

EXECUTIVE SUMMARY

The objective of this study is to describe and analyze the hydrologic, institutional, legal, and economic issues involved in assessing and interpreting estimates of water availability for synfuels development in four major river basins: (1) Upper Mississippi, (2) Ohio/Tennessee, (3) Upper Missouri, and (4) Upper Colorado. In addition, the study evaluates the adequacy of currently used estimates of water availability as a basis for energy planning in these four basins.

To meet the objectives of this study, assessments of water availability for the four basins were reviewed and analyzed. In addition, case studies of water availability for synfuel development in the Upper Colorado and Upper Missouri River Basins were completed. The general conclusions resulting from these analyses and case studies are detailed in the Discussions and Conclusions section herein.

Estimating water availability for synfuel development is a difficult and complex task involving incomplete and inadequate data, unforeseen and unpredictable future judicial decisions and legislation, imperfect demand forecasting methods, and political constraints on the entity responsible for assessing water availability. As a result, considerable variation exists in quality, detail, and scope of water availability assessments.

It is suggested that the primary use of these assessments will be to evaluate the availability of water for initial development of synfuel industries in the respective river basins. "Initial development" refers to that period of approximately 10-12 years in the future during which those synfuel plants which are presently in some stage of planning will be constructed. The considerable uncertainty that exists concerning almost all aspects of forecasting future water availability for synfuel development in, for example, 2000, severely limits the dependability of these forecasts and, consequently, their usefulness.

Therefore, it is suggested that rather than focus on predicting, the objective of water availability assessments should be to acknowledge this uncertainty and play out the consequences of some of the ways that unpredictable political, judicial, and administrative decisions may affect water availability.

WATER AVAILABILITY FOR SYNFUEL DEVELOPMENT

Upper Mississippi River Basin

From a regional perspective water supplies for synfuel development in the Upper Mississippi River Basin are adequate. Localized problems, however, may result depending on the specific site for a synfuel plant. Water supply shortages and negative impacts on water resources are most likely to occur for synfuel sites on tributaries. These shortages and negative impacts can be eliminated or reduced by construction of reservoir storage on tributaries, conjunctive use of ground and surface water or other measures to reduce diversions from unregulated streams during low flow periods.

Ohio/Tennessee River Basin

The water availability situation for synfuel development in the Ohio and Tennessee Basins is comparable to that in the Upper Mississippi. From a regional perspective sufficient water is available for projected present and future synfuel development but localized problems or deficiencies may occur for synfuel plants sited on tributaries. The extent and nature of these deficiencies can only be predicted with site specific studies.

Upper Colorado River Basin

Water is available, and can be made available, in the Upper Colorado River Basin to meet presently proposed and future oil shale development. The question is not whether water is available, but rather what the impacts on agriculture and other sectors will be from allocating this water from its present and potential use to synfuel development. For, example, approximately 150,000 acre-feet of water storage presently exists in two Federal reservoirs on the western slope of Colorado which in part could be made available for synfuel production. Assuming the consumptive use requirements

of a 50,000 bbl/d oil shale plant is approximately 5,700 acre-feet per year, the available stored water in these two Federal reservoirs alone could supply a number of unit-sized synfuel plants, more than the number of synfuel plants presently in some state of planning within Colorado. This available stored water could be more efficiently used and stretched further as a source of synfuel water supply when combined with the existing junior water rights of energy companies. If, however, the projected plants were to rely on water transferred from agricultural use rather than on existing available water in Federal reservoirs, the impact on the agricultural sector would be much more severe.

The case study of the Upper Colorado River Basin in Colorado herein goes into detail concerning the economic, political, institutional, and legal uncertainties which make it difficult to predict the level of future synfuel development in the Upper Colorado River Basin, and the source and amount of water supplied for this projected level of development.

Upper Missouri River Basin

To provide necessary water for projected synfuel energy development in this basin, major new water storage projects will be required because of the significant inter- and intra-year variation of streamflows for all rivers in the basin. Furthermore, the legal, institutional, political and economic issues are of such magnitude in this river basin that they do not allow unqualified conclusion as to availability of water for synfuel development. In the Yellowstone River Basin and the adjacent coal areas, it is not a matter, as in the Upper Colorado River Basin, of merely what the effects of transferring existing water for synfuel development will be, but rather whether this water will be available at all. Major state reservations of water on the mainstem Yellowstone River, Indian reserved rights, and the Yellowstone River Compact all present major uncertainties as to the availability of necessary water for synfuel development in this area. Section V, herein, details the nature and effects of these legal and economic, institutional and political uncertainties.

PHYSICAL AVAILABILITY

Estimates of water availability for synfuel development are based on stream-flow measurements, groundwater data, and other hydrologic data.

Of the many data and information bases required for assessing water availability (e.g., future municipal demand projections, future cooling water requirements for coal fired electric generating stations, etc.), recorded historic streamflows are probably the most accurate and dependable. In the eastern basins, this recorded data base is used more or less directly to assess water availability based on 7-day, 10-year minimum low flows. The use of 7-day, 10-year low flow data for this purpose is desirable since this flow parameter: (1) coincides with many water quality regulations, (2) provides indication of low flow conditions for navigation, and (3) provides a useful estimate of flow in rivers with limited storage. Generally, the 7-day, 10-year minimum low flow estimate is based on original historic data. As flow depletions increase in the future, however, the frequency of the 7-day, 10-year minimum low flow estimate based on historic data will increase; i.e. the low flow associated with the 7-day, 10-year frequency will actually occur more often in the future than the expected 7-day, 10-year frequency would indicate. This bias in the 7-day, 10-year minimum low flow parameter must be understood by decision-makers when considering water availability for synfuel development based on 7-day, 10-year minimum low flow estimates.

In the western basins water availability assessments are based on virgin flow estimates *since* western state water laws and interstate compacts are generally predicated on this concept. Virgin flow estimates are based on recorded streamflow data and estimates of depletions. Significant effort is often made to estimate virgin flows, but the resulting data set may be inaccurate because of poor records of diversions, irrigated acreages, inaccuracies in estimating irrigation consumptive use, lack of records concerning return flows, etc. Therefore, the principal parameter in western basins on which water availability estimates for synfuel is based, mean annual virgin flow, incorporates considerable uncertainty. Furthermore, studies assessing

water availability in western basins for synfuel development tend to treat mean annual virgin flow estimates as deterministic rather than stochastic variables. These studies do not clearly assess the uncertainty and risk (in the statistical sense) that exist in mean annual virgin flow estimates, thereby giving an unwarranted degree of certainty to the data set.

The use of mean annual or mean monthly flow estimates for assessing water availability is acceptable for rivers and tributaries where adequate storage exists to control the river. However, where little or no storage exists, or will exist in the near future, some estimate of low flows is needed. This could be weekly, monthly, or 7-day, 10-year minimum low flow data depending on local hydrologic conditions and data availability. Without this low flow data, decision-makers will have little idea how proposed synfuel water demands will affect instream uses: fish and wildlife habitats, run-of-the-river hydropower generation, recreation, and water quality. Low flow data is especially important to assess the cumulative effect of all present and proposed depletions.

Groundwater quantity and quality are inadequate in all of the basin analyses and assessments reviewed. Some reports more or less ignore this potential water supply source for energy development because of insufficient quantitative data. Individual energy companies may have adequate groundwater data to assist in a specific siting decision, but this data may be unobtainable or do not exist on a regional scale for governmental decision-makers or entities concerned with state or regional water resources management. Use of groundwater for supplying synfuel development could, in some instances, reduce streamflow depletions, especially during low flow periods. Planned conjunctive use of ground and surface waters could result in more efficient use of surface water resources; i.e., more synfuel plants could be sited within the basin with less impact on the water resource if conjunctive use is employed. However, because adequate groundwater data are not generally available to regional or state decision-makers, this opportunity may be lost.

ECONOMIC FACTORS

Within limits, cost data may not be very important to energy companies for selecting water supplies for synfuel development since cost of water is generally minor with respect to total capital and operating costs for a proposed synfuel development. Cost of water, however, is one determiner of the nature and extent of trade-offs that will occur as a result of water for synfuel development and, therefore, may be a very important parameter to governmental decision-makers or entities concerned with state and regional water resources management.

The cost data presented in most assessments of water availability for synfuel development are generally inadequate. There are several reasons for this inadequacy. First, dependable cost data are difficult to collect. No central collection of, for example, reservoir construction cost data exists and it must be collected from a number of individual sources. Second, cost data are site or project specific and generalization is often risky and inaccurate. Third, developing or obtaining comparable cost data may be impossible. For example, obtaining data on selling prices of irrigation water rights often results in a set of individual prices for widely different commodities. One selling price may be for a senior irrigation right or another may be for a junior right requiring construction of storage. Several examples of the variation are presented in the Upper Colorado River Basin section herein.

LEGAL, INSTITUTIONAL, AND POLITICAL FACTORS

Perhaps the most difficult requirement in assessing water availability for synfuel development is estimating the effects of legal, institutional, and political factors on future water availability. Future judicial decisions, compact interpretations, implementation of certain compact provisions, administrative decisions on marketing Federal reservoir storage, resolution of Federal and Indian reserved rights, reservation of water by states, and uncertainties in riparian law can all have a profound effect on water availability for future synfuel development. Estimating the quantitative effects of these possibilities in a water availability assessment and communicating

these effects to decision-makers is a large task. This task is complicated by the fact that not only must the possible effects be indicated and analyzed but also some effort must be made to indicate the likelihood of occurrence.

In general, the reports and assessments reviewed herein contain highly variable analyses of the quantitative effects of future legal, institutional, and political constraints. These analyses are discussed further in Sections II through V herein.

Political, legal, and institutional factors affecting water availability are generally less numerous and less complex in the eastern basins than in the western basins. Complex local situations may exist but, in general, the political, legal, and institutional factors affecting water availability for synfuel development are less involved in eastern basins. The probable reasons for this are: (1) less competition for water in the eastern basins, (2) the relative simplicity of riparian water law for surface water, and (3) the general lack of, or relatively simple, groundwater regulatory law in the eastern states. As a result, forecasts of future water availability for synfuel development in the eastern United States may be somewhat less involved because of the reduced complexity of political, legal, and institutional factors.

The relative simplicity of riparian water law and riparian based groundwater law can, however, result in significant uncertainty concerning future water availability because of lack of protection given users against upstream diversions or pumping adjacent to their lands. In contrast, however, water law in western states can be a barrier to implementation of water supply alternatives. For example, western state water law is an obstacle to implementation of measures to increase irrigation efficiency since the Appropriation Doctrine does not generally allow users to retain a right to salvaged water.

Uncertainty resulting from legal, institutional, judicial, and political factors causes energy companies to be conservative in their water supply planning and require redundant supplies in order to be assured of adequate future water supply. The delays and uncertainties inherent in acquiring water rights, obtaining reservoir storage or otherwise initially securing water supplies also tend to cause energy companies to obtain redundant water supplies. This redundancy may extend until a firm supply is assured, or the additional water rights might be retained for future development.

WATER SUPPLY ALTERNATIVES

For all basins studied, the principal source of water supply considered in water availability analyses for synfuel development were: (1) direct diversion from rivers, (2) reservoir storage, or (3) acquisition of agricultural water rights. However, numerous other potential sources exist including: (1) development of groundwater, (2) conjunctive use of ground and surface water, (3) weather modification, (4) improvements in efficiency in agricultural and municipal use, (and subsequent use of water "saved" by synfuel industry), (4) change to more water efficient processes in synfuel production, and (5) watershed management to increase discharge. But in actual practice, significant legal, political, and economic forces oppose the implementation of these alternatives. In general, alternatives for synfuel water supply, other than the usual reservoir storage and direct diversion, are detailed in synfuel water assessment studies and reports with some limited discussion, without analysis of the legal, political, economic and institutional constraints which limit their consideration and practical implementation. Specific alternatives and problems with their implementation are discussed in Sections IV and V herein.

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The objective of this study has been to: (1) describe and analyze the hydrologic, institutional, economic, and legal issues involved in forecasting water availability for synfuel development and (2) evaluate the adequacy of currently used estimates of water availability for synfuel development. Based on this analysis and investigation, it is important to

develop some possible recommendations for improving the future assessments of water availability for synfuel and energy development.

Because of the significant uncertainty which exists for forecasting future water availability beyond a 10-12 year period in the future, it is suggested that the primary use of synfuel water availability assessments should be to evaluate the availability of water for expected development of a synfuel industry in the next 10-12 years. Furthermore, it is suggested that rather than focusing on predicting water availability, the objective of the synfuel water availability assessment should be to acknowledge the significant uncertainties that exist and play out the consequences of some of the ways that generally unpredictable political, judicial, and administrative decisions may affect water availability.

It is likely that the present controversy and uncertainty concerning water availability for synfuel development will continue in the future. Doing additional studies in order to get "better" or more refined estimates of water availability for synfuel development will probably not significantly reduce the controversy surrounding water availability. The reason for this is that many assumptions must be made in aggregating data into forms useful to decision-makers and in forecasting future demand and supply. These assumptions cannot all be explicitly detailed, communicated to decision-makers and properly used by decision-makers in their own analyses. As a result of the general uncertainties surrounding these assumptions, there will always be potential for controversy over water availability.

This is not to say that "improved" analyses of water availability cannot be made: they can and should be completed. Improved water availability assessments for synfuel "development as well as other sectors (municipal, industrial, and agricultural), can probably not be done by devoting increased resources to improving the studies themselves. Rather, improvement of these assessments is contingent on improving water resources planning in general in the United States. The results of the inadequate water resources planning system existing in most areas of the United States today is

continuously evident in the water availability forecasts analyzed herein. Without general improvement in the existing water resources planning system, data discontinuities at state boundaries will continue, incremental studies will ignore cumulative effects of depletions, local or site specific studies will ignore downstream or basin impacts, and analyses of water availability for synfuel development (or many other purposes) will continue to be a one-time effort with no one responsible for a continuous update or modification. These deficiencies cannot be cured by concentrating additional resources on the reports or assessments -- the system itself must be improved.