years; however, few companies have taken these water rights through the 6 to 24 month transfer process. The only major transfer of irrigation water rights for oil shale development purposes has been by Union Oil (Division 5, Water Court Case W-2206) where in 1975 more than 50 irrigation rights were acquired and transferred from ranches in the Roaring Fork and Parachute drainages to Union Oil operations in Parachute Creek. These irrigation rights total over 150 cfs which could have theoretically diverted 50,000 acre-feet if there were water physically available and they were in priority. After protests against the transfer by other water users such as the City of Denver, ARCO, Garfield County and several individuals, who sought to protect their rights from injury as a result of the transfer, the court allowed the transfer of about 5 percent of the original decrees, or approximately 2500 acre-feet.

Therefore, while transfers of water from agriculture provide an obvious alternative source to oil shale companies, the process is legally cumbersome and the final result is beset with considerable legal and institutional uncertainties which are inherent in the water rights appropriation system.

Increased efficiency in irrigated agricultural uses of water is often proposed as an alternative which would result in increased water availability for synfuel development. It has been suggested that energy companies could pay farmers for water conserving measures plus a premium for any inconvenience in return for water rights to water "saved" by the water conserving measures.

Measures can be taken to reduce both conveyance losses and on-farm losses. The most likely means of reducing conveyance losses is through channel and ditch lining. Channel lining will reduce seepage from canals; however, it must be recognized that losses due to seepage from a canal or ditch are not truly losses to the hydrologic system. Water that seeps from a ditch or canal will eventually return to the groundwater or the river to be used by others. However, downstream users and alluvial well owners in Colorado and elsewhere have become dependent on the return flows from unlined canals and ditches and are legally entitled to that water.

The other category of measures involves reducing losses on the farm. Measures that may be taken include changing to crops that require less irrigation water and changing to more efficient irrigation methods. The most likely of these include improved application and tailwater recovery systems. *Since most consumptive use of farm irrigation water is the result of evapotranspiration and seepage of excess water into deep substrata, significant "savings" in water consumption can be achieved by these methods.

However, the same problems that confront implementation of ditch lining also confront measures to increase efficiency on the farm: under

Colorado water law, downstream water rights holders are entitled to return flows resulting from the existing inefficient practices. A change in agricultural or irrigation practice to "save" water for sale to an energy company and subsequent use in oil shale processing can be, and probably will be, legally challenged.

- o Reduced Basin Exports. The Section 13(a) report provides detailed discussion of potential improvements in water use efficiency by non-synfuel users. This alternative could be a potential source of supply for synfuel development since a reduction in projected water demand for uses other than synfuel development would increase the supply of surface water remaining for synfuel development. The report points out that reduction in exports from the entire Upper Colorado Basin for municipal use, primarily to the front range area of Colorado, could be achieved by the year 2000. The report concludes that a 20 percent reduction in per capita use by only that increment of population growth that is the basis for projected increases in exports would result in a reduction of 60,000 to 80,000 acre-feet per year in projected exports. The report further concludes that this is a "highly conservative estimate" and that if these demand reduction measures were applied to all customers, and not just new customers, then exports for municipal uses could perhaps be reduced by as much as 200,000 to 300,000 acre-feet per year. Since the report estimates approximately 200,000 to 250,000 acre-feet per year of consumptive use would result from the 1.5 million bbl/day synfuel industry, it is apparent that this reduction of 200,000 to 300,000 acre-feet per year would be quite significant.

No institutional nor financial mechanisms currently exist for achieving this 200,000 to 300,000 acre-feet per year reduction in out-of-basin exports. In order to implement this alternative an energy company on the western slope of Colorado seeking water supply for its synfuel development would have to go to a major exporter from the basin, such as the Denver Water Board, and attempt to buy necessary water rights. The proceeds of the sale could go toward implementation of water conservation

measures such as universal metering. For political and institutional reasons, it is highly unlikely in the foreseeable future that the Denver Water Board, for example, would sell a water right to a major energy company. In addition to the lack of an institution to facilitate more efficient water use as a source of water supply for synfuel development, there are substantial legal and political obstacles arrayed against this alternative water supply source. The constitution of the State of Colorado protects the right of appropriation; therefore, there can be no restrictions against continued exportation by municipalities on the east slope. Colorado water law and the prevailing frontier ethic favor continued development of new sources of water supply rather than more efficient use of existing supplies.

In the future, a major out-of-basin exporter, such as the Denver Water Board, may be unable for legal, economic, or political reasons to construct necessary additional storage and conveyance facilities for transmountain diversion thereby: (1) reducing forecast exports, and (2) meeting future increases in demand by more efficient use. Such an eventuality, however, does not offer a potential source of supply to an energy company for synfuel development; the uncertainty of its occurrence is simply too great.

- o Non-tributary Groundwater. In Colorado there is currently uncertainty concerning who can develop and use non-tributary groundwater. Non-tributary water is outside the normal appropriation doctrine and is governed by State law which allocates nontributary groundwater based on saturated aquifer thickness, specific yield, and the amount of overlying land owned by the well owner. Under Colorado law, a landowner can annually withdraw 1/100th of the volume of water contained in the aquifer beneath his property, assuming no recharge and providing this withdrawal will not interfere with preexisting wells in the area.

The existing law presents uncertainty for the shale oil industry. In order to develop much of the deep groundwater in the Piceance Basin, oil

shale developers will need to prove to the State Engineer and the court the non-tributary nature of the aquifer.

- o- Federal Reserved Rights. Federal reserve claims in Colorado, other than those claimed by the Naval Oil Shale Reserve, are currently before the Colorado Supreme Court, with a decision expected this year. The lower court decision has limited the uses to which the water could be put and has specified a time period and method by which the claims are to be quantified. At this time, there is no quantification of the cloud which these claims hold over the river basin.

In its original brief the Naval Oil Shale Reserve at Anvil Points, Colorado, has claimed the "direct, storage, and well water rights at such quantities of water unappropriated as of the reservation dates as are or will become reasonably necessary to fulfill the current and future purposes for which said Reserves were created." The reservation dates are 1916 and 1924, which if granted, would provide senior water rights to the reserve and would curtail current junior rights. The anticipated quantity reserved, as identified in the original brief 'for informational purposes only,' is 200,000 acre feet per year (Department of Interior, Water for Energy Management Team, p. 10). However, this can be a misleading value given the uncertainty of potential needs of the reserve and the court process. The Naval Oil Shale Reserve case is temporarily dormant, with no foreseeable activation of the issue, but the senior nature of the yet unquantified claim presents a significant uncertainty to the assessment of water availability for oil shale development.

Economic Factors

Economic factors can be viewed from several points of view: the synthetic fuel industry, the other users within the basin, or the government decision-maker.

While the cost of water supply will be one variable used by energy companies to determine which source of water to use, it is not likely to be a critical

factors. If a 50,000 bbl/d oil shale plant which uses 5,700 acre-feet of water costs \$1.7 billion dollars and the cost of water were as high as \$1,000 per acre-foot, the water cost would only represent 0.3 percent of the **total cost**. Therefore, ease of acquisition and certainty of yield will probably be more decisive factors in acquiring a water supply for synfuel development. The cost of water supply will probably be more of a constraint to those competing users--municipalities, agriculture, and other industries--than to synfuel development.

Obtaining reliable and comparable cost data on recent water sales is difficult, because of the variation in conditions surrounding each sale. For example, the seniority of a water right and the historic water use are important factors in determining the value of the water right. The location of the point of diversion of the original water right with respect to the site where the buyer proposes to use the water further determines how much a buyer is willing to pay. The necessity for additional conveyance or other water control structures required for utilizing the water by the buyer also determine costs. In order to provide some indication of the complexity and difficulty of comparing of water costs, the following examples are presented:

1. The Los Angeles Department of Water and Power recently negotiated a contract for about 39,000 acre-feet of water rights at \$1,750 per acre-foot in Utah for cooling water purposes for the Interbasin Power Project. This sale compares to approximately \$200-\$300 per acre-foot for agricultural water rights under present sales in the area. In addition to the \$1,750 per acre foot, the Los Angeles Department of Water and Power will have to expend additional sums for various water control structures.
2. The Colony Shale Oil project is currently negotiating with the U. S. Water and Power Resources Service for approximately 6,000 acre-feet of water from the WPRS's Ruedi Reservoir in Colorado. While negotiations are not yet complete, the WPRS'S presently proposed contract gives some indication of the final water price. It must be emphasized that this

sale is not for a water right, but rather a contract for water delivery. Colony Shale Oil project will divert this water under existing water rights from the Colorado River downstream from Ruedi Reservoir. The WPRS' S presently proposed contract calls for:

- a. A \$15 per acre-foot stand-by charge
- b. A delivery charge of:
 - o - 1000 acre-feet at \$35 per acre-foot
 - 1000 - 4000 acre-feet at \$60 per acre-foot
 - 4000 - 6000 acre-feet at \$85 per acre-foot

In addition, there would be a requirement to pay annually the delivery charge on at least the first 1,000 acre-feet.

3. **In contrast** to the WPRS' S proposed Ruedi Reservoir water sale to the Colony Shale Oil project, WPRS is proposing to sell water to Battlement Mesa, Inc. (a new town under construction by the Exxon Corporation near Parachute, Colorado) for a stand-by charge of \$6.00 per acre foot and a delivery charge of \$9.00 per acre-foot. This proposed **sale would be a** contract for delivery of up to 1,200 acre-feet of water annually.
4. A western slope community of approximately 1,000 population about 60 miles west of Denver has recently completed negotiations to buy a water right for approximately 2 cfs of flow from a small tributary of the Blue River, a tributary of the Colorado River, in western Colorado. The town would pay \$100,000 for this water right which can be expected to provide the town with approximately 54 acre-feet of depletion in a dry year. The town will be able to pump considerably more water under this right but will only be able to deplete the flow of the stream by an expected 54-acre-feet during a dry year under this right. Furthermore, this depletion must occur in a pattern comparable to the irrigation depletion pattern of the original water right, i.e., this water right does not permit depletion outside the normal irrigation season. This 54

acre-feet will cost the town approximately \$1,850 per acre foot of consumptive use.

The purpose of presenting these four typical examples is to demonstrate the difficulty of developing comparable data on water sales.

Industry will also, through site specific studies, have more cost data than will the governmental decision-maker or regional water resources manager. Even then there are uncertainties regarding cost of Federal reservoir water, cost of groundwater development, and cost of new storage and transmission facilities. The decision-maker, however, must often rely on such generalized cost data regarding surface water and groundwater supplies that it is of limited use. This lack of specific data, coupled with industry's decision criteria generally being outside the market pricing mechanism, results in difficulty predicting which source industry will favor and use.

The economic constraint will be more of a factor to those competing uses-- municipalities, agriculture, and other industries. The lack of certainty on availability of supplies and the quantity needed by various technologies leads oil shale company planners, their engineers, and water attorneys to be conservative in their planning needs and incorporate redundancy in their efforts to procure supplies. This redundancy increases the competition for supplies. As the synthetic fuels industry is able to pay higher unit costs for water, other activities may be constrained by costs of water rights and water development.

Demand Estimation

Two categories of demand are identified in the Section 13(a) Assessment: demand for synthetic fuel development (this is termed "emerging energy technologies" or EET in the 13(a) Assessment) and demand for non-EET uses.

Non-Emerging Energy Technology Demand. The Section 13(a) Assessment identified three future development scenarios from **low to** high development. The estimated depletions without synfuels development for the year 2000 are

listed below. The Section 13(a) Assessment selected the middle scenario on which to base its conclusions.

	Upper Basin <u>(values in ac/ft)</u>	Colorado <u>(values in acre-feet)</u>
Low Scenario	4,099,000	2,129,000
Medium Scenario	4,482,000	2,211,000
High Scenario	4,783,000	2,304,000

The inaccuracies and uncertainties inherent in estimating depletions have been discussed earlier. Given those depletion estimates, however, what should be the basis for selecting one scenario over the other? It is unlikely that all three scenarios have an equal probability of occurrence. Thus, without using relative probabilities of occurrence, the criteria for selection of the middle scenario is purely subjective. A more precise decision-making mechanism (yet still influenced by subjective judgment) would give an estimation of probability for each of the scenarios and then develop an expected value of occurrence.

Very little attention in the Section 13(a) report is given to non-consumptive, instream uses such as kayaking, fishing, and other recreational benefits, as well as hydropower and water quality control. The various analyses indicate that such uses are difficult to quantify, and for a basin-wide assessment the occurrence of low flows and the impacts on instream uses for specific stream reaches cannot be adequately determined.

Synthetic Fuel Demand. The Section 13(a) report incorporates a range of synfuel industry demands. The forecast synfuel depletions for year 2000 are:

<u>Condition</u>	<u>Synfuel (acre-feet)</u>	<u>Associated Growth (acre-feet)</u>	<u>Total (acre-feet)</u>
<u>Colorado Only</u>			
Baseline	23,000 ^a	6,000	29,000
Accelerated	70,000 ^b	14,000	84,000
<u>Total Upper Basin</u>			
Baseline	217,000~	35,000	252,000
Accelerated	374,000	68,000	442,000

^aEntirely for oil shale development

^b13,000 AF for low-Btu coal gasification

^c68,750 AF for high Btu coal gasification in Wyoming and the San Juan Basin in Colorado and New Mexico

^d13,000 AF for low-Btu coal gasification in Colorado and 82,700 AF for high-Btu coal gasification in Utah, Wyoming, and the San Juan Basin in Colorado and New Mexico.

The amount required for associated growth includes uses for municipal, power, dust control and irrigation of revegetated plots.

There are many uncertainties associated with these estimates for oil shale plants because: (1) the mix of technologies is unknown, (2) there are no commercial plants in existence on which to base estimates of water requirements for production levels, and (3) the industry is continually revising its estimates of water requirements. Currently estimated requirements for a 50,000 bbl/d surface retorting plant, as noted in the Section 13(a) report, range from 3,500 to 9,000 acre-feet per year. Estimates for a modified in-situ plant range from 2,000 to 5,000 acre-feet consumptive use per year. As noted in the Section 13(a) report, the choice of 5,700 acre feet per 50,000 bb/d oil shale plant is an arbitrary estimate. Assuming the availability of 250,000 acre-feet in the entire Upper Colorado Basin, the number of unit-sized oil shale plants could vary from 27 to 125 exclusive of associated growth, depending upon the technologies used and the extent to which coal is developed.

The Section 13(a) Report has assumed use-of the Lurgi process in high-Btu coal gasification and estimates the water consumption for a unit-sized plant (250 million scf/day) to range from 5,000-7,500 acre-feet per year. The Section 13(a) Report uses the high value (7,500 acre-feet) in order to be conservative. Similarly, for low-Btu gasification, the demand ranges from 3,000 to 14,500 acre-feet per unit-sized plant. The conservative figure of 14,500 acre-feet is used. The range of demand in both cases is dependent upon the extent to which dry cooling systems are employed, and this uncertainty is noted in the Section 13(a) Report.

Discussion and Conclusions

Physical Availability. It can be concluded that while water is available in the Upper Colorado River Basin to meet initial synfuel development the physical availability on certain tributaries and at certain locations may be limited. "Initial synfuel development" involves those synfuel plants presently in some phase of planning and which will be constructed within the next 10-12 years. The errors in the data base and the uncertainties in assumptions become magnified as the focus narrows from basinwide to sub-basin to tributary to specific site application.

The estimates of depletions and virgin flows are very sensitive to assumptions and techniques in the methodology. For example, the "population mean" for virgin flows has not been determined. The estimates of annual average virgin flow which have been determined vary by 2.7 million acre-feet as noted between the 1906-74 period (15.2 maf) and the 1954-63 period (12.5 maf).

Because of the inability of reservoirs on tributaries to create the long-term carryover storage which is assumed in the basin-wide studies, dry year yields, rather than average annual flows, might be the limiting number.

The lack of data on the availability and access to non-tributary groundwater supplies provides a significant uncertainty regarding the quality and quantity of a potentially major alternative supply.

Economic Constraints. The cost of water will probably not be a limiting factor to development of oil shale because of the small proportion of water costs to total plant costs. Water source selection by oil shale companies will be outside the market system, and primary factors of selection will be ease of acquisition and certainty of yield.

Because of the uncertainties of acquisition, however, synfuel planners are pursuing and optioning several water sources. Because of the redundancy in their search for and procurement of supplies, the economic constraint of rising water prices will be felt more keenly by the other water users, such as municipalities.

Demand Uncertainty. The various scenarios are given equal weight, so the choice among them is more subjective. The variation between the scenarios amounts to 175,000 acre feet for the Colorado River in Colorado, and 684,000 acre feet for the entire Upper Colorado River Basin. Estimates for oil shale water demands have such a wide range that it makes demand estimations unrealistic. However, the lack of adequate demand estimations means that high range of oil shale development cannot be determined, but a lower range can be estimated based on the surplus of supplies from other uses. This is similarly true for coal gasification.

Therefore, while the recent reports on the Upper Colorado River basin in Colorado indicate that sufficient water exists for a 1.5 million bbl/d synfuel industry (i.e., 200,000 to 250,000 acre feet), there is enough uncertainty in the data, assumptions, and estimation methodology to either erase that surplus or magnify it.

Legal Availability and Institutional and Political Constraints. The legal uncertainty of the requirements of the Mexican Treaty of 1944-45 alone could reduce the amount of water to the Upper Basin by 750,000 acre feet, with the potential reduction in Colorado amounting to approximately half that amount.

Within the Upper Basin water will continue to be developed until limited by the Colorado River Compact, which is expected to occur by about 2000. However, within Colorado there are no state guidelines regarding how the water rights will be administered within the state to meet state line commitments for the Compact. The lack of an allocation plan means that the maximum water legally available to the various sub-basins within Colorado is unknown. The Naval Oil Shale Reserves in Colorado at Anvil Points, under the Federal Reserve Rights Doctrine, has filed on the water necessary to develop its oil shale resources. Such claims could range as high as 200,000 acre-feet per year, with appropriation dates of 1916 and 1922.

The conclusions of the Section 13(a) Assessment were premised on the availability of water from existing reservoirs or the construction of new storage facilities. However, the institutional and political constraints on two Federal reservoir facilities--Ruedi Reservoir and Green Mountain--could amount to a withdrawal from sale of up to approximately 100,000 acre feet annually from the available supplies.

Alternative supplies to synfuels include the transfer of agricultural water rights. The current amount of agricultural rights owned by energy companies is unknown; however, the extent to which synfuels interests will seek to transfer agricultural rights might be limited by the court transfer process.

General. The Upper Colorado River Basin Section 13(a) report meets some of its objectives as specified in the report:

.....to assess, at a broad regional level of detail:

- (1) The water requirements of coal gasification and oil shale technologies and associated growth.
- (2) The availability of water for the potential development of these emerging energy technologies and the associated growth.

(3) The effects which these potential emerging energy technologies would have on the hydrology of the Upper Basin. . . .

In meeting these objectives, the assessment report does a good job in clearly laying out many of the assumptions, describing some of the various uncertainties resulting from potential legal and institutional constraints, and indicating some of the uncertainties that surround projections of future consumptive use. It does not address some of the important elements such as instream flows and trade-offs, nor does it quantify uncertainties. However, in short, this report probably does about as good a job as can be done in assessing future water availability for synfuel development and presenting the results in a form, and at a level, that will be of use to state, regional, and national decision-makers.

Despite this generally good effort, controversy and uncertainty will continue to surround the availability of water for synfuel development in the Upper Colorado River Basin. The reason for this is that so many assumptions must be made in aggregating data and information into a form useful to state, regional, and national decision-makers, that these assumptions cannot all be explicitly detailed in their entirety and communicated. As a result of the uncertainty surrounding these assumptions, there will always be potential for controversy over water availability.

A simple example from the Upper Colorado River Section 13(a) Assessment report can serve to demonstrate why controversy and uncertainty continue to exist in the entire Upper Basin about availability of water for synfuel development. Based on the report, assume that 13.8 million acre-feet is the mean annual streamflow for the Colorado River. Subtract from this the 7.5 million acre-feet that the Upper Basin States must deliver to the Lower Basin States:

$$\begin{array}{r}
 13.8 \text{ maf (estimates mean annual streamflow} \\
 \text{of Colorado River)} \\
 \underline{-7.5 \text{ maf (required delivery to Lower Basin)}} \\
 6.2 \text{ maf}
 \end{array}$$

Then, subtract the 750,000 acre-feet potential obligation of the Upper Basin states to fulfill their half of the Mexican Treaty requirement:

$$\begin{array}{r}
 6.3 \text{ maf} \\
 - 0.750 \text{ (Upper Basin Mexican Treaty Obligation)} \\
 \hline
 5.550 \text{ maf}
 \end{array}$$

Finally, subtract an estimated 645,000 acre-feet of estimated annual evaporation from Flaming Gorge, Lake Powell and the Curecanti Unit Reservoirs:

$$\begin{array}{r}
 5.550 \text{ maf} \\
 -0.645 \text{ (estimated annual evaporation from} \\
 \text{Flaming Gorge, Lake Powell, and the} \\
 \text{Curecanti Unit Reservoirs)} \\
 \hline
 4.905 \text{ maf}
 \end{array}$$

This computation indicates that about 4.9 million acre-feet is available for consumptive use in the Upper Basin States. Significant uncertainty and controversy, however, surround this estimate of potential consumptive use in the Upper Basin states.

A dispute exists concerning whether or not the Upper Basin states are responsible for one-half of the Mexican treaty obligation (i.e., 750,000 acre-feet) or whether the Lower Basin states are responsible for the total 1.5 million acre-feet. Uncertainty also exists concerning the virgin flow estimate for the Colorado River with estimates ranging from 13.8 million acre-feet annually to 15.0 million acre-feet.

The Upper Colorado River Basin Section 13(a) report estimates that the annual consumptive use for non-synfuel development will increase from the present (197\$) levels of about 3.116 million acre-feet to a 4.099, 4.482, or 4.783 million acre-feet depending on assumptions. The report estimates that consumptive use of the proposed 1.5 million bbl/day synfuel industry* would be approximately 200,000 to 250,000 acre-feet per year. Comparison of the

*This represents 26 unit-sized oil shale plants" and 8 unit-sized high Btu gasification plants.

above estimates of future increases in consumptive use by non-synfuel users with the water remaining for consumptive use in the Upper Basin indicates that the possibility exists that there may not be 200,000 to 250,000 acre-feet of water remaining for synfuel development.

Furthermore, these estimates say nothing about possible additional future constraints on water availability resulting from salinity control programs, low flow requirements in tributaries to preserve squaw fish habitat and other endangered species, and realization of Federal reserved rights claims.

Therefore, even at highly aggregated levels for the entire Upper Colorado River Basin, the confidence limits or ranges that are placed on estimates of water availability are so broad that they tend to subsume the amount of water needed for synfuel development. It is clear from the rough estimate above, as well as from the Upper Colorado River Section 13(a) analysis, that adequate water exists at present for initial development (as defined earlier) of the synfuel industry in the Colorado River Basin. However, to go beyond that and make forecasts of water availability for the year 2000 requires discussion and quantitative analysis of the many uncertainties which surround crucial estimates of water availability for synfuel development. Reasonable people can disagree over many of these estimates. This is why there will be continuing controversy concerning future water availability for synfuel development.

ANALYSIS OF OTHER REPORTS

Water Supply Should not be an Obstacle to Meeting Energy Development Goals

The GAO report to Congress, "Water Supply Should not be an Obstacle to Meeting Energy Development Goals," is largely based on the Section 13(a) assessment prepared by the Colorado Department of Natural Resources. Since the later report is reviewed in depth herein, only a limited review is made of the GAO report.

Water Availability. Indeed, the GAO report relies too heavily on the Section 13(a) Report. The uncertainties which surround the prediction in the Section 13(a) Report are not identified in the GAO report. The conclusions are not only carried forward without adequate explanation but also are given with greater emphasis and certainty than in the original report. The report states flatly on its title page:

This report disputes the common impression that the energy industry's thirst for water will create severe shortages throughout the water-short, energy-rich West. Recent evidence indicates that these predictions are unfounded or outdated and that adequate water is available for energy development through at least the year 2000.

The Interior Department in commenting on the report noted correctly that the potential constraints which would affect the predictions were not clearly identified. "We believe these constraints [legal, judicial and administrative, instream flows, Federal reserve rights, physical and economic barriers, etc.] are of significant magnitude to require reference in the digest and conclusions." (GAO, p. 54)

In response to these comments the GAO indicates in the digest (executive summary) that the uncertainties only limit the location of development, not the total quantity of water available.

Uncertainties exist about the extent of energy development, the future of reclamation projects, environmental requirements, reserved water, instream flows, water rights transfers, and project development delays. However, since water requirements are modest and water supplies very large and broadly scattered, excessive water supply problems in one location will result in new site selection. With few exceptions, limited opportunities in one sub-basin will simply open opportunities in another sub-basin. (GAO, p. iii)

However, there is uncertainty regarding the quantity of water available, for example, in the Upper Colorado River Basin. The report notes that for the Upper Colorado River Basin, "The 1979 projections, combined with

conservative flow estimates, indicate there will be sufficient water in the Upper Basin for all consumers in 2000.^u (Emphasis added) (GAO, p. 39) In fact GAO does not use the most conservative estimate. The most conservative estimate of water available to the Upper Basin by WPRS is given in the Appendix (GAO, p. 78) as 5.45 MAF per year. The GAO report, however, uses 5.8 MAF per year. Even then, as noted earlier, the achievement of those average annual flow yields depend on location and capacity of storage, permanent climatological changes, and accuracy of flow estimating methods.

Institutional, Legal and Economic and Social Aspects. The report does identify the legal and institutional complications which have arisen surrounding leasing of federal reservoir water. However, social factors (see discussion of Ruedi Reservoir, Chapter IV herein) are not identified.

In other areas there is only summary treatment of these factors. For example, the GAO elucidates the advantage of coal slurry lines and mentions general opposition has blocked development; however, adequate treatment of the legal, environmental, and social constraints is not given.

Effectiveness for Decision-Making. The GAO report is a summary statement which does not adequately qualify the sources of its data or the assumptions and the uncertainties implicit in its conclusions, thereby forcing the reader and decision-maker to accept at face value the conclusions and recommendations made in the report. The conclusions tend to be over-simplistic and dogmatic--as indicated by the title of the report.

Review of Energy from the West by EPA

"Energy from the West: Policy Analysis Report" is a report produced by the U.S. Environmental Protection Agency concerning the various expected impacts from energy development in the eight state Rocky Mountain area (Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado, Arizona and New Mexico). As its title implies, it is concerned not only with synfuel development but with all forms of energy development in this area.

The analysis and conclusions of the report with respect to water availability are necessarily general and concern regional level impacts. The unique factor, and major strength of this document, is its detailed analysis of alternatives for water supply for energy development. For example, with regard to increasing water availability by implementing more efficient irrigation practices, the report not only summarizes the technical literature concerning the feasibility of various irrigation practices with increased efficiency, but also discusses the significant legal constraints against implementation of more efficient irrigation practices. In discussing various alternatives for increasing water availability for energy development, the report makes prominent note of the role played by the courts in western states and how they have characteristically operated very slowly and generally created piecemeal, localized, and short-term resolutions to problems.

Therefore, the "Energy From the West" report is a valuable adjunct to the reports such as the State of Colorado, Section 13(a) report because of the indepth analysis of alternatives presented in the EPA report.

Review of the Draft Environmental Impact Statement for the Colony Development Project

The draft environmental impact statement for the "Proposed Development of Oil Shale Resource by the Colony Development Operation in Colorado" is a site specific study of water availability for the proposed Colony Shale Oil plant located near Parachute, Colorado. The report discusses the statistical problems with estimating annual stream flows for the Colorado Basin and other data problems. In addition, it summarizes and discusses the various compacts and treaties which affect water availability in the Upper Colorado River Basin (the Colorado River Compact of 1922, the Mexican Water Treaty of 1944 and the Upper Colorado River Basin Compact of 1948). The report also presents available estimates of present depletions of the Colorado River. Some projections for future water use and depletions are presented but not extensively developed.

The major problem with this report as with most site specific studies, is that the data and discussion and conclusions are presented in isolation from

the proposed future development of the entire river basin; i.e., the incremental impacts from development throughout the river basin are not developed for discussion. For example, the estimated 12 cfs depletion from the proposed Colony Development is minuscule when compared to the estimated mean annual Colorado River flow of 3,659 cfs in nearby DeBeque, Colorado. This 12 cfs depletion only represents 0.7 percent of the lowest mean monthly low flow (February). This fact, when presented by itself and without reference to the cumulative impacts of expected future depletions, is somewhat misleading.

Therefore, the report does an adequate job of presenting many of the uncertainties facing water availability in the Upper Colorado Basin for synfuel development, but does not provide an overall picture of water availability in the future due to the accumulative impacts of depletions for synfuel and other development.

OTHER ISSUES IN THE UPPER BASIN

Introduction

Much of what has been discussed earlier has applied to the entire Upper Basin - and has been so noted in the Background Section and the analysis of the Section 13(a) Report. However, certain points concerning the White River Basin which are not covered earlier are discussed below.

The Setting

Additional shale oil development in the Upper Colorado River Basin would occur primarily in the Washakie Basin in Wyoming, Green River Basin in Wyoming and Utah, and the White River Basin in Utah and Colorado (see Figure 5). High Btu coal; gasification projects would occur in the Green River basin in Utah and Wyoming and the San Juan basin in Colorado and New Mexico (see Figure 6). Of these areas, the White River basin represents the area with the most uncertainties with respect to water availability.

The White River Basin in Colorado and Utah

The estimated average annual yield of the White River (1906-1974) is approximately 568,000 acre-feet, 61 percent of which occurs between April and July (DNR Section 13(a) Report, page 7-7). Baseline synthetic fuel development with associated growth, coupled with a middle scenario for non-EET development, would mean estimated depletions of 222,000 acre-feet by 2000. Of this amount, 142,000 acre-feet would be required for EET development and associated growth. The comparison of total annual virgin flow to total depletions is deceiving because sufficient storage is not present to even out the flows. The Section 13(a) Report properly points out that the necessary monthly diversions for even the low scenario/baseline EET development could not be met in August and September in one out of 10 years on the average. Therefore, adequate storage is a critical factor in providing reliable supplies in the White River Basin. Uncertainty surrounding construction of new reservoirs in the White River Basin contributes to general uncertainty of water availability for synfuel development in the White River Basin. Reservoir construction at prime reservoir sites on the White River has been stymied by wilderness designation for the area.

The future legal availability of water on the White River is clouded by the fact there is no compact between Colorado and Utah concerning the White River:

The lack of such a compact will undermine the reliability of private water rights on the White River in Colorado. Other Upper Basin states, Utah in particular, will attempt to claim as much of the White River as possible for delivery to the Lower Basin, and for their own development. Water users on a number of other Colorado River tributaries will attempt to protect their existing and projected water uses against curtailment under the Upper Colorado River Compact by excluding as much of the White River from Colorado's share under the Upper Compact as they can - the allocation of any part of Colorado's Upper Compact share to the White River will correspondingly reduce the amount of water which is legally available on all other Colorado River tributaries in Colorado.

All of the recent studies ignore the inevitable need for a compact apportioning the White River among the Upper Basin states and fail to consider how such a compact might legally constrain the availability of water for oil shale development in Colorado. These studies instead primarily base their conclusions about the

availability of water on the White River on its unapportioned, virgin flows (Musick, p.15).

Institutional factors also contribute to the uncertainty of water availability for synfuel development in the White River Basin. The Section 13(a) reports that the water required for either baseline or accelerated EET development could only be achieved "if there is a highly coordinated scheme of reservoir regulation." Such a scheme would probably require common ownership by a conservancy district or the state. Interstate coordination would be required, and there is no current mechanism to provide that function.

DISCUSSION AND CONCLUSIONS

The attention regarding water availability for synfuel development in the Upper Colorado River Basin is directed primarily to the White River in Colorado and Utah and the Colorado River Basin in Colorado which contain significant oil shale deposits.

Within the White River Basin sufficient supply depends upon the construction and management of new reservoirs. There is considerable uncertainty posed by the existence of wilderness areas at prime reservoir sites and the existence of endangered fish species in the White River. The magnitude of these constraints, as well as the lack of an interstate compact on the White River, is not sufficiently emphasized in the analyses of the Upper Colorado River Basin.

While water can be made available for synfuel development in the White River Basin, there are significant trade-offs. These trade-offs are similar to those in the Upper Colorado in Colorado and include higher water costs for the non-energy sectors and potential reduction in agriculture. Constraints on availability are also similar and include institutional management of reservoirs, allocation of water resources once the Upper Basin is fully developed, and lack of legal and financial mechanisms to institute effective water conservation programs.