THE IMPACT OF AN ACCELERATED COAL-BASED SYNFUELS PROGRAM ON WESTERN WATER RESOURCES

HEARING

BEFORE THE

SUBCOMMITTEE ON ECONOMIC GROWTH AND STABILIZATION

OF THE

JOINT ECONOMIC COMMITTEE CONGRESS OF THE UNITED STATES

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WEDNESDAY, NOVEMBER 14, 1979

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON ECONOMIC GROWTH AND
STABILIZATION OF THE JOINT ECONOMIC COMMITTEE,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:10 a.m., in room 457, Russell Senate Office Building, Hon. George McGovern (member of the subcommittee) presiding.

Present: Senator McGovern.

Also present: Philip B. McMartin, professional staff member; Jim McIntire, research assistant; Mark R. Borchelt, administrative assistant; Katie MacArthur, press assistant; and Stephen J. Entin, minority professional staff member.

OPENING STATEMENT OF SENATOR MCGOVERN, PRESIDING

Senator MCGOVERN. The subcommittee will come to order. As we all know, the Senate has recently endorsed a major synthetic fuels program. This proposal places very heavy emphasis on the rapid development of coal and oil shale to develop synthetic fuels.

It also includes an alcohol fuels section, a major portion of which was drafted in the Senate Agriculture Committee and then incorporated with the synthetic fuels bill on the Senate floor.

I had a major part in the drafting of that legislation in the Agriculture Committee, and I was pleased that the Senate supported that title of the bill.

However, while I for one voted with some degree of hesitation for the final version of the synthetics bill after it had been scaled down considerably from the administration's original request, I did so with considerable apprehension about the impact of that program, if we go ahead on it, on water resources in the northern Great Plains. And that's the focus of our consideration this morning: The demands which an accelerated synfuels program is likely to place on very substantial water resources in the northern Great Plains.

I think the central issue on which I would like the witnesses to focus is this: Will the synfuel program system that we are now promoting create conflict with other uses of water in the northern Great Plains?

Anyone who is familiar with that part of the country knows that water is not in overabundance in some of those States. If the synthetic

fuel process is going to consume enormous amounts of water, and every indication is that it will, what public policies will be necessary to mitigate and eliminate any conflicts between the water requirements of the synthetic fuel process and the water needs of ranchers and farmers, municipalities, industrial plants, and other users—recreational uses, fish and wildlife, and so on?

Studies by both the Department of Energy and the Missouri River Basin Commission indicate that without new water storage projects and without interbasin transfers of water, a major synthetic fuels program would create a potential for conflicts over the uses of the region's supplies of surface water.

I think it's fair to point out that little recognition was given to the environmental acceptability of these water projects.

Additionally, both of these studies—those by the Department of Energy and the Missouri River Basin Commission—were prepared prior to the development of surface water preservation programs by some States; programs which may further limit the available water for energy development.

Just to take my State as an example, the water supply picture in South Dakota is critical. Several of the towns in the southwestern part of the State depend almost entirely on underground supplies of water for their municipal needs. Some have plans to use these water supplies as a heat source for schools and other public buildings.

There is reason to believe that the underground water in the Madison formation in the southwestern part of our State is one of the larger geothermal sources of energy. Although South Dakota has very little coal and does not expect to host many synfuels plants, our ground water supplies could be threatened by nearby energy development in Wyoming, which seems to be a prime candidaate for the location of synthetic fuels plants.

But the Department of Energy has yet to specify how much of the planned synthetic fuel development will depend on the use of these vital ground water resources.

In any event, these are serious issues, and I am pleased to see that we have a fine panel of witnesses this morning to comment on them.

Just for the sake of conserving time and to make the hearing as productive as possible, I am going to ask that the witnesses appear in two groups.

The first will be composed of Hon. Ruth Clusen, Assistant Secretary for Environment of the Department of Energy, and Hon. Guy Martin, who is the Assistant Secretary for Land and Water Resources at the Department of the Interior.

If you folks will come up together now, I will ask each of you to make a brief oral statement of about 10 minutes, and then any prepared statement you have that goes beyond 10 minutes we will, without objection, insert in the record, thus allowing some time for questions.

Is Mr. Martin also here? [No response.]

Well, we'll go ahead, then, with you Ms. Clusen. Then when Mr. Martin comes, we will take him in turn.

STATEMENT OF RUTH C. CLUSEN, ASSISTANT SECRETARY FOR ENVIRONMENT, DEPARTMENT OF ENERGY, WASHINGTON, D.C.

Ms. CLUSEN. Thank you, Senator. I would like to submit my prepared statement for the record.

Senator MCGOVERN. Fine. We would be glad to have that, Ms. Clusen. It will be made part of the record.

Ms. CLUSEN. In the next 10 minutes, I would like to focus on some of the findings of our study as they relate to the questions which you have posed to us in advance, and in your opening statement this morning.

I think we all know and understand that the development of a large synthetic fuels industry will necessitate some rather substantial quantities of water to support it, primarily for cooling purposes and also as a transportation medium, perhaps in coal slurry pipelines.

Last summer, my office undertook this preliminary look at the environmental and regulatory situation as regards synthetic fuels production and, in the course of it, we addressed a number of potential environmental impacts from synthetic fuel development, of which water availability was a major part.

Basically, our study was a conservative one in that we looked at the worst cases. In addition to that, it was done on a regional basis. So, throughout this, in replying to questions, you will find us saying that we agree that more site-specific studies need to be done since the area we are talking about today varies so greatly according to both the technology used and the resources as regards water development which are present.

But our study basically concluded that for the first generation technologies, we were looking at surface oil shale retorting, indirect coal liquefaction, and biomass conversion. For these things, there appeared to be sufficient siting opportunities for a 1-million-barrel-per-day level of production nationwide.

All through this we continued to say that higher levels of production may experience rapidly increasing siting difficulties from a number of causes.

Senator MCGOVERN. Ms. Clusen, you talk about 1-million-barrels-a day capacity there. How big a geographic area are we talking about? What part? What is the scope of your study?

Ms. CLUSEN. Our study was nationwide.

Senator MCGOVERN. Nationwide. But where is the main focus of these plants? Where in your judgment are they likely to be located?

Ms. CLUSEN. Of course, the site will in the end not be chosen by DOE, but the primary focus was in seven States, in the course of our analysis—primary opportunities.

Senator MCGOVERN. Are those largely in the Great Plains section?

Ms. CLUSEN. A good proportion of it. In the course of this, we also concluded that the implementation would require resolution of a number of water-related institutional constraints, including water rights, permit delays, and State and community acceptance.

The conclusions provided by this assessment in the northern Great Plains are primarily an outgrowth of the assessment of the Upper

Missouri River Basin, which was done by the Mississippi River Basin Commission on water availability assessment.

In addition to that, the latest study and its origins, which come out of section 13 of the Nonnuclear Energy Act of 1974, DOE requested the Water Resources Council to undertake this kind of energy-related water resource assessment, and there have been two major assessments completed as draft reports, and we have been using these as the basis of our analysis.

I emphasize that these are regional, not site-specific, studies; that they have been directed and managed by State or regional entities who are actively in water planning, because they feel the need to maximize the use of local knowledge.

The results, however, of both of these two water basin regional assessments show that water can be made physically available with minimal impacts. But the studies recognize that institutional issues related to water planning and management again cause physically available water to become unavailable for specific projects in the specific places.

We think more detailed studies are needed, undertaken by the States and the river basin commissions, in order to see how affected regions would develop in management and planning.

We are currently developing a study with the Water Resources Council for a more detailed analysis of, for instance, the Upper Colorado Basin, and we will request the Water Resources Council to perform independent assessments of the water-related impacts of specific energy plants, as is our mandate.

It appears, when one looks at the upper Missouri assessment, that the energy development scenarios under consideration for the northern Great Plains can be accommodated to the year 2000 without a major impact on other water uses, provided that certain institutional issues regarding management do not create conflicts.

Let me say first that when our assessment was done, the level of energy development that was assumed in both our study and the upper Missouri assessment appears considerably higher than the kind of the scenario we are now talking about by virtue of the congressional action which has taken place.

Recent studies have shown that in many instances, water requirements can be reduced substantially, however, up to as much as 50 percent or more, through the use of dry cooling in combination with wet cooling, and by increased water reuse through recycling. And we intend to pursue studies which offer a potential for those particular changes.

The Upper Missouri study examined two types of water management: Taking water directly from the nearest available source, and the use of aqueducts or canals for interbasin transfers. We recognize that the first alternative involved some conflicts with previously committed water and that the second alternative—transporting water from more distant sources—involves some conflicts of committed water, but also some problems of acceptance.

The principal conclusion that can be drawn from this assessment is that physically, water is available for a level of development higher than the current congressional or administration proposals, but dis-

tribution within the region to some of the site-specific places will cause some problems and raise some issues.

We looked briefly at the impacts on water quality due to mining, conversion, population increases, and other kinds of development, and found them to be in an acceptable range.

One of the major water quality problems in the northern Great Plains region is the large sediment loading due to natural erosion. Energy-induced increases in total suspended solids are generally expected to be only a few percent.

When we turn to institutional issues, most of the water assigned to increased energy development by the Missouri assessment was anticipated to be drawn from Federal Bureau of Reclamation reservoirs. And we looked at the industrial allocations, for instance in the two Yellowstone Basin reservoirs, and in other developments in this part of the country. However, no 1978 transfers were made for industrial allocations by the Bureau of Reclamation because of the slower than anticipated development of coal gasification facilities and because of uncertainty over the Bureau's right to market water from existing reservoirs for industrial purposes.

As we go along, we believe that the preparation of environmental impact statements will clear the way for resolution of some of the remaining questions surrounding the use of Federal water for industrial purposes.

This does not mean that the Federal Government can allocate water projects at will. States still have the power to deny requests for unappropriated water projects. We recognize this.

When we turned to the question of interbasin transfers, we know that attitudes toward this and institutional requirements range from approval to strong opposition.

We know, as an example of a major institutional constraint, if water is transported via aqueducts outside the Yellowstone Basin, the Yellowstone River compact requires unanimous consent of its three signatories.

We recognize that one of the major present uncertainties in assessing the adequacy of the western region's water resources is the fact that the amounts of Indian and Federal reserved water rights have not yet been established and that this may turn out to be significant.

We looked at instream flow reservations for the protection of ecological values and for aesthetic and recreational uses, which are increasingly being recognized as an environmental necessity, as they should be.

The Missouri Basin assessment addressed this issue and concluded that for preferred water management approaches, that the effects on instream flow would be minimal.

We think it is necessary to look at the potential for improvement in irrigation efficiency and to point out that conservation of water by all the users is certainly one key to assuring that there are ample resources for all beneficial uses.

We know that ground water is an alternative, but we think it's premature to predict the availability of ground water for energy development without additional study.

Basically, the studies completed to date indicate that surface water supplies in the northern Great Plains are physically sufficient to support energy development without adversely affecting the non-energy-users. But we recognize that a number of institutional issues relating to allocation and management must temper this conclusion.

The States retain final control over the use of their waters and can often exercise veto rights.

We believe that current Federal laws as well as the President's announced policy of preserving the rights of States to manage and allocate their water supplies, will assure that the energy development will not outstrip water supplies and have an adverse impact.

We believe that the results of the studies which we have done, and those of the Water Resources Council, indicate the greater attention that must be paid by both the Federal Government and States to coordinating energy policy and water policy at both the national and local level, and that the linking together of these two concerns can do much to resolve the institutional uncertainties regarding water and energy.

Senator McGOVERN. Thank you very much, Ms. Clusen.

[The prepared statement of Ms. Clusen follows:]

PREPARED STATEMENT OF RUTH C. CLUSEN

Senator, I appreciate the opportunity to appear before the Subcommittee on Economic Growth and Stabilization on behalf of the Department of Energy to discuss the impact of coal-based synthetic fuel development on water resources in the Northern Great Plains.

As you know, the President, in his July 15, 1979, energy address to the Nation, set a limit to the amount of oil this country will import at the level of 1977. He also set the further goal of cutting our dependence on foreign oil by 50 percent by 1990—a reduction to over 4.5 million barrels per day of imported oil. To help meet his 1990 import reduction goal, the President proposed the development of 2.5 million barrels per day of oil substitutes from coal liquids and gases, oil shale, biomass, and unconventional gas. Of this 2.5 million level, the plan proposes between 1.0 and 1.5 million barrels per day in 1990 be from coal-derived liquids and gases. Production facilities would be distributed throughout all coal regions in the country, East, Mid-West and West.

Mr. Chairman, as you know, the Department of Energy plays an integral part in water management through two basic activities: (1) the hydropower licensing, rate review and allocation, water resources studies of the Federal Energy Regulatory Commission (FERC); and (2) responsibility for the five Federal power marketing administrations.

Further, the Federal Government plays significant roles in the management of the Nation's water resources. These roles range from pollution control programs, through navigation and flood control programs, to grant programs to States for water management and planning to States. The Federal Government also exercises many other authorities and programs. These Federal programs and authorities, however, require State participation to be meaningful. As the President recently stated in connection with his Energy Mobilization Board initiative, the states must allocate (with the exception of federal and Indian water rights) their water resources in the manner best suited to themselves. In this context the Department of Energy is interested in ensuring only that the development and deployment of energy technologies will not produce adverse environmental effects and will be consistent with sound, comprehensive River Basin and Regional Planning and Management of Water and Related Land Resources.

To this end, the Department has undertaken or funded studies on the environmental impacts of synthetic fuels and on the regional water availability impacts of energy development in the West, which I will discuss later in my statement. These studies have generally supported the President's decision to develop coal-derived substitutes for imported oil.

WATER AND ENERGY

The Development of a large synthetic fuels industry will necessitate substantial quantities of water to support it. Water is required in the production of synthetic fuels from coal. This is primarily for cooling purposes (at least 40 percent of total production facility requirements), but water is also used for production of hydrogen in the coal conversion process itself, as well as in support of mining, reclamation, dust control, and flue gas desulfurization (if utilized). Another use of water that has been discussed frequently over the past several years is as a transportation medium in coal slurry pipelines. Thus, the interplay between reliable sources of water, environmental controls, and energy development becomes a critical factor in this country's ability to meet its future energy needs.

This is not meant to imply that water availability is the only environmental issue related to synfuel development. A number of other environmental, public welfare and socioeconomic concerns could prove critical depending upon the specific technology and location under consideration.

DOE SYNTHETIC FUELS REPORT

My Office undertook a preliminary environmental and regulatory analysis of synthetic liquid fuels production. This study, titled "Environmenal Analysis of Synthetic Liquid Fuels," was published on July 12, 1979.

The study addressed a number of potential environmental impact areas from synthetic fuel development, including air quality, water quality, water availability, health effects, and socioeconomic issues. It concluded that first generation technologies—surface oil shale retorting, indirect coal liquefaction, and biomass conversion—appear to have sufficient siting opportunities to deploy a 1 million barrel per day level of production nationwide, but that higher levels of production may experience rapidly increasing siting difficulties from a variety of causes. The study also concluded that implementation of any major synfuels program would require resolution of a number of water-related institutional constraints, including water rights, permit delays, and state and community acceptance.

The conclusions provided by this assessment with respect to water availability for coal liquefaction plants in the Northern Great Plains are primarily an outgrowth of a draft assessment of the Upper Missouri River Basin undertaken by the Missouri River Basin Commission titled, "Water Availability Assessment for Coal Technology Requirements," dated January 1979. There have also been a number of previous studies on this topic including the report of Northern Great Plains Resources Program and various studies by private, state and Federal agencies.

I would now like to address this latest study and its origins briefly. Section 13 of the Federal Non-Nuclear Energy R&D Act of 1974 called for the Energy Research & Development Administration (ERDA)—now Department of Energy (DOE)—to request the Water Resources Council (WRC) to undertake energy-related water resource assessments. Two major regional assessments have thus far been completed as draft reports. One is the study I just mentioned, concerning the Upper Missouri, which is the major river basin of the Northern Great Plains. The other is a companion water resource assessment of impacts of coal and oil shale development in the Upper Colorado River Basin, prepared by the State of Colorado Department of Natural Resources.

These assessments are regional—not site-specific—studies to determine whether there are potential overriding constraints on energy development due to physical availability of water, water quality, environmental impacts, and institutional or water management issues. They have been directed and managed by state or regional entities active in water planning so as to maximize use of local knowledge of competing potential uses, as well as information on the institutional and physical environment related to water availability to the year 2000. This approach should identify issues which need to be factored into national and regional planning for energy development and water resource management. The results of both of these water basin regional assessments show that water can be made physically available, with minimal impacts, for projected high levels of future energy growth in these Western regions without adversely impacting non-energy uses of water. Nevertheless, the studies recognize that institutional issues—related primarily to water planning and management can cause physically available water to be unavailable for specific projects.

More detailed studies of water management, undertaken by the States and by River Basin Commissions, may be necessary to allow affected regions to develop effective water management plans consistent with all user demands. I believe that DOE can constructively cooperate with studies of this type. For example, we are currently developing a cooperative study with the Water Resources Council for a more detailed analysis of the Upper Colorado Basin that would further examine impoundment and adequate alternatives. Finally, pursuant to Sections 13(b) and (c) of the Federal Non-nuclear Energy Research & Development Act, the Department of Energy will request the Water Resources Council to perform independent assessments of the water-related impacts of these specific energy plants.

UPPER MISSOURI BASIN ASSESSMENT OF WATER AVAILABILITY

As for the results of the Upper Missouri Assessment, it appears that the energy development scenarios under consideration for the Northern Great Plains region can be accommodated to the year 2000 without any major impact on other water uses, provided that certain institutional issues regarding water resource management do not create conflicts. I will discuss some of these institutional issues later.

Let me first say that the level of energy development that was assumed in the Upper Missouri Assessment appears considerably higher than any proposed development being made today, including the President's July proposals which would entail the building of a (1.5 million barrels per day of capacity)[1] nationwide. For the year 2000, the Upper Missouri Assessment scenario projected a combination of high BTU coal gasification and coal liquefaction capacity totaling the equivalent of 1.7 million barrels per day (or perhaps 35 plants) for the Northern Great Plains alonge, using an aggregate of approximately 275,000 acre-feet of water per year.

These water use projections of the Upper Missouri Assessment average out to approximately 8,000 acre-feet/year per 50,000 barrels per day plant equivalent. Recent studies[2] have shown that in many instances plant water requirements can be reduced substantially—up to 50 percent or more. This can be done primarily through maximizing the use of dry cooling in combination with wet cooling, and by increased water reuse through recycling with necessary treatment performed before the recycling. It has been estimated that the increased cost of applying all of these water-conserving techniques is no more than 5 percent of the total facility cost.

The Upper Missouri study examined two alternative types of water management, (a) taking water directly from the nearest available source and (b) use of aqueducts or canals for inter-basin transfers from more appropriate, but more distant, sources. The first alternative, involving water from the nearest available source, was found to involve some conflicts with previously committee water as identified in the Yellowstone Level B study, which was formulated by the Missouri River Basin Commission to identify options for use of the basin's water resources to meet regional and national needs. The latter alternative, transporting water from more distant sources, involved minimum conflicts of committed water including no apparent conflicts with existing or anticipated future agriculture uses. The principal conclusion that can be drawn from this assessment is that physcally, and in the aggregate, water is available for a level of development higher than current Administration or Congressional proposals, but distribution of the water will be necessary within the region to some specific coal-rich subregions that have locally inadequate water accessibility.

WATER QUALITY ISSUES

The impacts on water quality due to mining, conversion, population increases, and associated non-energy industrial development are expected to be acceptable. One of the major water quality problems in the Northern Great Plains region is the large sediment loading due to natural erosion. Energy-induced increases in total suspended solids are generally expected to be only a few percent of accepted standards. It is also expected that individual plants will approach the

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[1] Assumes a facility size of 50,000 barrel per day replacement of crude oil.

[2] Probstein and Gold, Water in Synthetic Fuel Production, MIT Press, 1978. Probestein. "Water for a Synthetic Fuels Industry" Technology Review 81 (August/September 1979) : pp. 3743.

goal of zero pollutant release to streams, for all pollutants. Therefore, while proper disposal of process solid concentrates must be assured, discharge of effluents directly to water courses will not be a problem.

INSTITUTIONAL ISSUES

Water from Federal reservoirs

Most of the water assigned to increased energy development by the Missouri assessment was anticipated to be drawn from Federal Bureau of Reclamation reservoirs. To satisfy anticipated water requirements for energy in the West, water was made available by the Bureau of Reclamation in several Federal reservoirs near large coal or oil shale deposits. The total industrial allocation of two Yellowstone basin reservoirs, Yellowtail and Boysen, is over 800,000 acre-feet/year, or three times the water requirements estimated by the Upper Missouri Assessment as necessary to support the high synfuel development scenario. However, no 1978 deliveries were made for industrial allocations by the Bureau of Reclamation because of the slower than anticipated development of coal gasification facilities, (none are yet operating) and because of uncertainty over the Bureau of Reclamation's right to market water from existing Federal reservoirs for industrial purposes. The recent decision of Ninth Circuit Court of Appeals in EDF v. Andrus (596 F2d 848) should help to resolve some of this uncertainty. The court affirmed a decision of the Federal District Court of Montana (420 F. Supp. 1037) which held that the Secretary of the Interior had the authority to provide Federally impounded water for industrial use as long as the sale does not impair the efficiency of the impoundment project for irrigation purposes.

The Ninth Circuit also established both programmatic and site-specific environmental impact statement requirements with respect to the establishment of an industrial water marketing program. Preparation of these environmental impact statements will clear the way for resolution of the remaining questions surrounding the use of Federal waters for industrial purposes. This does not mean that the Federal Government can allocate project waters at will; states still have the power ot deny requests for unappropriate project waters. For example, the Bureau proposed to sell to Montana Power Company 4,000 acre-feet of water from Yellowtail Reservoir, but because the State recommended denial of Montana Power Company's request, the sale was not completed. Instead the power company must construct its own private reservoir to assure a reliable water supply.

Interbasin transfers

Once water is obtained from a reservoir, it may have to be transported some distance to the facility site, in some cases crossing from one basin to another. Attitudes toward and institutional requirements for interbasin transfers, however, range from approval to strong opposition. As an example of a major institutional constraint, if water is transported via aqueducts outside the Yellowstone basin, the Yellowstone River Compact requires unanimous consent of its three signatories—Wyoming, Montana, and North Dakota.

Indian and Federal reserved water rights

One of the major present uncertainties in assessing the adequacy of Western region's water resources for energy is the fact that the amounts of Indian and Federal reserved water rights have not been established. These rights may in some areas be significant because of the large quantities of water which flow through public and Indian lands in the region.

Instream flow reservations

Instream flow requirements for protection of ecological values and for aesthetic and recreational uses are increasingly being recognized as an environmental necessity. Some States have recognized the need to reserve water for these purposes.

The Missouri Basin Assessment addressed this issue and concluded that for preferred water management approaches (use of aqueducts or canals for interbasin transport from more substantial, rather than nearest, sources) effects on instream flow would be minimal. The only changes in aquatic habitat would occur in some stream reaches of the Bighorn River.

The State of Montana has recently reserved substantial amounts of water for the preservation of instream flows in the Yellowstone Basin. This reservation will almost certainly place a further limit on the quantity of water available for energy development. Additional study to assess the impact of this new constraint on all water uses in the region, as well as development of mitigation methods for the adverse impacts of reduced instream flow, is required.

Irrigation efficiency improvements

I have already discussed the potential for mimimizing water use by the energy technologies, but conservation of water by all users is certainly one key to assuring ample water resources for all beneficial uses.

The Federal Interagency Task Force on Irrigation Efficiencies recently concluded that improvement of irrigation water management in the United States, at a cost of up to $5 billion over the next 30 years, could result in from 2 to 5 million more acre-feet being made available for other uses. The Task Force recommended that the States should initiate and maintain a cooperative program with Federal, State, local and private participation to bring about improvement in irrigation water use and management.

Ground water

Before concluding, I would like to briefly address the issue of ground water use for energy development. Both the Upper Missouri and Upper Colorado Assessments focused primarily on using "uncommitted" surface water supplies without requiring development of ground water supplies. Ground water is however an alternative means of water for increased western energy production that was cited in both reports.

In general, it is premature to predict the availability of ground water for energy development. Additional information on the geologic and hydrologic characteristics of this aquifer are required before adequate predictions can be made concerning the expected yield or economics of water withdrawal from the aquifer. In addition, based upon the existing studies of surface water physical availability, the use of substantial ground water may never be required.

Existing information does, however, indicate a wide variability in the overall basin that would affect the usefulness of the certain aquifers for particular locations on energy plants. For example, the Madison aquifer is comprised of several discrete basins formed by past tectonic and faulting activity; the degree to which these basins are interconnected or separated by the faulting system is not fully known so that overall effects on the aquifer of pumping in one basin are not yet known. The depth to deep ground water varies considerably between basins and within basins; in some places a 4,000 foot well could reach the aquifer; in others a 20,000 foot well might be needed. The quality of the ground water also varies considerably from a minimum of 300 to 2,000 milligrams per liter to perhaps 120,000 to 350,000 milligrams per liter.

CONCLUSIONS

In conclusion, the studies which have been completed to date indicate that surface water supplies in the Northern Great Plains are physically sufficient to support energy development in the Northern Plains area without adversely affecting non-energy users. However, a number of institutional issues related to water allocation and management temper this conclusion.

The States retain final control over the use of their own waters, and can often exercise veto rights on the uses of other States through interstate compacts. I believe that current Federal laws, as well as the President's announced policy of preserving the rights of States to manage and allocate their water supplies according to their own needs, (with certain stated exceptions) will ensure that energy development will not outstrip available water supplies and adversely impact other vital uses.

I believe also that the results of these and other studies indicate that greater attention must be paid by both the Federal Government and the States to integrating and coordinating energy policy and water policy, at both the national and local levels. The linking together of these two critical concerns will do much to resolve the remaining institutional uncertainties regarding water and energy.

Mr. Chairman, this concludes my statement and I will be happy to respond to any questions.

Senator McGOVERN. Before I direct any questions to you, Mr. Martin, I think we can go ahead with your testimony.

Mr. Martin is the Assistant Secretary for Land and Water Resources of the Department of the Interior. We are going to ask you, Mr. Martin, if you can, to hold your oral statement to about 10 minutes and then we will insert your full prepared statement in the record.

STATEMENT OF GUY R. MARTIN, ASSISTANT SECRETARY FOR LAND AND WATER RESOURCES, DEPARTMENT OF THE INTERIOR, WASHINGTON, D.C.

Mr. MARTIN. I will be glad to summarize, Senator, and I apologize for being late. We apparently got the wrong hearing room and spent some time in the other building.

Senator McGOVERN. It's all right. We are just getting underway.

Mr. MARTIN. Let me start by noting how important I think these hearings are and paying a word of compliment to this subcommittee. Even though there has been much talk about water and energy and the relationship of these new energy development programs, and particularly synfuels, to water development and to the availability of water in the West, so far as I know, this is the first hearing that anybody has had the foresight to call to actually begin looking at the facts.

The truth is that there has been a good deal of work done on it, but in spite of the concern about it, this is the first hearing. I would like to thank you because it has the effect not only of putting it on the record, but focusing some of our work as well. This is valuable by itself, and we appreciate it.

Senator McGOVERN. Thank you very much, Mr. Martin. I have lived out in the West all my life, and I have studied the history of that area; and I know that for 100 years or more, the bitterest fights in that part of the country have been over water, over who was going to control it.

We are in a real dilemma right now, in our own State, about what to do with the water in the Missouri River Reservoir. You actually paralyze the whole State in terms of any intelligent water development policy because we can't make up our minds what we want to do with the water that is backed up in those enormous reservoirs. There is a long history of battling, as you know, over water rights and control of water.

And what I see coming, if we don't think this thing through now, is an enormous battle somewhere down the pike between the ranchers and the farmers and the municipalities and the environmentalists and the fish and wildlife people and the recreationists, on the one hand, and the synthetic fuels plants on the other.

I am no expert in this field, but I have read that to carry out a major synthetic fuels program is going to consume enormous quantities of water. And the question is: Where does the water come from? Is there enough of it? Or does it require new management policies? Does it require new transfer capabilities? What are the implications of

committing this country to a major program of developing synthetic fuels virtually on a crash basis, in terms of other claims that are going to be made on those water resources?

Of course, if the water is limitless, and we can't foresee the day when there will ever be a shortage for any reason, why, then, this hearing is pointless. But if it is just possible that the alternative needs for water in that part of the country are just as legitimate for other purposes as they are for the development of synthetic fuels, then we had better begin thinking how we are going to resolve those dilemmas before they're on top of us.

So I wish you would just speak as frankly as possible about what you see as the issues that are developing here—if there are issues—and how you think we ought to address them.

Mr. MARTIN. Thank you, Senator, for that. I think you are going to hear a tone in my testimony, which I will summarize very briefly, that you are asking the right questions. I think you are asking them at a time when, at least in this geographic area, we still have the capability and the water supplies to respond in an intelligent way before the problem becomes acute.

There are other areas of the country, particularly the Southwest, where the situation, even without coal-based synthetic fuel development, is going to be substantially worse, substantially earlier. As I go through this you will get a feeling for some of the differences between various areas and for some of the things we have been doing, and can do, to address the problems.

Let me start by just giving you a very quick summary of some of the things that are going on now.

And I am appearing here today, as you know, both as the Chairman of the Water Resources Council and as the Secretary's alternate representative of the Department of the Interior, and I want to talk about what each of those two very important entities is doing.

Among the work the WRC is doing is the following:

First, the second national assessment is out. I have entered that in the record in my prepared statement. It's a truly excellent national summary which goes to a fairly high level of detail about regional and national water problems, and deals specifically with the kind of water and energy tradeoffs that you are discussing today. One of the things it deals with is competing water usage.

A second thing that the Water Resources Council has done very recently is to update and, we think, upgrade the so-called principles and standards. Those are the rules by which Federal projects whether they be for agriculture, irrigation, or for energy development or for a combination of uses, are planned. The President made a major point of this in his water policy.

We have invested about a year and a half in upgrading the principles and standards, and writing a manual which makes uniform the way in which each of the Federal construction agencies deals with them so that, insofar as possible, taxpayers, Members of Congress, and others can have some confidence that each of the agencies is responding to them in a similar way.

Third, the Water Resources Council is responsible for the coordination of regional planning. That is the work that is done primarily by

the river basin commissions. Later today, you are going to be hearing from Wayne Hall, who is the Federal Chairman of the Missouri River Basin Commission. I have read his testimony and I won't tread on his material. I think Mr. Hall will have some very interesting facts and specifics about their regional work.

I might point out to you that the Water Resources Council oversees the same kind of regional work everywhere, but it does it particularly well for the States which have a river basin commission.

As you know, there are no river basin commissions either in the Southwest or in the Far West, and that is their own choice, but to some extent it impairs regional planning and we think there are some benefits to having it done through a commission.

Finally, theWRC, under the Federal Non-Nuclear Energy Research and Develompent Act, does a series of unified Federal assessments of water use for certain energy technologies.

Basically, the Council contracts with the Department of Energy to look at the water implications of a series of energy initiatives. There is ongoing work in that regard, and that also will be talked about by Mr. Hall, because a center of that work is the Missouri River Basin Commission, where we have invested, say, substantial time and expertise.

Turning to the Department, let me give you an idea of how we have been involved in the problems you are interested in.

First, we have done a series of water resource studies that relate to the Missouri River Basin. My prepared statement summarizes 13 of those studies. A quick glance at them will tell you that they are largely on target with the kinds of concerns that you have.

They go right to the heart of the water/energy tradeoffs and the kind of planning that we need to do to solve those problems.

I also point out that we are now charged, particularly under the Federal Land Policy and Management Act, with carrying out all of our programs in such a way that there is a balanced, multiple-use approach.

The program which is most representative of that, and important to you today, is the coal leasing program which we have recently put in effect. I only mention it because when we talk about the energy/water tradeoff, one of the key elements may not be the simple availability of water, but the fact that we do sensible, balanced planning in terms of where we allow and sponsor coal development to occur. Because of the very wise provisions of FLPMA, combined with the kind of coal leasing program we put together, there is some insurance, that might not have been there a couple of years ago, that we will have coal development take place in areas that simply make sense.

The coal leasing program, while it is controversial in some respects, has very, very high marks from the States, particularly the Western States, where Federal coal occurs. The Governors are very favorable toward it, and I think that is because it is a program sensitive to their local requirements.

My prepared statement also summarizes the specific figures you asked for with regard to water requirements for synthetic fuels, Senator. I think that the Department of Energy is basically the expert in that, but I have given those to the subcommittee for their use.

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Let me talk about a few specific problems, to wind up here, that I think and hope will be useful to you after discussing those tools and the ongoing work.

First, the issue of water availability and marketing is key. I understand you know this issue in detail. The Bureau of Reclamation, now the Water and Power Resources Service, has worked with the corps for years to deal with the Missouri, both the main stream and tributaries, and that resulted some years ago in a memorandum of understanding that dealt with the marketing of the waters from the Missouri River.

That memorandum of undertanding is now under review, but I think the numbers that relate to that memorandum of understanding and the water marketing from the Missouri are very significant here. Basically, what the Bureau and the corps agreed was that 1 million acre-feet of water stored in the six main stem reservoirs on the Missouri could be made available for interim industrial use.

That represented a finding by the corps and the Bureau that there was a period of 50 years during which firm water, stored water, would be available for industrial use without impacting any planned agricultural or irrigation use.

The resolve, at that time, was to try to find uses which were beneficial to industrial development and not injurious to agricultural use and were acceptable to the States, and to get that water into the hands of people who were looking to develop industrial energy supplies.

That experiment—the so-called water marketing program and the memorandum of understanding that accompanied it—have had only limited success. There are actually only 36,000 acre-feet of that 1 million that have actually been set aside and have been approved for site-specific uses. There are 19,000 acre-feet for the Basin Electric Plant near Beulah, N. Dak., and another 17,000 acre-feet for the ANG coal gasification company in the same area.

Montana, as you know, has a contract for 300,000 acre-feet. We offer these contracts to States as a bloc of water that they could market themselves as a way of safeguarding the State's prerogatives. Only Montana immediately took us up on that, and has now the right to market that bloc, and I believe they hold it until 1983.

The only other State that took us up, as you know, is South Dakota. It was taken up by the executive branch in that State, but their assumption of that water is now pending legislative approval. In the past, that has not been forthcoming. I am told by some people that there is a slightly greater chance now that the South Dakota Legislature will approve it. They would then gain control of a bloc of that 1 million acre-feet.

As you know, that 1 million acre-feet is only a small part of the Upper Missouri annual flow, which we report here as 21 million acre-feet at Sioux City. That is a figure that contemplates the dowstream instream needs, as well as the virgin flows of the river.

I point out in my prepared statement that even if that entire 1 million acre-feet which is available for 50 years was used, it would mean a loss of only about 5.4 percent of hydropower at the main stem reservoirs; but, granting those figures, we believe generally that there

would be a tremendous multiplier if the water were used for coal gasification rather than for hydroelectric generation.

To summarize, we are looking at continuing that water marketing agreement now. We have made no final decision on it. We are concerned that after having instituted it, many of the States are reluctant or disinterested in taking up what we thought to be a rather useful offer for them to market this water as they saw fit and to safeguard their own prerogatives.

In addition to the main stem reservoirs, we have the Yellowtail and Boysen reservoirs on the Bighorn and Wind Rivers in Wyoming and Montana. They also provide sources of additional water. The main stem reservoirs and the last two that I mentioned, Boysen and Yellowtail, they practically comprise the total of water available.

I note also, as Secretary Clusen did, that there is a limitation in the compact with regard to movement of that water. I know that is going to be discussed by Mr. Hall.

Now we are preparing to do an impact statement, a programmatic impact statement, before we proceed further with water marketing. We are required to do that by court, and that impact statement itself will give us a lot of the information we need to think through some of the problems you're raising in your hearing today.

So I guess, in summary, I want to report to you that this is an issue that we have looked at fairly closely and feel reasonably comfortable, along with the corps, that the 1 million acre-feet, at least in terms of water supplies, specifically is an amount that is available and, so far, unused for industrial development.

Let me turn just briefly, Senator, to the questions that you asked me and try to give you at least summary answers regarding the Upper Missouri.

First, you asked how much we have done, how closely we need to look at this issue, and who should be in charge of looking at it.

We believe that the basin itself, on a regional basis, has been studied fairly well. I can't guarantee you that every problem and every permutation has been studied, but this is a basin that has been subjected to considerable analysis.

Where we are now, as a general matter, is that we have identified an amount of water that's probably available for several decades for industrial development, not at the expense of present agricultural or even future planned agricultural development.

What is essential now is to move toward a more site-specific approach. What is missing here, even in the face of the President's synfuel proposal, is a series of site-specific development proposals to give some form to the general program of energy development that we believe will occur there in the future.

It's only by looking at site-specific problems in the "first wave" that we are going to be able to identify further problems. We in the Federal Government should begin to set ourselves up, whether it's Congress or the administration, to begin to focus more and more on site-specific development scenarios.

Your second question relates to whether or not an accelerated coal-based synfuel program, such as that being considered by Congress, threatens the future growth and development of the agricultural econ-

omies and municipalities of the northern Great Plains; and you ask whether our present institutional structures are adequate.

I think the best general answer I can give you to that is that we do not see that water availability as a specific problem, as an isolated problem, is the limiting constraint on coal-based synfuel development in the northern Great Plains.

As I say, that 1 million acre-feet is available for 50 years and, as you know, there are also 3 million acre-feet of firm water available in the Missouri basin that could be made available later.

What we have done, basically, is to take only a fourth of that, or 1 million, and committed it to possible industrial development. The 3 million acre-feet acts as a buffer on that which we haven't even proposed touching.

The questions are larger than water supply. The real questions are issues of land use planning, of community impact, of transportation, of all of the things that go with the development of these large projects, and not solely water.

Third, you ask how much new management storage and interbasin and transfer programs are necessary to accommodate this program.

Let me say, again, that we believe that there's a sufficient quantity of stored water presently available now. To move from that to a general representation that we need a large number of additional storage facilities or regulation facilities is not a judgment that we could make at this time. That will depend on the site-specific developments as they occur. We see that the volumes are now available to continue development, at least at an initial level, for 10 or more years without new storage facilities.

We do believe that we are going to have to do some very careful planning as to how we use those stored volumes we now have, and I think that's the challenge.

Finally, you asked what are the implications of Montana's water reservation program; what are the threats of this development. We think its' very difficult, as a general matter, to tell you how serious those conflicts are going to be until we look at site-specific proposals for development.

We do believe that the water is there. The challenge will probably be to decide how to site those facilities so that we minimize the need for lengthy and expensive conveyance facilities from the existing storage units or how to site and how to plan those facilities so that, where we can avoid it, we don't incur the huge public expense of new regulation facilities and new storage facilities where it's unnecessary.

It's extremely important, also, that we begin to orient this region, as well as the rest of the country, to a conservation of water effort, particularly in the case of the new industrial M. & I. uses. As we begin to feel a pinch, which we feel may be years away, we should be at least ethically and, hopefully, institutionally prepared to cope with it by conservation as well as new facilities.

Senator, that's basically our summary of the situation. We are pleased to be here and answer your questions.

Senator McGovern. Thank you, Mr. Martin.

[The prepared statement of Mr. Martin, together with attachments, follows:]

PREPARED STATEMENT OF GUY R. MARTIN

Senator, I appreciate the opportunity to testify before the Subcommittee on Economic Growth and Stabilization on the important subject of coal-based synfuel development and water resources in the Northern Great Plains States. I appear today on behalf of both the Water Resources Council which I chair as alternate to Secretary Andrus, and the Department of the Interior.

Both the Water Resources Council and the Department of the Interior are deeply involved in the development of our Nation's energy and water resources systems. Working in concert with other Federal agencies, as well as State and local interests, the Council and Department have contributed greatly to the development, management, and conservation of our Nation's water and energy resources. Those resources are essential to human needs, food and fiber production, industry, extraction and conversion of energy resources, and other multipurpose activities.

I would like to begin my testimony today, Senator, by summarizing the current activities of the Council and Department in the water for energy field.

WATER RESOURCES COUNCIL

Since its creation in 1965, the Council has been involved in many activities and programs aimed at developing the Federal policies and assessments for water and energy development. The Council has responsibility for analyses of the adequacy of water supplies in reference to present and expected future uses. A summary of several of its more important activities follows.

National water assessment

The Council recently published its Second National Water Assessment covering the existing and future situation of ground and surface water supplies and uses on a national and regional basis. (A copy is attached for the record.) The report indicated several concerns that need attention, including:

The systematic coordination of water resources quantity and quality planning and management, based on economic, social, and environmental considerations, and involving local, State, Federal and non-governmental interests.

The evaluation of competing and increasing water uses, particularly in regard to energy production.

An improved system for recognition and resolution of local water supply problems that may occur despite sufficiency of supply on a basin-wide basis, such as in the Upper Missouri River Basin of the Northern Great Plains States.

Principles and standards for planning

The Council has the responsibility for development of Principles and Standards (P&S) for planning and evaluating water and related land resources plans and projects. These provide the basic procedures and criteria for project formulation and decision. Federal water projects which generate hydroelectric power or provide supplies for energy development are formulated under these rules. Improvements in the P&S have been developed in response to the President's Water Policy of June 1978, resulting in the preparation of a manual for the analysis of the benefits and costs associated with Federal projects. All member agencies of the Council will rely on that manual for project evaluation, assuring uniform and consistent appraisal methods for all projects, including those where issues of energy and other uses are involved.

Comprehensive planning

The coordination of comprehensive river basin planning is another major responsibility of the Council. Under the direction of the Council and within the statutory program responsibilities of the member agencies, the workloads, staffing, and budgets for the various water resources plans are developed. State participation is obtained through the six river basin commissions or the Federal-State inter-agency regional committees. The Water Management Plan for the Yellowstone River Basin and Adjacent Coal Areas, recently completed by the Missouri River Basin Commission, is an example of comprehensive river basin planning under the direction of the Council. Improvement of the Federal-State relationship in water planning is a major theme of the President's water policy, and work on improving regional plans themselves is a major current effort of the WRC.

Section 13, Nonnuclear Act

The Council conducts a water for energy assessment program under provisions of Section 13 of the Federal Nonnuclear Energy Research and Develop-

ment Act of 1974. Section 13 provides for unified Federal assessments of water use for certain energy technologies, demonstration projects and commercial scale energy facilities. Specifically, the Council has been studying water use for coal conversion technologies in the Missouri River Basin (Great Plains area). Technical phases have been completed by the Missouri River Basin Commission with major participation by key Upper Missouri River Basin States (North Dakota, South Dakota, Montana, Nebraska, Wyoming). Further details regarding this report will be provided by Chairman Wayne Hall of the Missouri Basin Commission in his testimony which follows my remarks.

DEPARTMENT OF THE INTERIOR

In response to the increased emphasis by the Water Resources Council on energy related development in the Northern Great Plains, the Department of Interior has recently prepared detailed information, inventories, and conducted several assessments of the area's resource base. Included among these efforts are:

Basin surveys

A significant number of water resources studies concerning potential energy development in the Missouri River Basin have been completed. A list of 13 of the most recent studies, with a brief description of each, is attached as a part of this statement. These studies and surveys describe water problem areas relative to energy development and include a very general description of the energy resource base. In addition to these studies substantial data is included in the Main Stem Missouri River Environmental Impact Statement and will be included in the forthcoming environmental impact statement (EIS) regarding the effects of marketing water from Yellowtail and Boysen Reservoirs on the Wind-Bighorn Rivers in Wyoming and Montana.

Minerals and land management

The Department of the Interior has management responsibilities over extensive areas of mineral deposits in the West. The Department controls planning, permitting, and leasing of Federal lands, and is charged with the regulation of all activities on these lands. While many authorities support this activity, the most important is the Federal Land Policy and Management Act, which is predicated on sound, balanced multiple-use principles. The Bureau of Land Management under its general resource management program and its coal leasing program utilizes the assistance of the Geological Survey and the Bureau of Reclamation to collect and analyze data relative to soils, overburden, geology, and certain aspects of water and revegetation for the Western United States. These programs will lead to formulation of lease stipulations for reclamation of mined lands in areas for future leasing of Federal minerals. Other Interior agencies including the Office of Surface Mining Reclamation and Enforcement, Bureau of Mines, Fish and Wildlife Service, Bureau of Indian Affairs, and Heritage Conservation and Recreation Service have major rules related to energy minerals development and land management.

The Department will continue to have a major role in the planning and regulation of energy resource development, particularly coal and water resources, in the Northern Great Plains States, and it is likely this role will help to insure a balance of uses where competition over scarce resources grows.

Water requirements for synthetic fuels

Mr. Chairman, in your letter convening this hearing, you requested information on the water requirements of commercial scale coal conversion facilities. Estimates currently being used by various Federal agencies for a unit size that would produce 50,000 barrels a day of synfuels range from about 5,000 to over 15,000 acre-feet of water per year, depending on the type of technology used and other criteria; in particular the water cooling requirements associated with the coal liquefaction process.

In addition to the direct uses of water within the conversion facility, there are other water demands which will accompany coal technology development. They include:

Coal extraction and processing (including land reclamation where strip mining occurs). Typical water use for coal extraction, processing, and land reclamation will be about 1,000 acre-feet annually for each commercial facility;

Electric power generation (i.e., a 1,000 mw coal fired generating plant requires about 15,000 acre-feet of water annually);

Potential development of ancilliary industries (e.g., petrochemicals); and

Population growth (municipal water supplies, water oriented recreation). Annual water requirement of about 1,000 acre-feet can be expected to serve a population influx of about 4,000 people at each commercial facility.

Therefore, a commercial size coal liquefaction facility (50,000 barrels/day) will consume from about 5,000 to 15,000 acre-feet of water to process 7 to 10 million tons of coal annually (depending on type of coal and conversion process). In strip mine areas (most coal in the Northern Great Plains will be strip mined), an area of about 100 to 200 acres may be disturbed annually for production of this volume of coal, depending on the thickness of the coal seams. In addition, there would be a wide range of other impacts which are difficult to state specifically except on a case by case basis.

The national goal is for the replacement of 2.5 million barrels of imported crude oil daily by 1995 through synthetic fuels production and associated technologies. Conversion of coal to liquid petroleum would be a major element of this objective and the Northern Great Plains coal resources will very likely play a significant role in achieving this goal.

Water availability and management

A Memorandum of Understanding (MOU) between the Departments of Interior and Army identifying the respective responsibilities in regard to water marketing from the six Federal mainstem Missouri River reservoirs was signed in 1975. This MOU was later expanded to include the Department of Enregy. The MOU specifies the Federal administrative procedures for handling requests for water for energy related industrial development in the Upper Missouri River Basin. The Bureau of Reclamation and the Corps of Engineers have agreed that 1 million acre-feet of water stored in the six mainstem reservoirs on the Missouri River could be made available for interim industrial use in the Missouri River Basin. This water was intended for future irrigation uses but considered surplus to that use for a period of 50 years.

Only 36,000 acre-feet of the 1.0 million acre-feet set aside for the water marketing program have been approved for site-specific industrial uses including 19,000 acre-feet for the Basin Electric Power Co-op's steam-electric generating facility near Beulah, North Dakota, and 17,000 acre-feet for the ANG Coal Gasification Company in the same area. The State of Montana has a contract that reserves 300,000 acre-feet of water per year for sub-contracting to industrial users. A similar contract proposed for the State of South Dakota, for 300,000 acre-feet of water per year, is pending before the State Legislature.

The 1 million acre-feet of water considered here comprises only a small part of the average annual flow of the Upper Missouri River (21 million acre-feet per year) at Sioux City, Iowa. Moreover, the instream environmental impacts associated with its use are not anticipated to be a major problem. We believe that if problems are encountered, they can minimized by slight modification of existing reservoir operations.

Diverting the 1 million acre-feet of water for industrial purposes would result in a loss of about 5.4 percent of hydroelectric power generation at the mainstem reservoirs; however, the water used for steam-electric generation and coal gasification would produce about 800 and 3,600 times more energy, respectively, than that amount of falling water would produce for hydroelectric power.

Interior is currently reviewing the water marketing program (WMP) that was initiated in 1975. Several actions regarding the program are being assessed, including: (1) future contractural relations with the Missouri River Basin States; (2) extention of the MOU; and (3) inclusion of the basin Indian tribes in the program. We expect to have our review completed and final decisions made in the near future.

In addition to the industrial water available in the six Missouri River reservoirs, the Yellowtail and Boysen Reservoirs on the Bighorn and Wind Rivers in Wyoming and Montana provide potential sources of additional industrial water. These reservoirs represent the major portion of stored water available for energy related development in this area outside of the Missouri River Reservoirs amounting to a useable supply of about 862,000 acre-feet annually. The effective use of this water is restricted to some extent by the Yellowstone River Basin Compact. Provisions of the compact will be discussed by Chairman Hall in his testimony.

Pursuant to the July 30, 1979 *Environmental Defense Fund, et al.* v. *Andrus, et al*, 9th Circuit Court Decision, Interior is required to prepare a programmatic environmental statement before proceeding further with the water marketing program in that area. It is highly likely that air quality and other socioeconomic factors will limit the use of the stored water in the basin to a quantity that is

considerably smaller than that available for industrial use. However, no final decisions will be reached until we complete the EIS.

The Department of the Interior has studied and will continue to study and carefully consider the environmental impacts of coal development in the Northern Great Plains. Regional coal environmental statements have been prepared for the eastern and northern Powder River Basins and a coal study made for west-central North Dakota by the Bureau of Land Management and the Geological Survey. Twelve site-specific environmental statements for individual mines have been filed. Each of these analyzes not only the mining and use of coal and water, but also the impacts on population, air and water quality, and the potential for reclamation of mined lands.

Mr. Chairman, with the foregoing remarks as a preamble, I will now address the questions that were posed in your invitation.

Question 1. How closely have Federal and State governments examined the availability of water for coal-based synfuel development in the Northern Great Plains? How closely do we need to look before proceeding with a synfuel program? Who should do the looking?

Answer. Federal, State, and other organizations have been studying the utilization of the coal resources of the Northern Great Plains for nearly a decade. We believe that those studies now justify proceeding with site specific studies for an initial level of development. That initial development should occur over the next 10 years and should be geared to a level that would utilize up to 200,000 to 250,000 acre-feet of available water. Recognizing, however, that the 1.2 million barrel/day program proposed by the President would consume this amount of water nationwide and not in an area limited to the Northern Great Plains. We believe that these site specific studies should be undertaken expeditiously and coordinated with the States by the Missouri River Basin Commission. Interior is now in a good position to take the lead in site specific studies.

At the same time basin-wide studies should continue, aimed at defining ultimate levels of development permitted by available water supplies. The Water Resources Council is in a good position to coordinate those continuing overall studies.

Question 2. Would an accelerated coal-based synfuel program such as that presently being considered by Congress threaten, in any fashion, the future growth and development of the agricultural economies and municipalities of the Northern Great Plains? Are present Federal and State laws and policies sufficient to safeguard present and projected non-energy uses of the region's water resources?

Answer. As shown on the attached chart, we do not believe water availability as a specific concern will be the limiting constraint on coal development in the Northern Great Plains. There are at least 1 million acre-feet of water available for the next 50 years in existing Federal reservoirs. In addition there are about 3 million acre-feet of uncommitted flows in the Missouri River that could be made available for industrial development. Utilization or development of those water supplies would not interfere with meeting forseeable agricultural and other water needs. The larger questions, of course, is the wide range of costs and impacts of developing this water and the energy associated with it.

Question 3. How much water management, i.e., water storage and interbasin transfer programs, would be necessary to accommodate a coal-based synfuels development program such as that being considered by Congress? How much water management would be environmentally tolerable?

Answer. Mr. Chairman, the scale of the program authorized by Congress is not yet known. We do know the range of programs you are considering, and we can project to some extent what the next few years of development might be. Based on that, we believe that there is a sufficient quantity of stored water presently available in the Northern Great Plains to carry out the level of synfuels development now being considered by Congress.

We, therefore, do not believe that additional storage facilities are necessary. Also, we believe that interbasin transfer of water is not necessary in the foreseeable future. Although there are physical, economic, and environmental constraints in conveying the water to some of the key coal areas, they are problems that can be overcome in the present system.

Question 4. What policy alternatives exist for mitigating any potential conflicts between coal-based synfuel development and non-energy uses of water in the Northern Great Plains? For example, what are the implications of Montana's water reservation program for non-energy water use in the Yellowstone

River Basin? Does it effectively foreclose synfuel development in the State of Montana? Does it threaten the water resources of other, downstream States? Would such a program be beneficial for other States to undertake? Or, from another angle, could more water-efficient technologies be used for synfuels production, thereby permitting energy development to be more compatible with the region's water resources? What incentives might be created to encourage the use of such technologies?

Answer. For utilization of up to 1 million acre-feet over the next 50 years we believe that, while conflicts in use could occur on a case by case basis, these can be resolved because of the general availability of water supplies. Inter-State conpacts, and non-energy water uses were considered in the determination to market the 1 million acre-feet of water for industrial purposes. We do not anticipate any severe supply constraints up to this general level. If supply constraints were to develop, however, there are a number of possible approaches to use. An extremely important approach is water conservation.

Encouragement of water conservation through more efficient systems is a policy of the President and central to his policy. The Department of Interior is now requiring in water service contracts that water users develop acceptable water conservation plans. Presently, the incentives to do so consist of the savings in water charges that would result from reduced usage. Other possible measures to encourage conservation are use of periodic rate review provisions in contracts, joint use of storage and delivery facilities, cost incentives, the flexibility to convert to utilization of lower quality water supplies.

In summary, Senator, there appears to be ample water available in the Missouri River Basin for development up to certain levels of coal-based synfuel and other methods of energy development. The major problem is the location of the water sources in relation to the coal supplies on a case by case and the need for further development of the synfuels scenario. Water availability is not the only constraint. There are other very important environmental and socio-economic considerations.

We believe that overall studies of the Basin should continue under the leadership of a broad policy organization, such as the Water Resources Council. Those studies would define the long term water requirements, water supplies, and constraints associated with full development of energy resources in the Basin. In addition, we believe site specific efforts should also continue to specifically define water needs and other impacts associated with proposed energy development projects. While we are on the one hand indicating that there appears, in this region, a sufficient supply of water to allow energy expansion, we will continue to be extremely attentive not only to the many non-water related impacts, but also to the issues of water itself to insure that our present projections are correct.

We would like to close by commending the committee for this inquiry, and for raising these important issues at such an appropriate and early time.

Attachments:

ATTACHMENT 1

List of Completed and Ongoing Studies for Energy Resource Development Impacts on Water Resources in the Upper Missouri River Basin

REFERENCES CITED (COMPLETED STUDIES)

"Report on Water for Energy in the Northern Great Plains Area with Emphasis on the Yellowstone River Basin" Prepared by the Department of the Interior, Water for Energy Management Team (Kenneth O. Kauffman, Chairman). January 1975.

Synopsis.—Conversion of coal to synthetic fuels or electrical energy is intrinsically linked to water supplies. This analysis was prepared as a guideline for determining future policy on energy water issues.

"Effects of Coal Development in the Northern Great Plains." Prepared through the cooperative effort of Federal, State, regional, local, and private organizations under the direction of the Northern Great Plains Resource Program (NGPRP), (Roysten C. Hughes, DOI Assistant Secretary/Program Manager). April 1, 1975.

Synopsis.—The report is a summary of information assembled by the seven work groups of the NGPRP and includes discussions issues involving coal development, land restoration, and water supply and water rights on Federal, Indian, State, and privately owned land.

"Water Work Group Report." Prepared by Water Work Group of the NCPRP (Land Agency—Bureau of Reclamation—Chairman, Phil O. Gibbs). December 1974.

Synopsis.—The task was to determine the potential of water in the development of coal in the region and the effects such development would have on the water and the related resources of the region.

"Possible Development of Water from Madison Group and Associated Rock in Powder River Basin, Montaina–Wyoming." Prepared by Frank A. Swenson for NGPRP. July 1, 1974.

Synopsis.—Large quantities of groundwater have been derived from wells in the Madison Group and Associates Rock since 1917 and a potential is believed to exist for developing large ground-water supplies for industrial use in the Powder River Basin of Wyoming and Montana. The water is considered moderate-to-good quality suitable for use in industrial purposes such as coal fired powerplants and coalgasification; but only marginal-to-satisfactory for irrigation or other specialized uses.

"Shallow Ground Water in Selected Areas in the Fort Union Coal Region (USGS Open-file Report No. 74–371)." Prepared by Ground-Water Subgroup, NGPRP. (Coordination Agency—U.S. Geological Survey). 1974.

Synopsis.—The purpose of this report is to describe the occurrence of shallow in the Fort Union coal region, to provide preliminary answers to questions regarding the impact of subsurface mining on the aquifers, and to recommend additional necessary studies. (Support information to Water Work Group report, December 1974).

"North Central Power Study—Report of Phase I, Volumes I and II." Prepared under the Direction of Coordinating Committee, North Central Power Study composed of 19 investor owned utilities, six cooperatives, two public power districts, one Federal agency, and eight municipal representatives (Study Manager, William F. Graham and James H. Bradly, Bureau of Reclamation). October 1971.

Synopsis.—Future electric and other energy needs can be melded between available water resources and the abundant available coal resources of the region.

"Main Stem Reservoir Regulation Studies, Series 1–74." Prepared by the Corps of Engineers, U.S. Army, Office of the Division Engineer, Missouri River Basin Division, Omaha, Nebraska. April 1974.

Synopsis.—Long-range regulation studies were updated to include contemplated coal development in Montana and North Dakota in a range from "no coal development" to "maximum coal development" resulting in an annual mainstream depletion of 3 million acre-feet. Results indicate that adequate water is available to serve needs for coal development and water anticipated maximum projected needs beyond the year 2020.

"Westwide Report on Critical Water Problems Facing the Eleven Western States." Prepared by the Bureau of Reclamation in accordance with legislation under P.L. 90–537 in cooperation with other Federal, State, local, and private organizations. April 1975.

Synopsis.—Western water supplies are a key to the development of large reserves of coal, oil shale, hydroelectric power, and other means to meet the energy demand by the year 2000. In the West, energy and water share an unique interdependence.

"Western Dakota Basins—Appraisal Investigations." Prepared by the Bureau of Reclamation. 1976.

Synopsis.—Study included comprehensive framework studies which contained a review of future needs of the area as much as half a million acre-feet of industrial water for coal-related industries, municipal water supplies, and related industrial development. Studies reveiled that available supplies were inadequate to meet all demands. The study was terminated pending a State study of priority of demand.

REFERENCES CITED (EXISTING PROGRAMS)

"Total Water Management Study, Missouri River Upstream of Gavins Point Dam." Prepared by the Bureau of Reclamation. Completion date 1981.

Synopsis.—The investigation will identify present water uses, water rights, alternative uses, local requirements, and where available water supplies can be made available on supplies of water to meet the needs for development of coal supplies.

"Eastern Montana Basins—Appraisal Investigations." Prepared by the Bureau of Reclamation. 1979.

Synopsis.—Project proposals studied in addition to other project purposes were the use of water supplies for development of vast coal supplies in the area

of study. Report scheduled for distribution December 1979.

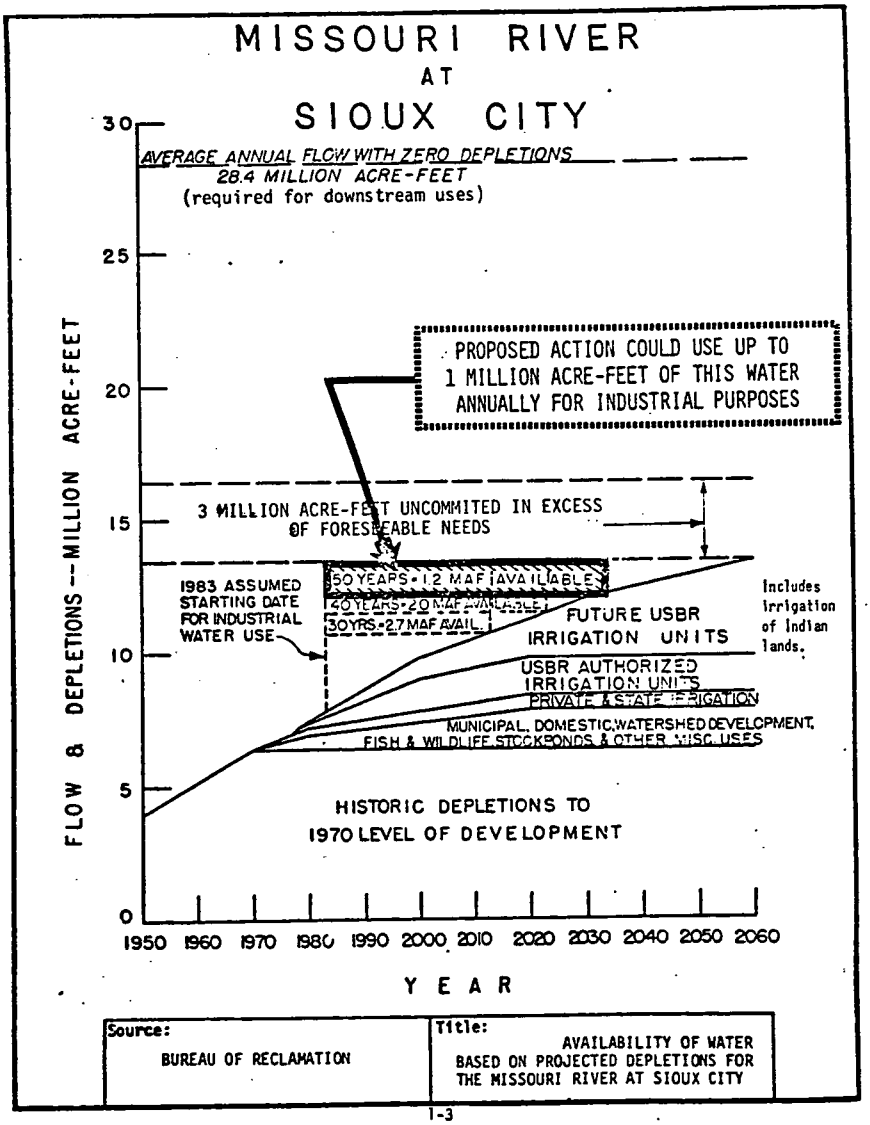
"Water for Energy-Missouri River Reservoirs. Final Environment Impact Statement." Prepared by the Bureau of Reclamation of December 1, 1977.

Synopsis.—The Bureau of Reclamation proposed to make available for energy related industrial purposes up to 1.0 million acre-feet annually from main-stem Missouri River Reservoirs. Hydropower losses are insignificant (5.4%) with the water producing 800 and 3600 times more power for steam generation and coal gasification respectively than for hydropower.

"Potential Industrial Water Service from Yellowtail Unit, Montana-Wyoming and Boysen Unit, Wyoming, Missouri River Basin Program." Prepared by the Bureau of Reclamation. Public hearings are pending for initiation of required environmental statements. 1979.

Synopsis.—Reclamation has water supplies available for industrial use in the two subject reservoirs. Preliminary figures shows approximately 800,000 acre-feet available.

ATTACHMENT 2



Senator McGovern. First of all, Mr. Martin, just underscoring the point you make, I certainly don't want to leave the impression here today that by looking at the water aspects of synthetic fuel development we are unaware of some of the other problems.

We have got a major transportation crisis confronting us in that part of the country right now that worries me as much as any issue on the horizon. Our major railroads are going into bankruptcy, and if we don't find some way to deal with that crisis, a lot of these other developments are going to be impossible. It even jeopardizes the whole future of our agricultural export program in that part of the country.

There is no question in my mind that the collapse of the Rock Island and the Milwaukee railroads is infinitely more serious in terms of the economy of this country than whether we have Chryslers or not. You can always get by on General Motors and Ford and some of these other companies. If we have to, we can get by without a Chrysler.

But if you look at the railroads in that part of the country, we are in very serious problems. It's going to involve an awful lot more money than trying to bail out Chrysler. Apparently, a couple of billion dollars may take care of Chrysler, but we're talking about $15 to $20 billion in terms of saving the railroads beyond what they are presently capable of generating out of their own resources.

I am very well aware that water is just one part of the problem when we're looking at the energy needs of the country. But I do think it's important that we look at that aspect of it.

There does seem to be a discrepancy, Mr. Martin, between the findings of your Department and the findings of the Department of Energy and the Missouri River Basin Commission. As I understand it, you are saying, in effect, that a sufficient amount of water for an accelerated coal-based synfuels program is there; that there is no real need that you see for additional water storage facilities, no real need for interbasin transfers of water.

Whereas, if I read the statement correctly of the Department of Energy and the Missouri River Basin Commission studies, while they agree that enough water exists, they point to real difficulties of getting it to the right place and at the right time. And they say that's going to require very substantial changes in water management policies.

I am just wondering, what is your explanation of the apparent contradiction between those various Government agencies?

Mr. Martin. Well, first of all, I am not fully in agreement with your characterization of my statement of our position. I think our position, Senator, is that we believe that an adequate volume of stored water now exists. All of the regional studies of this area indicate that, at least quantitywise and to some extent in terms of location, the water is there, at least for some decades into the future.

The problem with drawing any further conclusion about specific need for interbasin transfers, new regulation facilities on, let's say, the Yellowstone system or others, is that it's impossible to draw any conclusion until we have a new and more specific idea of what this accelerated synfuels program will mean in terms of site specific developments.

You can look at the volume and, by comparing the volume and the likely base of construction, see that the water is there. I just don't see

that the differences are that great. It may be that the DOE is willing to say earlier than I am that it is a foregone conclusion that we need large-scale interbasin transfers, a large number of new storage facilities, and a series of other physical solutions. They are willing to say that earlier than we are.

I think that we have a much larger chance, given the amount of stored water we have and given the fact that a lot of that water will not be used under any scenario for agricultural purposes for many years, to utilize that water through sound planning and by good siting decisions than apparently they do. I guess that's a statement of confidence in our capability to plan rather than simply solve the problems with new construction.

Senator McGOVERN. Well, let's talk a little bit about those siting decisions.

And, Ms. Clusen, this is a matter that occurred to me listening to your testimony.

The Department has assured us that water is physically available, but what planning is being done to avoid the location of those plants in areas where it would appear you're going to have a significant conflict of competing uses of water? In other words, where is the decision-making process in the Government that tries to avoid the location of a plant that would seem to set up a conflict for water uses?

You specifically stated that it's premature to predict the availability of ground water for energy development and the physical amount of surface water may rule out even the need to use ground water. But, unfortunately, companies are already trying to site energy facilities which would draw down considerable ground water, and those ground water supplies are already being used for municipal and agricultural needs.

It seems to me the Department would be registering concern over the probable conflict of uses, and I am just wondering how the Department can continue to say that a substantial use of ground water may never be required so that that's something we don't have to be too concerned about.

Maybe I am being unfair to the Department's position, but I don't see the evidence that you're really looking at what seems to me to be a very serious conflict of use over these ground water supplies.

Ms. CLUSEN. I assure you, Senator, that we do indeed take this seriously and are deeply involved in looking at the next steps. In the first place, as you know, the Department will not in and of itself be making any siting decisions, since the development of the industry is primarily in the hands of private developers with the exception of the pilot demonstration plants which will, of course, be done by the Department.

Nevertheless, we do feel a responsibility for looking exactly at the kinds of questions which you raise. To some extent, the ongoing processes which exist, like the requirements of the National Environmental Policy Act for an environmental impact statement which must address these questions in the proposed sites as they are picked up, will draw attention to this.

In addition to that, we are engaged at the present time in contracting again with the Water Resources Council for further assessments

with greater specificity. We are also currently involved in a new generation of the environmental analysis of synthetic liquid fuels, which I have submitted for the record earlier, which is a closer, more refined look.

But it will never be within our prerogative to say that some sites are fully appropriate and others aren't, because, for the most part, this is not within the mandate of the Department of Energy. And in addition to that, a great deal of it is in the hands of either interstate compact groups or State and local municipalities. So, in a sense, we can do the investigations, offer advice, and perhaps be a good example ourselves in our siting of pilot and demonstration plants.

Senator McGovern. Well, on that point, Ms. Clusen, since the type of coal and labor and mining and transportation costs that would be associated with synfuel production all seem to be most favorable in the northern Great Plains, if you leave these judgments up to private companies, which I understand is the way most of it is going to be done, why won't they all locate in the northern Great Plains?

That's where the conditions seem to be the most promising. You've got the coal there and you've got the mining and transportation costs somewhat lower there. You have the labor. All of the signs would seem to me to point to private companies moving into that part of the country. What is to prevent the whole emphasis from being located there?

Ms. Clusen. Well, it seems to me this is a point at which several forces come into play, as you know. Prime among them, I think, must be the constant interaction of the State government in the region and the interstate arrangements, the interstate compacts as well, to get together, in a sense, to decided for themselves how much of this weight they want to carry in any given region.

I think that you are right, that there will be driving forces, given the availability of resources and transportation going in the northern Plains States, but I would not expect that the States or the political institutions involved would choose to sit idly by and be overcome by these forces.

In addition to that, there is a great deal of competitiveness for this kind of development. One of the surprises to us when we did the environmental analysis and projected where the greatest resources were and the development might occur—we were merely looking at siting opportunities, but one of our surprises was that we did not get complaints from any of the areas that we suggested might become sites. Instead of that, we received a great many calls from places that we did not mention.

In other words, I sense a strong economic factor in play that seemed to say that we should not ignore other parts of the country as well. So, I think that it will be highly competitive in the end.

Senator McGovern. I guess there are kind of conflicting signals here. You get the assurances that the States and the local areas are going to have something to say about this, and yet the real thrust of the energy mobilization board, as I understand it, was to give greater authority to the central decisionmaking process and, in a sense, override the concerns of the States and local interests.

Mr. Martin. Senator, I would like to comment, if I could, on that issue and the question you raise. I think you asked a good question,

and that is how we are going to deal with the siting question and where the locus of the Federal Government is to deal with it. I think the answer to that is probably that there is not one, that we are not now embarked upon a federally oriented or federally dominated siting process.

Both this administration and, in its considerations of the Federal Land Use Act, Congress has rejected that basic orientation. We not only respect that; we agree with it. I think that the primary locus of siting decisions is probably going to fall at the State level, notwithstanding whatever the final provisions of the EMB are.

It's a little hard to predict the bill is going to be, but I think it will best be described as an "expediting statute," rather than one that will be capable of making substantive decisions.

Now, it may turn out differently, but that seems to be the course of the debate, even though there are still some tough issues left. The key decisions on siting, it seems to me, are going to be made by States exercising their powers of water permitting—which are unthreatened by any version of the EMB bill, so far as I am aware, and certainly are not threatened by the intention of the administration—and by States and local governments exercising their powers of land use control.

Now, insofar as the Federal Government goes, wherever Federal land is involved, that power will be exercised under FLPMA. We have a rather elaborate scheme, as well as a firm intention, under that act, to do it in concert with the States.

I won't belabor the record now, but let me say that we have done this successfully and with enthusiastic response and applause from Governors in places like Utah, where we have sited the intermountain power project in a way which turned out to be most acceptable to most interests.

There is a real capability to do such things, but I would suggest the locus you're looking for is going to be at the State level, and that their powers are going to be rather extraordinary in that regard.

Senator McGovern. Mr. Martin, you state that 1 million acre-feet of water have been allocated from reserves at Federal water projects by the Bureau of Reclamation for industrial use. The water is referred to as "not in demand for agricultural use of the next 50 years," and after that time it could or would revert to agricultural use.

Now, realistically, if the water is committed for energy purposes or industrial purposes for the next 50 years, looking down the road to the demands for energy, what are the practical chances of the State getting that water back for agricultural or municipal use? I am wondering if that isn't part of the State's anxiety and lack of enthusiasm for the program. Is it really likely that the need for energy demand is going to decrease over the next 50 years?

Mr. Martin. Well, let me say a couple of things about that. First, I think your characterization of what was done is correct. The amount that was so allocated was specifically agreed on to be a much smaller amount than what was thought to actually be available considering other future uses. In other words, there is a firm water surplus of not just 1 but some 4 million acre-feet in that system, and only 1 million of it was allocated to this purpose; that is, from agriculture to industry.

At the time that was done, although there were some differences of opinion, my understanding is that, by and large, the States did not object or raise serious concerns about the actual act of making that allocation. So, the lack of enthusiasm for actually picking up the blocks of water was not signalled at any time by heavy opposition to the plan.

The last thing I would say is that I appreciate your logic. You are right. At the end of 50 years, if we have locked into a series of energy-related uses of that water, it is going to be difficult to bring it back. Depending upon the circumstances, we can make firm contracts and we can do a number of things for safeguards.

The problem I have to look at is the alternative: If we say the threat is so important to not allocate or run the risk of not getting it back in 50 years, our major alternative is basically to do nothing. Since we know that for that period of time, however, 1 million acre-feet are very unlikely to be used for agricultural purpose and that there is in excess of another 3 million, then we are probably talking about an opportunity cost now in the name of preserving flexibility later. That's a trade-off that had to be made, and, essentially, it was.

Senator McGovern. Ms. Clusen, you touched on the relationship between surface and ground water supplies vis-a-vis energy development. I would like to just explore that with you a little further.

For example, in Montana, the surface water reservation program for the Yellowstone River does, as you suggest, reduce the water available for synfuel development. Will there be increased pressure to use ground water resources, like the Madison aquifer that I referred to earlier, for synfuel development? There are several communities in South Dakota that depend on that Madison aquifer for their municipal water needs, and some of them are planning to use the water for heating schools and other public buildings. What institutional relations or laws exist that protect those communities? How are they protected against drawdown on those underground waters?

We have got the same problem in terms of proposed uranium mining out there. There is great anxiety about these uranium mills that are moving into that part of the State and the possible contamination of those underground water supplies. Now you have another potential threat in the drawdown of underground water for synfuel development. What protection do areas like that have against that possible loss of water that they're going to need to maintain these cities and towns and their municipal water supplies?

Mr. Martin. I talked to Ms. Clusen and I think that I am probably better prepared to answer that than she is.

I am familiar with this problem—very familiar—and I am concerned about it because it was brought to my attention most recently when Representative Abdnor raised it in connection with the ETSI situation. There they plan to pump ground water, and this has caused a controversy between Wyoming and South Dakota.

Senator McGovern. The same problem.

Mr. Martin. The same problem. You say, what institutional devices exist to protect against that? The answer is, at the Federal level, very few. The reason is, there have been few areas which have been

regarded as more sacred to the State control of its water resources than the area of ground water.

We examined this issue very, very carefully as we developed the President's water policy, and where we came out is a conclusion that we ought not to create a Federal ground water management regime or set up authorities. What we did do is to say that, for the future as a policy, we are not going to develop any new Federal facilities without insuring that, concurrently, the States take measures to resolve their ground water difficulties.

The classic example of this is central Arizona, where the CAP, a tremendously expensive Federal project, is only going to put a reasonable dent in the ground water overdraft that is likely to continue in the future.

To the extent that there are institutions that deal with ground water overdraft, they are specifically and traditionally in the hands of the State.

Most States have been very reluctant to establish, even at the State level, strong, authoritative, specific ground water control mechanisms because, as you know, these people that have mined ground water for years are both politically powerful and sensitive to regulation. In a few cases—I always cite Salt Lake City as an example—they have bitten the bullet and they have put into effect, at the local level, ground water control mechanisms. In South Dakota, they can do so by an act of the legislature. It would probably be the best protective mechanism they could have, although they would again certainly wind up in litigation with Wyoming over the technical determinations with regard to the size of the Madison and the drawdown that was occurring.

Our preference would be to see the States continue to control their resources until Congress made a determination that it ought to be federally controlled, and we do not sponsor that conclusion at this time.

Senator McGovern. All right. Well, I have some additional questions, but we have another panel here, so I'd like to reserve the right to submit a few additional questions to Ms. Clusen and Mr. Martin in writing.

We do appreciate your testimony here today.

The final three witnesses are: Wilson Clark, professor of physical science at Eastern Montana College and a member of the Montana Board of Natural Resources. I would like to call you, Mr. Clark, and Millard Hall, Chairman of the Missouri River Basin Commission, and Mr. John L. McCormick of the Environmental Policy Center.

STATEMENT OF WILSON F. CLARK, MEMBER, MONTANA STATE BOARD OF NATURAL RESOURCES AND CONSERVATION AND PROFESSOR, DEPARTMENT OF PHYSICAL SCIENCES, EASTERN MONTANA COLLEGE, BILLINGS, MONT.

Senator McGovern. I think we will follow the same procedure here as we did with Ms. Clusen and Mr. Martin. If each of you could open with about a 10-minute oral statement and print your prepared statement in the record, that will give us a little time for some questions, and we'll begin with Professor Clark.

Mr. CLARK. Let me introduce myself first. I'm Will Clark, from Billings, Mont. I am a college teacher out there, but I have been 6 years on the Montana State Board of Natural Resources and was very much involved in the Yellowstone River water reservations program as a result.

I am wearing two hats here today; one is to represent the Montana State Department of Natural Resources that has filed a position paper with your subcommittee, Senator, from Mr. Ted Doaney, with the approval of Governor Tom Judge, which represents an official statement. The major thrust of that position paper, just to spend a few minutes on it, is that States—or at least in Montana—there's a real concern that State water law is recognized throughout this whole process, that the State finds it extremely difficult to answer specifically your several questions until it gets down, as Mr. Martin and other people have mentioned, to site-specific studies.

Of course, obviously, general statements about how much and where and when are pretty hard to answer until you really nail it down to site-specific things.

My primary testimony has been filed with your subcommittee, and I am restricting my remarks to Yellowstone River water reservations. They have been referred to by some of the previous people and we need to recognize that the Yellowstone basin is a very large basin and the Yellowstone River is a highly fluctuating river, going all the way from 17 million acre-feet in high flow years at Sidney, where it hits the North Dakota line, to as low as a 3 million acre-feet in low years. There's an awful lot of water there.

A few years ago, in 1974, the State legislature passed the Yellowstone Water Moratorium, in response to the very legitimate concern by agriculture and the municipalities that the heavy filings by industrial groups would preclude the development of irrigation agriculture within the State. The Yellowstone reservation process was set up, whereby public parties were allowed to make requests for reservations through some future period of years, to see to their long-range development, and that industrial entities were specifically excluded from that reservation process.

When the dust finally settled, reservation requests came from 8 cities, 14 soil conservation districts, 2 irrigation districts, 4 State agencies, and 2 Federal agencies.

It was a long and involved process, as you are well aware, and the State board made its decisions on December 15, 1978. Apparently, the decisions weren't too far wrong since we aren't in serious litigation about it, which is a pretty good sign, I think.

The board first took up the matter of these reservations, once we actually had the case before us to consider—and this, of course, was after the EIS business and hearings and filings of the blizzard of findings of fact and objections and so on.

The board made several broad philosophical decisions early in the game. One of the major points was that the board did not wish to commit the total supply of water to the reservation process, and that there should be, in average flow years, a significant quantity of water for filings from industry, from agriculture not covered by the reserva-

tion process, from the municipalities, and so on. We very distinctly made an effort to do this.

Another major point is, we felt that the future of the Yellowstone Basin would depend very strongly on the development of off-stream storage. Now, there has been testimony presented here this morning to the effect that there didn't seem to be too much need for additional off-stream storage. I don't think that is true in the Yellowstone Basin. In the process of reservations, we did approve three fairly significant Bureau of Reclamation off-stream storage reservations. We also approved an enlargement of the Tongue River Dam, which is under the jurisdiction of the Montana State Department of Natural Resources.

A third major point that the board held to quite strongly was that there was a primary obligation that sufficient in-stream water be allocated to maintain the quality of the water and to maintain a healthy aquatic biological community in the whole basin.

Now, we come right down to the basic question, is there water for energy development and other sorts of uses, whether synfuels or whatever it might be?

My prepared statement refers to a document that is attached to it that summarizes the "Yellowstone Water Reservation Case," and the last page of that summary has a water budget in it. This water budget points out that after the reservation process—and this includes the city reservations, the instream and irrigation reservations—at Sidney, in an average flow year of 50 percentile, there's about 2.6 million acre-feet per year that is unallocated, unused now, unreserved, and essentially that is available to be filed on, irrespective who might file on it.

At Livingston, there's 600,000 acre-feet; at Billings there's about 800,000; in Miles City there's about 2.4 million; and at Sidney there's 2.6 million acre-feet per year.

Now, the catch to this, if one studies that water budget, is that these quantities of water left unreserved disappear in low flow years, and it essentially boils down to the fact that when you get to the 80th percentile flow year there's almost none at Livingston. At about the 70-percentile year, there's almost none available at Billings. At the 80th, it zeros out at Miles City, and zeroes out at Sidney.

What this means, then, is essentially that there is water available for energy development in the Yellowstone Basin, but there's a great big "but" attached to it, and that is that if industrial or other users file on portions of the water, they can be assured of the water directly from the river only in 5 or 7 years out of 10.

And there are several straightforward answers for this apparent dilemma. One is for them to sign a long-term purchase contract from either those dams that were referred to—the 300,000 available out of Fort Peck; the 600,000 out of yellowtail, and so on, or to sign long-term contracts for the purchase of industrial water from the off-stream storage reservation projects that were approved in this whole process.

And a second solution is that the industries need to recognize that where they do file on water, they would be junior to the reservation holders and they therefore have to build their own off-stream storage reservations or storage reservoirs. And this seems to me to be the primary problem in the Yellowstone Basin; that is, they could not count on a continuous flow coming right out of the river.

As for the in-stream reservations, there's been a lot of misunderstanding about them and their effect on potential industrial users within Montana. We need to recognize that these in-stream reservations, according to Montana State law, now amount to a legal beneficial use of the water, and these in-stream reservations are in competition with all the diversionary uses, but now under Montana water law they do constitute a legal use, even though they are not diverted waters. And that hard fought principle is now clearly established.

Many irrigation, municipality, and industrial users screamed and hollered when in-stream reservations were first proposed for they felt that any water not diverted was wasted, and you all heard the cry, "if you don't use it, you lose it." But over time, many came to see the in-stream reservations were essential to maintaining a reasonably healthy productive acquatic environment. The Montana State Board by no means accepted the magnitude of the original requests of in-stream reservations, but in general gave fairly high percentile of flows, that is, low percentage of flows, during irrigation months to in-stream reservations, and low percentiles during the nonirrigation months.

Apparently both the Montana State Department of Health and the State Department of Fish and Game are generally satisfied with the outcome of this, although they're not exactly elated.

When the in-stream reservation water finally flows out of the State below Sidney it has served its purpose for Montana. We have used it but without depletion or deterioration.

During our flow years of 70 percentile or better, flows to 5½ million acre-feet per year represent the in-stream flow leaving Montana. What that means to downstream States is this—to me, it seems, anyway—that Montana is giving a guarantee to downstream States that in years of 70 percentile flow or better, that is, 7 years out of 10, there will be at least 5½ million acre-feet of water flowing out of the State. It's the best guarantee that they have had in many a year. To the extent that we don't have extended periods of drought, those downstream States can fairly well count on that water.

But just as in Montana, in downstream States industrial users filing on an allocated portion of this downstream flow will need to plan on their own off-stream storage to tide them over the dry years, or to plan on these long-term purchase contracts from existing dams.

One other major point needs to be made. The State board, as a basis for its decision, was rigidly restricted by the Montana Administrative Procedures Act to the legal record; that is, EIS and so on. And in that legal record almost nothing appeared about Indian water rights, and the State board had no recourse but to essentially ignore them, even though we certainly recognized their importance. But we could not—and the Montana State Supreme Court would not let us—hold our breath for the Indian claims to be settled. When they are finally settled, it will materially affect the present reservations on the Big Horn, the Tongue, and the Rosebud. The State board may well have to go back to the drawing board at that time.

Similarly, the Big Horn and Tongue coming in from Wyoming are covered by the Yellowstone Compact, but again, there was very, very little in the record.

So, both of these situations are ones in which the omission in the reservation was not from oversight, but from lack of data in the record to which the State board was restricted.

Just a couple of other points as to Montana's attitude about water for energy development. There is a deep-seated concern among citizens of the State that it, the State, should largely maintain jurisdiction over the waters of the State. And this is, as you know, built into our State constitution. There is genuine deep-seated concern that the Federal Government, in its headlong drive toward expanding energy generation facilities, might roll right over the State. There is truly little trust that citizens and that congressional represenatives from relatively humid areas of the Nation have any concept of the western water problems, management, and dependence, and I think you are well aware of this, sir. The history is replete with horrible examples of this lack of understanding, and I caution you and the committee to strenuously avoid the big-daddy-knows-best syndrome, that is too often displayed. Don't go it alone, ignoring the State water laws, merely because you may have the bucks and power to do so.

In conclusion, in my judgment:

One: There is adequate water in the Yellowstone Basin for considerable industrial use in 7 years out of 10.

Two: Industrial users, both in Montana and downstream, will need to build their own off-stream storage, or sign long-term purchase contracts from other sources.

Three: With the expected future needs of both agriculture and municipalities largely met for the next 25 to 30 years, by virtue of the Yellowstone water reservation program, the basic fear of irrigation agriculture in Montana that it will be put out of business by industrial water filings has to a considerable extent been laid to rest.

Four: The in-stream reservations aspect of the Yellowstone basin program should be viewed by downstream States as the best guarantee of adequate water for future growth, in at least 7 years out of 10. Rather than Montana's in-stream reservations threatening water development of downstream States, I see those reservations as largely encouraging such downstream development, but they must plan to cover the dry and low flow years.

Last: From the aspect only of water supply, synfuel development in Montana is not foreclosed. The tenor of the State, however, seems to be quite hostile to massive energy generation and synfuels systems, for reasons other than water supply.

I thank you very much, sir, for this opportunity to speak to your subcommittee, and I will be glad to answer any questions.

Senator McGOVERN. Thank you, very much, Mr. Clark, and before we question you I'd like to move on to Mr. Wayne Hall, who is chairman of the Missouri River Basin Commission.

[The prepared statement of Mr. Clark, together with an attachment; a Montana State position paper entitled "Impact of Coal-Based Synfuel Development of Water Resources"; and a paper entitled "The Reservations Challenge," follows:]

PREPARED STATEMENT OF WILSON F. CLARK

THE YELLOWSTONE RIVER WATER RESERVATIONS IN MONTANA, AND THEIR POTENTIAL IMPACT ON INDUSTRIAL AND ENERGY DEVELOPMENT

Members of the committee, by way of self-introduction, I'm Wilson F. Clark, a college teacher at Eastern Montana College in Billings, Montana. My teaching is involved largely with environmental education and science education, as a

member of the faculty of the Physical Sciences Department at the college. I've been involved in such teaching for thirty years, having held my first conservation workshop for teachers in 1949 at Cornell University, where for five years I was in agricultural extension work. Since moving to Montana in 1954, and outside of my college training, I've been involved in many groups, programs, and citizen endeavors. I've worked with the U.S. Forest Service, the Bureau of Reclamation, the Soil Conservation Service, the Bureau of Land Management, and the National Park Service on various programs.

For the past six years I've been a member of the Montana State Board of Natural Resources, a governor-appointed citizen board with quasi-judicial, decision-making powers. Our Board is involved in decisions on energy generating plants, energy transmission systems, many aspects of water resources, forestry as far as the State Forest Lands are concerned, and various other topics large and small. It evidently is in my capacity as a State Board member that I was invited to this hearing. I was reluctant to come, not only because of the distance and having to play hookey from my classes, but also because I know little about synfuel plants. But once it was understood that I'd come to discuss Yellowstone River Basin water use, I then agreed to do so. I'm also carrying for delivery to the Committee a statement and written testimony from the State Department of Natural Resources and Montana Governor, Tom Judge. But the remarks in this paper and testimony are entirely my own.

THE YELLOWSTONE BASIN

The Yellowstone River enters Montana at Gardiner, on the north edge of Yellowstone Park. It runs almost due north for 53 miles to Livingston, then wanders generally northeastward to the Montana-North Dakota line just below Sidney. It joins the Missouri River just a few miles into North Dakota. From Gardiner to Sidney is about 440 road miles—and probably over 500 river miles. The Yellowstone fluctuates widely in its flow. At Sidney the flow varies from over 17 million acre feet per year to about 3.5 million acre feet per year. So when we're dealing with the Yellowstone Basin, we are talking about a considerable chunk of territory, and a large volume of water, and this is territory underlain by a significant portion of the Fort Union Coal formation.

THE YELLOWSTONE RESERVATIONS

The Yellowstone River Water Reservations represent a distinct departure from the usual water allocation systems of the western states. A rather thorough article with data tables accompanies this testimony, and I refer you to it for details. In brief, the Montana State Legislature put into effect in 1974 a moritorium on water filings above a certain modest amount. This was the result of a growing concern that the large industrial filings in the coal-rich Yellowstone Basin would close off opportunities for expansion of irrigation agriculture, would significantly deplete the water supply of the basin to the detriment of the present high recreational and fish and wildlife values, and would cause deterioration of water quality from a municipal standpoint. The moritorium was designed to give "public bodies" time and opportunity to make reservations for expected future needs for water. It specifically excluded industrial reservations. When the dust settled, the reservation requests came from 8 cities, 14 Soil Conservation Districts, 2 Irrigation Districts, 4 State agencies, and 2 Federal agencies.

After the long, involved, and often confusing process produced a legal record, the State Board of Natural Resources then had to study, deliberate, analyze, disect, recalculate, and generally thoroughly work over the mountain of material, and ultimately make decisions on who got how much of a reservation for what purpose. The final decision was made December 15, 1978. The quantitative decisions finally made are summarized in the data tables attached to this testimony.

A major point pertinent to this hearing was that the Board early in the process fully agreed that the total water supply should not be committed, and that in average flow years there should be significant quantities of water left unallocated, unreserved, and presently unclaimed, for future industrial use, irrespective of what that use might be.

Another major point was that the Board felt it should strongly encourage the development of off-stream storage—that is, storage dams on small tributary

streams, to be filled by pumping from the main Yellowstone only during periods of high flows, as in the late spring runoff.

A third major point was that we had as a primary obligation the allocation of sufficient in-stream water to maintain the quality of the water and to maintain healthy aquatic biological communities in the whole basin. This last matter of in-stream reservations was a radical departure from previous western water law. Montana, as essentially a headwaters state, had a unique opportunity to plan for and allocate water to remain in the streams. In the Yellowstone Basin we had the unallocated water available to do this.

POTENTIAL INDUSTRIAL USE OF YELLOWSTONE WATER

With this much-abbreviated background setting the stage, I now want to get down to the matter of the availability of water for industrial uses in the Yellowstone Basin—including energy plants of various sorts. The situation is best explained by reference to the last data table of the attached material, entitled Water Budget.

Each vertical column represents the "account sheet" for years or different levels of flow, showing how much water would be at each of the major stations in that flow year under present patterns of use, plus the inflow between stations, minus the municipal, irrigation, and in-stream reservations granted. The last figure under each station (lines 6,13,20,27) gives the amount of water not now used, claimed, allocated, or reserved, for each flow year shown. You'll note that in a 50 percentile flow year (or an average flow year) there are over 600,000 Acre feet per year (abbreviated Afy) at Livingston (downstream 53 road miles from Yellowstone Park), over 800,000 Afy shortly below Billings, over 2,400,000 Afy at Miles City, and over 2,600,000 Afy at Sidney, very close to the North Dakota state line. That's the situation in an average year. The other columns show the situation in years of lesser flows. (Do not confuse 90 percentile flow year with 90 percent of high flow. The percentile flow is best thought of as the inverse of the percent flow. Thus a 90 percentile flow year is one that would be a low flow occurring only one year out of ten. So a high percentile means a low percentage of the flow.)

For the years less than average flow, Line 6, "Unreserved water at Livingston" shows that somewhere between an 80 percentile flow year and a 90 percentile flow year, there is no unreserved or unallocated water. At Billings this happens a bit below the 70 percentile flow. (Line 13). At Miles City and at Sidney this happens at the 80 percentile flow year. (Lines 20 and 27). In flow years of average (50 percentile) and better flows, there is an abundance of water unallocated, unreserved, and available for filing right now.

But—

If industrial or any other users file on portions of that water, they can be assured of adequate water directly from the river for only 5 to 7 years out of 10, depending on where their diversion is located.

I believe that there are several straight-forward answers to this apparent dilemma.

One solution is that Industrial users can arrange long-term purchase contracts to buy water from the Bureau of Reclamation off-stream storage projects—projects not yet built but for which storage reservations have been approved. These Bureau of Reclamation off-stream reservoirs would be filled by pumping from the main river during periods of high flows, which usually means mid-May to possibly early or mid-July. The water would be delivered from the dam to the site of use by an aquaduct system or pipeline system.

A second solution to the dilemma, if long-term purchase contracts are not possible or attractive, or if there are too long delays in obtaining authorization for the Bureau of Reclamation to build those three off-stream dams, is for any industrial corporation to build its own off-stream storage, in order to be assured of an adequate water supply in lower flow years. In a sense, Montana Power Company has done this with its pipeline from the Yellowstone River at Nichols to its Colstrip generating site and a holding-lake. A condition of certification of those Colstrip plants was that pumping would cease when the river dropped to or below a certain cfs (cubic feet per second) value. In the Colstrip case, however, the capacity of the holdinglake is (or will be) adequate to supply the plants for only 50 days without further pumping. Since any new industrial water user would have water rights junior to the established rights and to the reservations ap-

proved December 15, 1978, such new users would be forced to find ways of meeting their water needs during low flow years.

As for the in-stream reservations and their effect on potential industrial users—within Montana those in-stream flows are considered to be put to a "beneficial use" by remaining in the streams and rivers. Those in-stream reservations thus are in competition with all diversionary uses, but they now under Montana law constitute a legal use. This hard fought principal is now clearly established. Many irrigation, municipal and industrial users screamed and hollered when in-stream reservations were first proposed, for they felt that any water not diverted was wasted. The cry in Montana was "Use it or lose it." But over time, many came to see the in-stream reservations as essential to maintaining a reasonably healthy and productive aquatic environment—and one which contributes mightily to the recreation of citizens and to the economy of the Yellowstone Basin. The State Board by no means accepted the magnitude of the original requests, but in general gave high percentiles (low percentage of the flow) during irrigation months, and low percentiles (high percentage of the flow) during non-irrigation months.

When the in-stream reservation water finally flows out of the state below Sidney, it has served its purpose in Montana. We've "used" it, but without depletion or deterioration. During flow years of 70 percentile or better, close to 5.5 million acre feet per year represents the in-stream flow leaving Montana. What this means to downstream states along the Missouri is this: Montana is giving a guarantee to downstream states that in years of 70 percentile flow or better (that is, in 7 years out of 10) there will be at least 5.5 million acre feet flowing out of the state, for those downstream states to use. It's the best guarantee they've had in many a year. To the extent that we do not have an extended period of drought, those downstream states can fairly well count on that quantity of water. But just as in Montana, so in downstream states—the industrial users filing on and allocated portions of this downstream flow will need to plan on their own off-stream storage to tide them over the drier years.

One other major point needs to be made concerning what appear to be omissions in the reservations. The State Board, as a basis for its decisions, was rigidly restricted under the Montana Administrative Procedures Act, to the legal record—that is, to the Environmental Impact Statement, the transcript of the formal hearings the many, exhibits, and the blizzard of each party's findings of fact and objections to the findings of other parties. In all this, almost nothing appeared about Indian water claims. The State Board had no recourse but to ignore them—even though we recognized their importance. But we could not—and the State Supreme Court would not let us—hold our breath for the Indian claims to be settled. When they are finally settled, it will materially affect the present reservations of the Big Horn, the Tongue and the Rosebud. The State Board may well have to go back to the drawing board at that time. Similarly, the Big Horn and Tongue coming in from Wyoming are covered under the Yellowstone Compact, but very little of that Compact data was in the record, and it too had to be largely ignored. Both Indian water claims and Wyoming claims under the Compact were omissions not from oversight, but were due to essentially no or very little data in the record to which the State Board was restricted.

MONTANA'S ATTITUDES

As to Montana's attitudes about water for energy development—there is a deep-seated concern among citizens of the State that it (the State) should largely maintain jurisdiction over the waters of the State. There is genuine and deep-seated concern that the Federal Government, in its headlong drive towards expanding energy generation facilities, might roll right over the State. There is little trust that citizens and their congressional representatives from relatively humid areas of the nation have any concept of western water problems, management, and dependence. History is replete with horrible examples of this very lack of understanding. I caution you to strenuously avoid the "Daddy knows best" syndrome that is too often displayed. Don't go it alone, ignoring the State water laws, merely because you may have the bucks and power to do so.

CONCLUSIONS

In conclusion—In my judgment, and speaking only as an individual not representing an official State position—I believe that:

1. There is adequate water in the Yellowstone Basin for considerable industrial use, in 7 years out of 10.

2. Industrial users, both in Montana and downstream, will need to build their own off-stream storage, or sign long-term purchase contracts from federal off-stream storage projects, to tide them over the dry years.

3. With the expected future needs of both agriculture and municipalities largely met for the next 25 to 30 years, by virtue of the Yellowstone Water Reservation program, the basic fear of irrigation agriculture in Montana that it will be put out of business by industrial water filings has to a considerable extent been laid to rest in the Yellowstone Basin.

4. The in-stream reservations aspect of the Yellowstone Basin program should be viewed by downstream states as the best guarantee of adequate water for future growth, in at least 7 years out of 10. Rather than Montana's in-stream reservations "threatening" water development of downstream states, I see those reservations as largely encouraging such downstream development, but they must plan to cover the dry, low flow years.

5. From the aspect only of water supply, synfuel development in Montana is not foreclosed. The tenor of the state, however, seems to be quite hostile to massive energy generation and synfuel systems, for reasons other than water supply.

I thank you for the opportunity to present these thoughts to you. I hope they will be helpful in your deliberations.

Attachment.

THE YELLOWSTONE WATER RESERVATIONS CASE

Summary tables

1. City Requests, and Reservations Granted.
2. Irrigation Requests, and Reservations Granted.
3. Storage Requests, and Reservations Granted, and In-stream Requests, and Reservations Granted.
4. Status of the Yellowstone before Reservations.
5. Water Budget of the Yellowstone after Reservations.

Disclaimer: These are working papers, and are not legal documents.

Purpose: The tables were prepared for public distribution, in order that people would have a factual base when discussing the final outcome of this case. The tables correctly state the requests, and correctly state the final Reservations granted by the Board at its Dec. 15, 1978 meeting.

TABLE 1.—YELLOWSTONE WATER RESERVATION CASE—CITIES

City	City requests, reservations granted, and total water											
	Water requested by applicant				Estimated present water use (A/ft/y)	Water reservation granted					Total water available	
	A/ft/y [1]	For year	For population	Gals/p/d [2]		A/ft/y [1]	For year	For population	Gals/p/d [2]	Depletion [3]	Present use plus reservation (A/ft/y)	For year (in year)
Livingston	15,060	2007	35–40,000	384	1,930	4,510	2007	23,000	250	−1,085	6,440	2007
Big Timber	4,483	2000	3,000	1,334	477	365	2000	3,000	250	−73	842	2000
Columbus	2,606	2007	4,500	516	379	883	2007	4,500	250	−176	1,262	2007
Laurel	16,830	2007	35,000	429	1,249	7,151	2007	30,000	250	−1,430	8,400	2007
Billings—Request	317,456	2070	600,000	472	16,450							
Data also in application and testimony	54,218	2010	206,000	235	16,450	41,229	2010	206,000	250	−8,245	57,679	2010
	43,440	2000	165,000	235	16,450							
Miles City	21,720	2000	31,000	625	2,721	2,889	2000	20,000	250	−577	5,610	2000
Glendive	12,757	2007	38,800	293	1,768	3,281	2007	18,000	250	−656	5,049	2007
Broadus (on wells)	605	1995	4,000	135	224	605	1995	4,000	135	not to River	829	1995
Total	[4] 127,674				24,974	60,308					85,282	
Broadus not in totals because on wells	[5] 390,912											

[1] A/ft/y means acre-feet per year. 1 a/ft is 325,900 gallons.
[2] Gals/p/d means gallons per person per day. (Often abbreviated gal/cd for gallons/capital/day.) Calculated from total gallons in a year divided population divided 365 days=gals/c/d.
[3] Depletion refers to that part of the total water taken that does NOT return to the river systems.
[4] Total with Billings at year 2010.
[5] Total with Billings at year 2070.

TABLE 2.—YELLOWSTONE WATER RESERVATIONS CASE—IRRIGATION

Applicant	Irrigation requests, and reservations granted						
	Requested water				Reservation granted		
	A/ft/y	Acres	A/ft/y	Percent depletion[1]	A/ft/y	Acres	A/ft depletion[1]
Park C.D	108,143	36,570	2.96	65.0	64,125	21,664	−41,694
Sweetgrass C.D	55,822	18,510	3.02	65.0	46,245	15,313	−29,772
Stillwater C.D	16,755	5,290	3.17	64.0	16,755	5,290	−10,723
Carbon C.D	47,557	21,015	2.26	80.0	22,676	10,034	−18,140
Yellowstone C.D	57,963	24,835	2.33	84.0	57,963	24,835	−48,688
Treasure C.D	19,978	7,645	2.61	84.9	18,361	7,035	−15,588
Bighorn C.D	21,200	9,645	2.2	84.6	20,185	9,175	−17,076
From Tongue River Dam[2]					1,034	470	−874
Total					21,219	9,645	−17,950
Rosebud C.D	94,129	37,360	2.52	83.4	87,003	34,525	−72,560
From Tongue River Dam					7,144	2,835	−5,958
Total					94,147	37,360	−78,518
North Custer C.D.:							
From Yellowstone River	18,301	7,440	2.62	69.7	18,301	7,440	−12,755
From Tongue Dam	10,897	4,605	2.62	69.7	10,897	4,605	−7,595
From Powder River (WS)	10,177	6,785	1.5	50.0	10,177	6,785	−5,088
From Powder River (FS)	78,480	26,150	2.62	69.7	(3)	(3)	(3)
Total	117,855	44,980			39,375	18,830	25,438
Powder River C.D.:							
From Powder (WS)	13,680	9,120	1.5	15.0	13,680	9,120	−6,840
From Powder (FS)	75,560	25,245	2.60	67.8	(3)	(3)	(3)
Total	89,240	34,365			13,680	9,120	−6,840
Prairie C.D.:							
From Yellowstone River	68,024	22,241	3.04	60.4	68,024	22,241	−41,354
From Powder River (WS)	443	295	1.5	50.0	443	295	−222
Total	68,467	22,536			68,467	22,536	−41,576
Dawson C.D	45,855	18,127	2.53	77.6	45,855	18,127	−35,583
Richland C.D	45,620	21,710	2.1	84.5	45,620	21,710	−38,548
Little Beaver C.D.:							
(FS)	[4] 8,566	5,300	1.61	74.7	4,283	2,650	−3,191
(WS)	12,000	8,000	1.50	50.0	6,000	4,000	−3,000
Stock ponds	[5] 3,600				1,800		
Recreation ponds	[5] 1,400				700		
Total	20,556	13,300			12,773	6,650	−6,191
Huntley I.D	27,372	4,000	6.84	74.7	(3)	(3)	(3)
Buffalo Rapids, I.D	124,435	41,306	3.01	74.7	11,997	3,100	−8,461
Department of State lands No. 9931:							
Yellowstone River and Bighorn	12,858	4,286	3.00	74.7	12,858	4,286	−9,604
From Tongue Dam	1,431	477	3.00	74.7	1,431	477	−1,068
From Powder	7,140	2,380	3.00	74.7	(6)	(6)	(6)
Total	21,429	7,143			14,289	4,763	−10,672
Department of State lands No. 9933:							
From Yellowstone River	25,889	9,236	2.80	74.7	25,889	9,236	−19,369
From Tongue Dam	390	130	3.0	74.7	390	130	−291
From Powder River (FS)	4,618	1,508	3.0	74.7	(3)	(3)	(3)
Total	30,897	10,875			26,279	9,366	−19,660
Department State lands No. 9934:							
Department State lands No. 9934: From Powder (WS)	15,078	10,270	1.47	50.0	15,078	10,270	−7,539
Bureau of land management:							
From Yellowstone River	17,476	8,738	2.0	74.7	17,476	8,738	−13,054
From O'Fallon CK	2,924	1,992	1.47	50.0	2,924	1,992	−1,462
From Powder	1,098	549	2.0	74.7	(3)	(3)	(3)
Total	21,498	11,279			20,400	10,730	14,516

See footnotes at end of table.

TABLE 2.—YELLOWSTONE WATER RESERVATIONS CASE—IRRIGATION—Continued

Applicant	Irrigation requests, and reservations granted						
	Requested water				Reservation granted		
	A/ft/y	Acres	A/ft/y	Percent depletion[1]	A/ft/y	Acres	A/ft depletion[1]
Bureau of Reclamation (Hardin Beach)	131, 700	42, 950	3.06	74.7	(7)	(7)	(7)
Grand total	1, 176, 559	443, 711			652, 809	266, 378	—476. 597

[1] Depletion—that part of the water taken which does NOT return to the rivers.
[2] Tongue River Dam is covered by Department of Natural Resources storage application, and has a condition to supply the irrigation water stated.
[3] Denied.
[4] All figures above Little Beaver for percent depletion column given by applicants. All figs below used average 74.9 percent.
[5] Storage excluded from final totals.
[6] Application withdrawn.
[7] Denied; already included in Yellowtail Dam.

KEY TO SYMBOLS

C.D.=Conservation districts.
I.D.=Irrigation districts.
A/ft/y=Acre feet water per year.
1 acre foot of water=325.900 gallons.
WS=Water spreading.
FS=Full service irrigation.

TABLE NO. 3.—YELLOWSTONE WATER RESERVATIONS CASE—STORAGE, INSTREAM

	Acre-feet requested, granted
Storage requests and reservations granted:	
Bureau of Reclamation:	
Buffalo Creek Reservoir (off stream), Yellowstone River	68, 700
Cedar Ridge Reservoir (off stream), Yellowstone River	121, 800
Sunday Creek Reservoir (off stream), Yellowstone River	539, 000
Department Natural Resources and Conservation: Increased storage, Tongue River Dam on Tongue River	383, 000
Total new storage	1, 112, 500
In-stream requests and reservations granted:	
Department of Fish and Game made 94 specific location requests.	
Department of Health and Environmental Sciences made only 3 specific location requests.	
Bureau of Land Management made 38 specific location requests.	
Many requests were at the same locations.	
The Reservations Granted cover all duplicate locations.	
Only major Reservations are included in this list.	

River and location	Department of Fish and Game request (acre-feet)	Department of Health request (acre-feet)	Single in-stream reservation granted
Yellowstone River at Livingston (May to August plus all flows September to Apr.	935, 007		1,879,813—this is approximately 95 percentile[1], May 1–Sept. 30, and 20 percentile Oct. 1–Ap. 30.
Stillwater River at mouth	438, 827		379.795—approximately 90 percentile.
Boulder River at mouth	217, 990		195,163—approximately 90 percentile.
Clarks Fork (of Yellowstone River) at mouth	504, 020		Had no flow data. Gone 70 percentile June–September; 90 percentile other.
Yellowstone River at Billings	4, 110, 343	2, 994, 815	3,914,455—approximately 75 percentile.
Bighorn River at mouth	2, 484, 187		2,477,987—approximately 75 percentile.
Tongue River at mouth	243, 090		54,289 average of 75 cfs.
Yellowstone River at Miles City	[2] 7, 876, 889	4, 448, 000	5,578,892—approximately 80 percentile less depletions through Miles City.
Powder River at mouth	198, 350		95,201—approximately 90 percentile.
Yellowstone River at Sidney	8, 206, 723	6, 466, 000	5,492,310—approximately 80 percentile less depletions to Sidney.

[1] Percentile—it is not the same as percent. A 90 percentile flow means that 9 years out of 10 there would be more than that amount of water. So the higher the percentile, the lower the flow. A 95 percentile means that in all but 5 years out of 100 years there would be more water than that.
[2] Approximately 55 percentile.

TABLE 4.—YELLOWSTONE WATER RESERVATIONS CASE

(Status of Yellowstone River before reservations—Summary: Yellowstone River Flows now at 4 gaging stations, and calculated inflow between stations now data base. Exhibits, USGS records of 39 years, 1936–74 (all monthly values are means.)

	50 percentile flows		70 percentile flows		80 percentile flows		90 percentile flows		Low flows	
	Ft³/s	A/ft	Ft³/s	A/ft	Ft³/s	A/ft	Ft³/s	A/ft	Ft³/s	A/ft
Section I plus Gardner to Livingston: Livingston flows (ref. USGS) (Gardiner to Livingston—about 53 road miles)	3,508	2,539,819	2,985	2,161,180	2,742	1,985,392	2,449	1,773,668	1,909	1,382,557
Section II minus Livingston to Billings:										
Inflow, Livingston to Billings (Billings flows minus Livingston flows) (Livingston to Billings—about 117 road miles)		+2,354,810		+1,767,712		+1,539,875		+1,242,395		+749,966
Billings flows	6,780	4,894,629	5,426	3,928,892	4,869	3,525,267	4,165	3,016,063	2,945	2,132,523
Section III minus Billings to Miles City:										
In flow, Billings to Miles City (Miles City flows minus Billings flows) (Billings to Miles City—about 145 road miles)		+3,470,717		+2,861,453		+2,371,861		+1,875,312		+1,520,034
Miles City flows	4,554	8,365,346	9,378	6,790,345	8,145	5,897,128	6,756	4,891,375	5,044	3,652,557
Section IV Minus Miles City to Sidney:										
Inflow, Miles City to Sidney (Sidney flows minus Miles City flows) (Miles City to Sidney—about 127 road miles)		+283,017		+224,914		+84,021		[1] −52,371		[1] 229,081
Sidney flows	11,945	8,648,363	9,577	7,015,259	8,261	5,981,149	6,683	4,839,004	4,728	3,423,476

[1] The negative values here mean that even now, in 1978, under the present use patterns, there is less water at Sidney than at Miles City, at 90 percentile and at low flow year.

TABLE 5.—WATER BUDGET: YELLOWSTONE BASIN, MAINSTEM, GARDNER TO SIDNEY: RESULTS OF RESERVATIONS

[Data Base: USGS Flow Records: see next Table: Status of Yellowstone R. before Reservations.]

[A/ft/y=acre=ft per year; ft ^{3}=cubic feet per second; t/ft ^{3}/s for 1 year=724 acres=feet.]

Item	50 percentile flow year		70 percentile flow year		80 percentile flow year		90 percentile flow year		Mean lowest flow year	
	A/ft/y	Ft^3/s	A/ft/y	Ft^3/s	A/ft/y	Ft^3/s	A/ft/y	Ft^3/s	A/ft/y	Ft^3/s
Section I:										
1. Livingston flows	2, 539, 819	3, 508	2, 161, 180	2, 985	1, 985, 392	2, 742	1, 773, 668	2, 449	1, 382, 557	1, 909
2. City depletions	−1, 085		−1, 085		−1, 085		−1, 085		−1, 085	
3. Irrigation depletions	−41, 694		−41, 964		−41, 694		−41, 694		−41, 694	
4. Livingston flow minus depletions (lines 1−2−3=4)	2, 497, 040	3, 448	2, 118, 401	2, 925	1, 942, 613	2, 683	1, 730, 889	2, 390	1, 339, 778	1, 850
5. Instream reservation	1, 879, 813	2, 596	1, 879, 813	2, 596	1, 879, 813	2, 596	1, 879, 813	2, 596	1, 879, 813	2, 596
6. Left unreserved (lines 4−5=6)	617, 227	852	238, 588	329	62, 800	87	−148, 924	0	−540, 035	0
Section II:										
7. Inflow, Livingston to Billings	+2, 354, 810		+1, 767, 712		+1, 539, 875		+1, 242, 395		+749, 966	
8. Available, Livingston to Billings (lines 4+7=8)	4, 851, 850	6, 701	3, 886, 113	5, 367	3, 482, 488	4, 810	2, 973, 284	4, 106	2, 089, 744	2, 886
9. City depletion, this section	−9, 924		−9, 924		−9, 924		−9, 924		−9, 924	
10. Irrigation depletions, this section	−115, 283		−115, 283		−115, 283		−115, 283		−115, 283	
11. Billings flows minus depletions (lines 9−9−10=11)	4, 726, 643	6, 528	3, 760, 906	5, 194	3, 357, 281	4, 637	2, 848, 077	3, 933	1, 964, 537	2, 713
12. In-stream reservations	3, 914, 455	5, 406	3, 914, 455	5, 406	3, 914, 455	5, 406	3, 914, 455	5, 406	3, 914, 455	5, 406
13. Left unreserved (lines 11−12=13)	812, 188	1, 122	−153, 549	0	−557, 174	0	−1, 066, 378	0	−1, 949, 918	0
Section III:										
14. Inflow, Billings to Miles City (lines 11+14=15)	+3, 470, 717		+2, 861, 453		+2, 371, 861		+1, 876, 312		+1, 520, 034	
15. Available Billings to Miles City (lines 11+14=15)	8, 197, 360	11, 322	6, 622, 359	9, 146	5, 729, 142	7, 913	4, 723, 389	6, 524	3, 484, 571	4, 812
16. City depletions	−577		−577		−577		−577		−577	
17. Irrigation depletions	−149, 673		−149, 673		−149, 673		−149, 673		−149, 673	
18. Miles City flows minus depletions (lines 15- 16−17=18)	8, 047, 110	11, 114	6, 472, 109	8, 939	5, 578, 892	7, 705	4, 573, 139	6, 316	3, 334, 321	4, 605
19. Instream reservation	5, 578, 882	7, 705	5, 578, 892	7, 705	5, 578, 892	7, 705	5, 578, 892	7, 705	5, 578, 892	7, 705
20. Left unreserved (lines 18−19=20)	2, 468, 218	3, 409	893, 217	1, 234	0	0	−1, 005, 753	0	−2, 244, 571	0
Section IV:										
21. Inflow, Miles City to Sidney	+283, 017		+224, 914		+84, 021		−52, 371		−229, 081	
22. Available, Miles City to Sidney (lines 18+21=22)	8, 330, 127	11, 505	6, 697, 023	9, 250	5, 662, 913	7, 821	4, 520, 768	6, 244	3, 105, 240	4, 289
23. City depletions	−656		−656		−656		−656		−656	
24. Irrigation depletions	−169, 947		−169, 947		−169, 947		−169, 947		−169, 947	
25. Sidney flows minus depletions (lines 22−23−24=25)	6, 159, 524	11, 270	6, 526, 420	9, 015	5, 492, 310	7, 586	4, 350, 165	6, 008	2, 934, 637	4, 053
26. Instream reservation	5, 492, 310	7, 586	5, 492, 310	7, 586	5, 492, 310	7, 586	5, 492, 310	7, 586	5, 492, 310	7, 586
27. Left unreserved (lines 25−26=27)	2, 667, 214	3, 684	1, 034, 110	1, 428	0	0	−1, 142, 145	0	−2, 557, 673	0

Impact of Coal-Based Synfuel Development on Water Resources[1]

This position paper is offered for the hearing record of the Joint Economics Committee's Subcommittee on Economic Growth and Stabilization in response to an October 18, 1979 letter from Senator George McGovern to Professor Wilson F. Clark, a member of the Montana Board of Natural Resources and Conservation. Before responding to the four major questions posed in Senator McGovern's letter, it is appropriate to present some of the basic tenets of Montana water law and policies upon which the State position is grounded.

Article IX, Section 3(3) of the Constitution of Montana states that "All surface, underground, flood and atmospheric waters within the boundaries of the state are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law." Additionally, the Constitution recognized and confirmed all existing rights to the use of any waters for any useful or beneficial purpose (Article IX, Section 3(1)) and directed the legislature to provide for the administration, control, and regulation of water rights (Article IX, Section 3(4)). By enactment of the Montana Water Use Act in 1973, the legislature delegated to the Montana Department of Natural Resources and Conservation the responsibility for administration, control and regulation of water rights and required the establishment of a system of centralized records.

The body of state water law has evolved over decades in Montana, as in most western states, establishing the state as the focal authority for allocating and managing its water resources. The state will insist on retaining this traditional role and will resist any federal intrusion or attempt to override state water law.

The general question, "Would an accelerated coal-based synfuel development program create conflicts with non-energy uses of water in Montana?" defies a definitive answer. Rather, it invites an outburst of corollary questions:

How much water will be consumed by an accelerated program?
Where will this water be diverted?
Where will this water be used?
When and for how long will this water be used?
Will this water be taken from existing uses?
Will large storage and diversion facilities supply this water?
Who will develop this water?

Without detailed responses to these questions, it is impossible to adequately, specifically and accurately respond to the original question. Depending on the responses to the associated questions the answer might range from an emphatic "yes" to a possible "no."

Synfuel development in Montana would most likely occur in the Yellowstone and/or Missouri river basins. These two basins cover 82 percent of Montana's land area and produce 39 percent of its water. Agriculture dominates all facets of life in this part of Montana; exemplified by the fact that irrigation accounts for 98 percent of the water diverted from the streams in these basins. In addition, from the internationally known trout streams in the headwaters to the productive and unique sauger, paddlefish, and shovelnose sturgeon fisheries in the lower reaches, the basins hold abundant water-dependent wildlife and recreational resources. As important, though of smaller volume, is the water from these streams that furnish the domestic water needs of Montanans. Large-scale depletions for an accelerated synfuel program would unquestionably and adversely affect these water uses in some areas. Moreover, Montana is concerned about potential impacts of synfuel development to traditional social economic and political values.

Montana's concerns have been reflected in the Western Governors' Policy Office (WESTPO) plan for energy self-sufficiency that established four major points:

A phased process of synfuels development be installed with Montana guiding the siting and pace of the development.

State-federal partnerships be implemented to achieve short-term energy conservation.

State-federal partnerships be implemented to mitigate undesirable socio-economic impacts of synfuel development.

Synfuel development must occur only under a scenario of improved intergovernmental consultation and concurrence.

[1] Position paper by the State of Montana.

More specific response to Senator George McGovern's additional questions posed to Professor Wilson F. Clark follow.

1. How closely have federal and state governments examined the availability of water for coal-based synfuel development in the Northern Great Plains? How closely do we need to look before proceeding with a synfuel program? Who should do the looking?

A number of state, federal and private research studies [2] have addressed the question of water availability for energy development in Montana. Several of these studies were quite detailed and although they did not evaluate precisely the same volume of water associated with synfuel programs being considered by Congress, they do conclude that water is generally available for a high level of energy development. However, significant caveats must be attached to this conclusion; for example, Indian reserved water rights may restrict water availability, large storage and/or conveyance facilities may be necessary, interbasin water transfers may be required, or in certain areas water may have to be taken from existing uses.

Such warnings clearly indicate that detailed site-specific water availability studies are essential before synfuel plants can be properly sited. Montana water law mandates that existing water users not be adversely affected by new developments. Significantly, it also stipulates that large agricultural water rights cannot be transferred to industrial use. The Montana Department of Natural Resources and Conservation would analyze water availability subsequent to receipt of a water permit application for a synfuel plant.

Several potential sources of water for synfuel development should be mentioned.

The U.S. Bureau of Reclamation and Montana Department of Natural Resoucres and Conservation (MDNRC) hold water reservations for four water storage projects in the Yellowstone River Basin. The total firm water supply for these projects exceed 500,000 acre-feet per year.

Yellowtail Reservoir, a U.S. Bureau of Reclamation impoundment on the Bighorn River (tributary to the Yellowstone River) could supply over 600,000 acre-feet per year on a continuous basis.

The MDNRC, through contract with the U.S. Bureau of Reclamation, can market up to 300,000 acre-feet of water per year from Ft. Peck Reservoir on the Missouri River.

However, Indian reserved water rights and an interstate compact may limit the utility of these sources for synfuel development in Montana.

2. Would an accelerated coal-based synfuel program such as that presently being considered by Congress threaten, in any fashion, the future growth and development of the agricultural economics and municipalities of the Northern Great Plains? Are present federal and state laws and policies sufficient to safeguard present and projected non-energy uses of the region's water resources?

As mentioned previously, Montana water law prevents existing water users from being damaged by new water developments and, in addition, precludes the transfer of large agricultural water rights to industrial use. As Dr. Wilson F. Clark will point out to the committee, the water law also provides for water to be set aside for future consumptive use and for protection instream. This action, known as the Water Reservation Doctrine, has been completed on the Yellowstone River Basin and will be briefly summarized in response to question 4.

Consequently, Montana water law is generally sufficient to safeguard present and projected non-energy uses of water. Any federal attempt to override Montana water law to provide water for synfuel development will preclude the possibility of expeditiously obtaining reasonable quantities of water through the state system and result in protracted state-federal antagonism.

3. How much water management, i.e., water storage and interbasin transfer programs, would be necessary to accommodate a coal-based synfuels develop-

[2] Northern Great Plains Resource Program. Report on the Work Group on Water. December 1974; Missouri River Basin Commission. Yellowstone River Basin and Adjacent Coal Area Level B Study. Volume 1. November 1978: Missouri River Basin Commission: Upper Missouri River Basin. Water Availability Assessment for Coal Technology Requirements. December 1978; Montana Department of Natural Resources and Conservation. Yellowstone River Basin Draft Environmental Impact Statement for Water Reservation Applications. December 1976: Montana Department of Natural Resources and Conservation. The Old West Regional Commission. The Yellowstone Impact Study. Vol. 2–11. 1977; Resources for the Future. Inc. Constance M. Boris and John V. Krutilla. An Integrated Approach to Analysis of Water for Energy with Special Application to the Yellowstone River Basin. 1978.

ment program such as that being considered by Congress? How much water management would be environmentally tolerable?

Several levels of synfuels development are being considered by Congress; furthermore, any adopted program may be significantly different than those now being offered. Accordingly, it is impractical and impossible to respond definitively to this question. However, it is apparent that a high level of synfuels development would require significant investments in water storage and/or conveyance facilities.

The vast number of alternative sites, sizes, corridors and mitigation measures possible for these facilities render a general statement on their environmental acceptability meaningless.

4. What policy alternatives exist for mitigating any potential conflicts between coal-based synfuel development and non-energy uses of water in the Northern Great Plains? For example, what are the implications of Montana's water reservation program for non-energy water use in the Yellowstone River Basin? Does it effectively foreclose synfuel development in the State of Montana? Does it threaten the water resources of other, downstream states? Would such a program be beneficial for other states to undertake?

The best possible mitigation measure the Congress can provide for synfuel development in Montana is to mandate that development corporations adhere to procedural and substantive state laws, including but not limited to the Montana Water Use Act, the Montana Major Facility Siting Act, the Montana Environmental Policy Act, and the Montana Water Quality Act.

The Montana Board of Natural Resources and Conservation established water reservations in the Yellowstone River Basin in December 1978. Water was reserved for eight communities, fourteen conservation districts, several irrigation districts and a number of federal agencies. Sufficient water was reserved for these cities and towns through the year 2005, while enough water was reserved for agricultural interests to irrigate 260,000 acres. Instream reservations at the lower end of the Yellowstone River total about 60 percent of the average annual flow. Dr. Wilson F. Clark will present much more detail on this process and the results in his testimony before the committee.

Water rights (through the water reservation process) have been obtained for municipal, agricultural and instream purposes that will largely protect non-energy uses in the Yellowstone River Basin through the year 2000. Some exceptions should be noted: (1) not all potential irrigators are represented by agricultural water reservations, (2) not all municipalities applied for reservations, and (3) unincorporated towns are not eligible to apply.

The water reservation process does not foreclose synfuel development in Montana, but it will make that development more expensive. Previously, a constant supply of water could have been diverted directly from the Yellowstone River—even during dry years and seasons. Now, all flows are reserved for other purposes in those low flow years and costly storage facilities will be necessary to ensure a continuous supply of water. Regardless, there are a number of water supply options (those mentioned earlier, e.g., Yellowtail and Ft. Peck Reservoirs) that are unaffected by the water reservation decision.

A major criticism of the decision to reserve large flows instream is that it guarantees water to downstream states—water that should be consumed in-state, according to water development advocates. Amendments to the Water Reservation Doctrine, passed by the 46th Montana legislature, clarified the authority of the Board of Natural Resources and Conservation to reallocate instream flows to consumptive uses. While it is doubtful that any large reallocation will occur in the near future, Montana will undoubtedly use the Water Reservation Doctrine (including recent amendments) to preserve its right to use state water.

Several western states have statutes that provide for the reservation of water for future use. A number of other states are considering such a system. While water reservation programs provide a mechanism to set water aside for future use, the only long-term solution to interstate water conflicts is the ratification of water compacts.

In summary, the question of water availability for synfuel development can be answered definitely only on a site-specific basis. Claims that water is generally available for synfuel development must have serious caveats attached. Most importantly, Montana reaffirms its authority for allocating and managing its water resources and will resist any federal intrusion or attempt to override state water law.

[From the March/April 1979 issue of "Montana Outdoors" (the Magazine of the Montana Fish and Game Department)]

THE RESERVATIONS CHALLENGE

A Free-Flowing Yellowstone[1]

(By Dr. Wilson F. Clark)

The final decisions on the Yellowstone River water reservations were made by the Montana Board of Natural Resources and Conservation on Dec. 15, 1978. Since then, each applicant for a reservation has been informed of the specifics of its own reservation. But few people aside from the applicants are aware of what those decisions were, what they really amount to or why some applicants received all or a large part of their requests while others received a much smaller part or were totally denied. This article endeavors to make those points clear.

The Yellowstone River moratorium went into effect in spring 1974 as a result of the growing concern over large industrial filings for water. The law invited "public bodies" to lay out their long range water plans and to apply for water reservations to meet their expectations of growth. The "public bodies" finally applying were eight cities, 14 conservation districts, two irrigation districts, four state agencies and two federal agencies. Industrial users were not allowed to request reservations.

Applicants got a slow start for many reasons. The actual eight weeks of hearings did not occur until summer 1977, and the final summary hearing did not occur until summer 1978. The board did not receive the full record until mid-September 1978. Only then could the board really start its deliberations. Because of several extensions of time granted by the Montana Supreme Court, the board had until Jan. 1, 1979 to complete the immense amount of work needed and to make its final decisions. It was a challenging task, but board members got the job done.

While all this was going on, much heat and little light were generated, for each applicant fiercely defended its own request and just as fiercely attacked the requests of some other applicants. Many absurd statements were presented as gospel, such as: "If all the applications were accepted, the river would be dry, because the sum of all the applications is two and one-half times the average flow of the river." How silly this statement was is shown by the final results. The board rather wistfully wishes that folks would not get needlessly upset, irate and polarized on the basis of such irresponsible statements, and it wishes that advocates would outgrow their tunnel vision. Despite all that, the laborious process was carried out and the decisions were made.

In making their decisions, the board members were in general agreement on several critically important concepts and on the philosophy with which they approached the decisions. These include:

(1) Board members believed their ultimate responsibility was to the people of Montana in general and to those in the Yellowstone River Basin in particular. Such responsibility transcended the reservation requests of the many applicants, each of which considered its own reservation paramount. The board endeavored to take a long-range overview, to put the applications into perspective and, as far as possible, to reconcile the many conflicting and sometimes excessive water reservation requests.

(2) Board members were fully aware of the complexity of this case. From the outset, it was evident that the newness of the reservation concept, the stringency of the regulations and the magnitude of the task of preparing applications put a heavy burden on the applicants and on the Department of Natural Resources and Conservation charged with reviewing the applications. The board viewed those difficulties with understanding and did not take an ultralegalistic stance.

(3) Board members were inclined to grant, in each case, the largest reservation that could be justified by the application, the record, the evidence and the available water supply. The decisions are not etched on stone, since the law requires a thorough review of the reservations at least once every 10 years, at which time the board may "modify" the reservation.

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[1] Members of the Board of Natural Resources and Conservation involved in decisions on the Yellowstone water reservations were Cecil Weeding, Jordan, chairman; William H. Bertsche, Great Falls, Dr. Wilson F. Clark, David G. Drum, Billings; Charles L. Hash, Kalispell; J. Viola Herak, Charlo; and Dr. Roy E. Huffman, Bozeman.—Ed.

(4) Board members believed that every encouragement should be given to development of off-stream storage with pumping from the Yellowstone River during high-water periods. We saw off-stream storage as the only way high-water flows could be made available for later release during low-flow periods to benefit all downstream users and in-stream reservations.

(5) Board members also believed they had an obligation to foster, encourage and suggest conservation measures for the use of water. The prodigal-use attitudes of the past are no longer tenable. Efficiency of water delivery and use, conservation in use and a sense of personal responsibility must be developed by each user. Only through such changes in attitudes leading to changes in habits and patterns of use will we leave a water legacy for future generations of Montanans.

In making decisions within this framework, board members recognized that Montana is a state where natural resources—especially water—support both economic activity and nonmarket uses. This has produced a classic conflict between economic values and environmental values. The availability of water is central to the natural resources situation in most instances. Board members had the responsibility of achieving a balanced allocation of water in the Yellowstone River Basin to meet the needs of consumptive uses and in-stream reservations. The major problem was to ensure realistic consideration of all factors that should enter into the water reservations.

DEFINITIONS

Before discussing the Yellowstone reservations, it is important that the following frequently used terms be clear:

(1) Acre-foot (Af)—An amount of water that covers one acre to a depth of one foot. This amounts to 325,900 gallons.

(2) Cubic feet per second (cfs)—a water flow. A flow of one cfs continuously for a year amounts to 724 Af.

(3) Gallons per person (or capita) per day (gcd)—derived by dividing the total gallons used by a city in a year by 365 days and then by the population.

(4) Percentile flow—River flows are commonly expressed as percentile flows and are calculated from many years of stream gauging records. Percentile flows are based on the amount of time a given flow is exceeded. A 90 percentile flow is the amount of water that would normally be exceeded in the river during nine years of 10 or, in other words, a fairly low flow. To put it another way, only once in 10 years can the river be expected to be so low that it would have less than the 90 percentile flow. An 80 percentile flow would be that amount normally exceeded in the river eight of 10 years. So the *higher* the percentile number, the *lower* the actual flow of the river. An average year is approximately a 50 percentile flow.

CITY RESERVATIONS

Within the Yellowstone Basin are some 60 towns and cities. Only eight actually applied for reservations. Many are very small; many do not have central town water systems; many are on wells. For the latter, the reservation applications were not necessary. Board members were concerned about some towns such as Sidney and Hardin that did not apply; but the board could not consider them since they did not apply.

Of the eight reservations received, only Broadus is on wells. The rest depend on the river. Of those seven river cities, each applicant estimated the population it would have by the year 2000 or beyond, then estimated the gcd (gallons per person per day) and finally came up with an acre-feet per year (Afy) value. What the cities did not seem to understand is this: The final reservation is for the water needed to meet the *increase* of use and population—it is not for the total water to be used in that future year. Each reservation was finally determined in terms of total water needed in that future year minus the estimated present water use.

When the board analyzed the applications, some astonishing gcd values were revealed. For instance, Billings for year 2070 wanted 472 gcd; Big Timber for year 2000 wanted 1,334 gcd, and Miles City for year 2000 wanted 625 gcd. These figures were considered excessive, particularly since the average gcd for all cities in the Yellowstone Basin in 1970 was 212 gcd. In 1975, for Billings alone the figure was 210 gcd; for Yellowstone County cities and towns in 1970 it was 198 gcd and for Custer County towns in 1970, the figure was 210 gcd. After a great

deal of discussion and calculating, the board adopted a standard of 250 gcd and applied it to all seven applicants.

For population estimates, the board relied on a number of careful studies and projections. For three applicants (Big Timber, Columbus, Laurel) population projections were accepted or only slightly modified. For Livingston, Miles City and Glendive, the population projections in the applications could not be supported, and considerable modification was made in each. Those six just mentioned applied for reservations to either year 2000 or year 2007.

With Billings, a different problem arose. Billings applied for the reservation for the year 2070, for a population of 600,000 people in the water service area. Growth studies, graphs and data tables all seemed to have an adequate basis up to the year 2000 and a little beyond. But then it seemed the projection from there to 2070 was made only by drawing the graph in an ever-steepening line. No. one could or can prove that the Billings projection for 2070 is wrong or right—only time will tell. But board members believed the projection was on shaky ground and we compromised by taking, from the evidence Billings itself supplied, the population of 206,000 (at 235 gcd) for the year 2010. The board finally used a population of 206,000 at 250 gcd. The result was that Billings actually received a bit more than it asked for up to the year 2010.

These city reservations all have first priority in the basin. With that assurance, plus the reasonable final reservations, the board believes the cities are now in a water rights position to vigorously pursue planning for their expected growth.

IRRIGATION RESERVATION

Applicants for irrigation reservations included 14 conservation districts, two irrigation districts, the Department of State Lands (three applications), one from the Bureau of Land Management and one from the Bureau of Reclamation. The total of all the irrigation applications was for 1,176,559 Af of water, to irrigate 443,711 new acres. These applications were only for new irrigation and in no way affected, changed, covered or reduced present irrigation water rights.

The basic problem in analyzing these reservations was in determining whether or not water was actually available either in the rivers or in planned storage dams. Of the 21 applications, 10 received as reservations the full quantity requested, or very nearly that amount. Three upstream applicants stated that parts of their applications depended on developing considerable storage, but the applicants further stated they had no plans to do so. For those, the board accepted at full value the parts of the request that did not depend on storage. One applicant asked for over 124,000 Af for a large number of small units, but then stated that only three of those were likely to be developed, based on economic, engineering and feasibility studies. The board accepted only those three.

One large application on the Bighorn was denied because the applicant stated that water for the Hardin Bench was already reserved in Yellowtail Reservoir. And one application (the Huntley Irrigation District) requested 6.8 Af of water per acre—a figure about three times the average water usage per acre for all other full service irrigation applications. This one was denied for a number of reasons.

The real problems came on the Tongue and Powder rivers. On the Tongue, after considerable study, the full-service requests were met by granting the Department of Natural Resources and Conservation its application for expansion of the storage capacity of the Tongue River Reservoir and stating the irrigation requests must be met by releasing water from the reservoir. On the Powder, the difficulty was that there was no storage, and that the flows of the Powder are low and laden with dissolved salts. The 29-year average (or 50 percentile) flow of the Powder was about 300,000 Af while the low flow was only about 32,000 Af. Yet the irrigation requests on the Powder were for 24,300 Af for waterspreading and 166,896 Af for full-service irrigation, for a total of 191.196 Af. The board finally accepted all the waterspreading requests and denied all the full-service requests on the Powder River.

For the 21 irrigation requests, most of the applicants came out vey well, except the Hardin Bench and Huntley Irrigation District which were denied, the three up-river conservation districts which would need storage but had not planned on any and the full-service irrigation requests on the Powder River.

STORAGE REQUESTS

Storage requests included three proposed off-stream reservoirs as applied for by the Bureau of Reclamation and one request from the Department of Natural Resources and Conservation to considerably expand the storage capacity of the present Tongue River Reservoir. The board granted all four of these. The off-stream reservoirs were seen by the board as the only long-range hope for supplying water downstream during low-flow years in the future, if all the irrigation reservations are actually developed. The idea, as stated in the conditions the board wrote, is to pump water into those reservoirs in periods of high flow, so that it is available for later release. Since those three would be federal projects, there are many problems to be worked out, but at least the board did what it could to assure storage water rights.

As for the Tongue River Dam, the Department of Natural Resources and Conservation says the present dam is becoming unsafe. The price tag for making the present dam safe is only a little less than the price tag for redesigning and raising the dam to allow about 5½ times as much storage. The board believed this enlarged reservoir was the answer not only for supplying the irrigation requests on the Tongue and assuring flows for fish and wildlife, but also for having some water available for industrial sales.

IN-STREAM REQUESTS

There were 135 specific locations where in-stream requests were made—94 from the Department of Fish and Game, three from the Department of Health and Environmental Sciences and 38 from the Bureau of Land Management. The whole idea of in-stream reservations is quite new. The board fully agreed with the legitimacy and necessity of assuring that adequate water remains in the streams to maintain fish, wildlife, water quality and recreational values. The problem was in balancing those requests against the equally legitimate requests for diversion of the water by cities and irrigation applicants.

The board met this problem in two ways:

(1) For the Yellowstone system above Billings, the board believed the in-stream values were of major importance; below Billings, the in-stream values were not as critical. To express this in legal form, the board signed the final orders in this sequence to establish priority: (1) municipal reservations, (2) in-stream reservations above Billings, (3) all irrigation reservations, (4) in-stream reservations below Billings and (5) all storage reservations.

(2) The board assigned fairly generous in-stream reservations during the nonirrigation months and considerably lower in-stream reservations during May through September, particularly for the system above Billings.

As a result of these two actions, the board was able to meet the major requests for irrigation and at the same time meet, to a surprising degree, a major part of the in-stream requests. For instance, at Livingston the in-stream reservation is at 20 percentile flows for Oct. 1–April 30, but only 95 percentile flows for May 1–Sept. 30. The 95 percentile in-stream flow means that in 95 years of 100, there will be more water than the in-stream flow value and no conflict with the irrigation reservations. So, even though in-stream water has priority over irrigation water near Livingston, a competitive situation would occur in only five of 100 years or, at worst, only 10 years in 100. Between Livingston and Billings, the competition may occur 15 or possibly 20 years in 100.

At Billings, an in-stream reservation of 75 percentile flows was granted. At Miles City and Sidney, the in-stream reservations granted were for about 80 percentile flows less the depletion up to those sites. In the lower reach of the river (below Billings), irrigation has a higher priority than in-stream concerns. Even there, the competition would occur at worst in only two years of 10.

Obviously, there was duplication in the many in-stream requests. Recognizing this, the board assigned reservations for duplicate requests as a single value for a specific site. Thus, the reservation at Billings, Miles City and Sidney serves both the Department of Fish and Game and the Department of Health and Environmental Sciences; on many smaller streams, the Department of Fish and Game and the Bureau of Land Management reservations overlap.

While the in-stream reservation at Sidney protects the river values for Montanans, it has another very significant effect: to assure North Dakotans that at least 5.5 million Af will reach them. The often-heard cry of "use it or

lose it" has been answered by the decision that in-stream water is now a "use," and yet this use does not deprive North Dakota of also being able to use the water that Montana has allocated for in-stream purposes. In addition, by making that much water available to downstream states, there is not much likelihood of the downstream water users eating into the unallocated and unreserved water still in the river in seven years of 10. If that presently unreserved water is filed on soon, it too would be protected.

THE WATER BUDGET

The object of this whole process is to find out what all these reservations do to the river. To get at this, the board first needed to know the status of the Yellowstone River before reservations. An analysis of the current status of the river reveals that it is in quite good condition down to Miles City. But it also shows that between Miles City and Sidney there is very little increase in flow even in the average year, and in low flow years, there is actually less flow at Sidney than at Miles City now.

With those figures as a base and considering the reservation applications, the water budget was developed. For each major segment of the river, the depletion due to diversionary uses was subtracted from the present flows for each of the percentile years. This gave an indication of what would be left in the river. Then the in-stream reservation was subtracted, and the difference represents the amount of water not now used and not reserved. This is the water to cover future filings.

Since most irrigation and city requests have been met through at least the year 2000, that unreserved water probably represents the water base for future industrial filings and for other small diversion filings. The problem, however, is that the unreserved quantity of water disappears in low flow years. It just isn't there. What this means for possible industrial users is that while a lot of water is available to them in average flow years or above average flow years, they would have to create their own off-stream storage to cover their needs in low flow years, or else they would have to hold firm purchase contracts for water to be supplied from the Bureau of Reclamation off-stream storage projects or from the Tongue River Reservoir.

INDIAN WATER RIGHTS

The comment has been made that the board was wasting its time making reservations, because Indian water claims are not yet settled. There are several facts which apply to that comment: (1) Indian reservations in the Yellowstone Basin involve only the Bighorn, Rosebud and Tongue rivers. (2) Because of this, the board's decisions on those rivers may well be in question and certainly if a large part of the Bighorn water is finally judged to be Indian water, then heavy diversions below the Bighorn would be affected. (3) The board was required to carry out the process and make final decisions by a certain time, and it did not have the option of waiting for the slow legal wheels to grind out the Indian water decision. (4) The decisions on water above the Bighorn are not involved in the Indian water claims. (5) The board's decisions were made to help put the long-range plans for uses of the Yellowstone into perspective.

Because the board made the decisions demanded of it by law does not mean the board was unaware of the potential impact the Indian water case might have. But the Indian water case was entirely outside the jurisdiction or influence of the board. Consequently, the board proceeded to discharge its obligations under the law.

CONCLUSION

The job of assigning water reservations is done. Now the monkey is on the applicants' backs, for the law states that all reservations will be reviewed at least once every 10 years and may be modified by the board after that review. In order to spur action on the part of the applicants, the board has directed each to report on progress within five years, with a few at three years. This does not mean that an applicant must be charging ahead and expanding beyond its means. But it does mean that applicants cannot let the reservation documents gather dust on a shelf. They must show significant progress in one or more areas such as planning, engineering or gathering more data than the sometimes sketchy data base of the application.

The board has done its job to the best of its ability. Only the future will show whether it was a sound, statesmanlike job, and whether the people of Montana have risen to and sensibly answered the challenge of assuring that future generations of Montanans will have an adequate and healthy water base.

Senator McGOVERN. Mr. Hall, please proceed.

STATEMENT OF MILLARD W. HALL, CHAIRMAN, MISSOURI RIVER BASIN COMMISSION, OMAHA, NEBR.

Mr. HALL. Thank you, Senator. I have submitted a prepared statement for the record. I am responding to questions that you raised in an earlier letter to me regarding this entire issue. I will try to summarize this testimony in a helpful way.

My testimony is based on three studies that have been done within the past 5 years in the upper Great Plains area.

The first of those was the study done by the "Northern Great Plains Resources Program;" the second one is the "Yellowstone River Basin and Adjacent Coal Area Level B study;" and the third is the "Upper Missouri River Basin Water Availability Assessment for Coal Technology Study," specifically looking at some of the questions that you have raised in this hearing today.

All three of these studies covered the same area and essentially the same data. The first was the Northern Great Plains Study which was a reconnaissance level study of the availability of information. The level B study was aimed at developing a comprehensive water and related resource management plan. The "Water for Coal Technology Assessment" looked specifically at the problems of water and coal development.

The Northern Great Plains Study, published in 1975, projected three levels of development for the area and concluded ample water to be available at all three of those levels. Furthermore, it concluded that water would be available for both the energy development and traditional uses of water, with the possible exception that extenive future irrigation development above Fort Peck might lead to requirements for additional storage water transfers.

The level B study established a base year for which conditions were known—1975—and projected those conditions forward to 1985 and the year 2000 at a high level of development, a low level of development, and a most probable level of development.

Again, the basic results of those efforts and projections was the conclusion that there would be sufficient water to the year 2000 for all projected uses—at even the maximum level of coal development used in that study—but that there might be problems with maldistribution of water in time and space at the maximum level of development.

The "Upper Missouri River Basin Water Availability Assessment for Coal Technology" looked at different scenarios for coal development than those used in the level B study, some higher level of activities than we had considered before; levels which I understand are somewhat higher than those now being considered by Congress for the synthetic fuels program. But, again, this study shows that at the projected maximum level of development water will be available for both synfuel development and for traditional needs. This study, like the

others, did demonstrate the possibility of some problem of supplying water for all the projected uses in certain parts of the basin, particularly the Tongue and Powder River Basin tributaries to the Yellowstone, during periods of low flow.

In summary, in answer to one of the questions you raised in your letter to me, it's my opinion that there have been adequate general studies of this subject in the northern Great Plains. I think that the three studies that I have cited have massaged all of the data that is now existing with regard to coal development and water availability and projected usages, and the three studies conclude essentially the same thing: That there's enough water; but that it might not be there at the right time or right place at the maximum level of development in the year 2000.

I suggest that further studies of this type really are not needed at this time. What might be more desirable would be researching the procedures and methodologies needed for the expression and integration of the national, regional, and State interests in this matter.

It's been mentioned that there will be some impact upon the traditional economy and communities of the northern Great Plains as a result of the proposed synfuel program. There will be, of course, the boomtown effect. That will have to be addressed. However, I want to look specifically at the water requirements.

It's my understanding that the maximum development level in the year 2000 would require about 275,000 acre-feet of water per year above and beyond the water protected for use by traditional users in this area.

Analysis indicates that this additional water requirement for new development of that type, would deplete the annual Yellowstone River flow at Sidney, Mont., by only 1 percent. The flow would be 99 percent of that which would occur without the proposed energy development. However, the annual discharge of the Tongue and Powder River would be reduced to approximately 75 percent of the level expected without the synfuel development. This is significant because it tells us that if development occurs in those areas, we are going to have to employ additional water management schemes of some type or another.

Now, another thing that has not been mentioned this morning—at least I haven't heard it—is that all such estimates about availability of water and its distribution in time or space has to be tempered with consideration of the unknown inherent in the Indian water rights question. And I don't know how you propose to get at that. We have ducked it and based our studies on certain assumptions about continuing to do things the way we have been doing them, with respect to Indian rights.

In terms of the questions you asked about the adequacy of present laws and regulations for safeguarding nonenergy water uses, the "Yellowstone Study" did address certain policy issues which I should point out to you. The study called for the Congress to adopt a national energy conservation program which would minimize the impact of energy development on the upper Great Plains. It also called for States to pass legislation that would put them in a position of being able to more effectively manage their resources in an interstate way under increasing demand for water.

"The Yellowstone Study" also spoke to recommendations—policy recommendations—regarding environmental concerns, when it asked the Congress to provide additional funding for accelerated programs, and for monitoring and research activities related to air and water quality and the effect of interaction between man and his environment in these sensitive areas.

It also asked for the States to look at policy decisions that would bring them closer to the national aims with regard to environmental concerns; that is, that the States should provide for full disclosure of the environmental impact of substantial actions other than those which are federally funded.

In terms of water management activity, you questioned Mr. Martin about his statements, both prepared and oral, and how they differed from Ms. Clusen's statements. I don't think, from my perspective, that there is a great deal of difference in the two, and I think my prepared statement supports both of them and supports all the other testimony that's been given this morning.

I think it's a question of when do you want the water and where do you want it. Undoubtedly there's sufficient water there. Undoubtedly we are likely to run into problems in reaching the maximum level of energy development projected by the year 2000. But we are unlikely to encounter these problems with the next 10 years.

It's a question of: Do you build new storage facilities or do you get at the problems inherent in interbasin transfer? Our studies looked at the possibility of providing water in low water years, and concluded that you could do that by an additional investment of somewhere between $25 and $50 million annually, depending on whether you choose to bring the water from the closest available sources or whether you choose to bring it from a more politically feasible source.

In terms of the environmental impacts associated with such activities, we looked at the impact on terrestrial ecosystems, fishery habitates, water quality, and air quality. All this is covered in the testimony and essentially boils down to the fact that if we follow all the current rules and regulations we think there should be little nonmitigable impact on the environment.

Now, that's a big if—if we do it the way we know how. That's because in many cases we don't really know how, very well, to control pollution from some of the kinds of proposed facilities that we are discussing. And that itself is going to require, I believe, considerable additional investment in research and development.

I would like to emphasize a point that has already been made with regard to conflict and litigation over water rights. I believe to get at this whole question of the allocation of water for energy and other development most effectively, we are going to have to continue to salute the States' water rights systems. I think it's perhaps the strongest, only workable method, for controlling and therefore mitigating potential conflicts between water users.

An additional opportunity for mitigation of such conflicts is increased technical assistance to the States for their research, planning, educational, and enforcement programs.

I agree with my colleagues' earlier statements regarding Montana and its water reservations program. It's a good program; one that will

improve the water situation in the downstream States. I don't think there's anything to fear from that program with regard to water for energy development. I don't think that I would recommend it particularly for other States, as its successful use depends upon other elements of State water law and institutions.

There are other ways of getting at the same thing. For example, I think enacting a comprehensive State water plan might do the job just as well. Also, I know that some States are considering the addition of certain in-stream uses as a beneficial priority item in their State water law considerations.

I think a more important element with regard to laws and institutions and their effect on water allocations would be the Yellowstone compact. Article X of that compact essentially prevents water being used or transferred even within the basin, even within the State of origin, without the consent of the other two States which are signatory to the compact.

For example, this compact is now preventing Wyoming from diverting water without the consent of Montana and North Dakota from the Yellowstone Basin to the vicinity of Gillette for use in coal processing, even though it's Wyoming water.

A couple of States think that that's a good deal and others think it's not. I don't know. But I do know that in terms of getting water to where it is going to be needed that article X of the Yellowstone compact is going to be a great consideration.

I think I will close with that, Senator, unless you have questions for me.

Senator McGovern. I will have some questions, but we will hold those for the moment. Thank you.

[The prepared statement of Mr. Hall, together with a paper entitled "Interbasin Transfers in the Missouri River Basin," follows:]

PREPARED STATEMENT OF MILLARD W. HALL

SUMMARY

This testimony presents the findings of three major regional studies dealing with water supply needs and environmental quality concerns arising from proposed development of coal resources in the Upper Missouri River Basin. It is concluded that further reconnaisance-level studies on these matters are not needed at this time. Further, there is an adequate quantity of water to meet traditional demands in the region as well as the new demands associated with the proposed level of coal development until at least the year 2000. However, changes in interstate compact agreements, alteration of State laws and regulations regarding transbasin diversion, and additional expenditures for water planning and management programs and structures are likely to be required to insure that this water is made to be at the appropriate time and place.

Present environmental regulations and programs undoubtedly will be useful in miligating or preventing major environmental damages. However, additional research and educational and technical assistance likely will be required at the state and/or regional level to assure minimal environmental impact.

INTRODUCTION

Skyrocketing prices for and shortages of petroleum products, especially gasoline, have driven home the fact of America's substantial and growing dependence upon imported oil. In response to this situation, demands for national energy independence based partially upon the development of "alternative" energy sources have become common.

One of the alternatives most frequently cited as promising is the development of the vast coal deposits in the West. In the Missouri River Basin, coal resources are concentrated in the Yellowstone River watershed and an adjacent area of western North Dakota[1]. Coal reserves in those portions of North Dakota, Montana, and Wyoming lying within the Basin have been estimated at approximately 165 billion tons.

The Federal Government and affected States have intensified their investigations of the impact of potential synfuel development upon the availability of water in this area since this issue became important in the early 1970's.

EXISTING STUDIES

Three studies generally assessing the anticipated impact of energy development in this part of the Northern Plains have been completed in recent years. They are the Northern Great Plains Resources Program (NGPRP),[1] the Yellowstone River Basin and Adjacent Coal Area B Study,[2] and the Upper Missouri River Basin Water Availability Assessment for Coal Technology Requirements.[3] All three studies involved both State and Federal entities; all three examined the issues surrounding water availability for energy-related resources development. Their principal differences were matters of overall scope and purpose.

NGPRP STUDY

The NGPRP, organized in 1971, was a joint effort by three Federal agencies: the Department of the Interior, the Department of Agriculture, and the Environmental Protection Agency; with the State governments of Montana, Nebraska, North Dakota, South Dakota, and Wyoming; and other entities also involved. Its purpose was to provide a focal point for the collection, coordination, and communication of knowledge about the natural resources of the Northern Great Plains and the relationship of human activities to these resources.

Among its tasks, NGPRP sought to determine water requirements for coal development in this region and the effects such development would have on water and related resources.

The NGPRP findings published in 1974 projected three levels of development for the area and concluded that ample water would be available at all three levels. Furthermore, water would also be available at all proposed energy plant locations in the Yellowstone Basin for each of the three possible levels of development although suggested instream needs would not always be met. This study further concluded that from Fort Peck Dam, Montana, on downstream, no additional storage would be needed for the alternatives considered, but that extensive future irrigation development above Fort Peck could lead to a requirement for new storage.

YELLOWSTONE LEVEL B STUDY

The Missouri River Basin Commission (MRBC) led the second study of water and coal development in this region—the Yellowstone River Basin and Adjacent Coal Area Level B Study—completed in 1978. This study involved several Federal agencies; the States of Montana, Wyoming, and North Dakota; and other entities. The impacts of energy development upon the area's water resources was one of four concerns addressed by the study. (Others included water needs for agriculture, maintenance of instream needs including water quality, and Indian water resource use.) The ultimate goal of the study was an overall plan for water and related resource development in the region.

The Yellowstone Study methodology established a base year for which conditions were known—1975—and projected conditions for the years 1985 and 2000 at high, low, and "most probable" levels of development. These projections formed the basis for recommendations.

The resulting plan included a single coal gasification plant in North Dakota and one in Montana with a total projected 1985 production capacity of 500 million standard cubic feet per day (mmcf/day). No other synfuel development was con-

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[1] Northern Great Plains Resources Program. *Report on the Work Group on Water.* December 1974.

[2] Missouri River Basin Commission. *Yellowstone River Basin and Adjacent Coal Area Level B Study, Volume I—Report and Environmental Assessment.* November 1978.

[3] Missouri River Basin Commission. *Upper Missouri River Basin Water Availability Assessment for Coal Technology Requirement—Final Report.* December 1978.

sidered for 1985. The requirements for land, labor, capital, and water associated with high, low, and most probable levels of coal development defined by the study are shown in tables 1, 2, and 3.

UPPER MISSOURI ASSESSMENT

More recently, the MRBC conducted a study entitled "The Upper Missouri River Basin Water Availability Assessment for Coal Technology Requirements." This assessment was very closely related to the Yellowstone Level B in that it considered the same region and the same data as the previous study, but examined an additional set of water demands for synfuel development above and beyond those considered in the Yellowstone Level B Study.

This assessment was intended to determine water supply availability for the development of emerging coal technologies against a background of conventional water needs. It showed that at the maximum level of development considered (see tables 4 and 5) water was available for both synfuel development and traditional needs. However, this study also demonstrated that problems would be encountered in the Tongue and Powder River Basins (tributaries of the Yellowstone River flowing primarily through Wyoming) during periods of low flow.

SUMMARY

In summary, these three studies provide adequate reconnaissance-level analyses of levels of coal development and related water demands likely to occur on the Northern Plains until the year 2000. The fact that no commercial-scale coal gasification plant has been operated in this country suggests that more knowledge might be gained from the construction and observation of a commercial-scale plant than through further studies of the type already conducted. Further research aimed at procedures and policies needed for the expression and integration of national, regional, State, and local needs and interests in this matter might also be appropriate.

IMPACT UPON TRADITIONAL ECONOMY AND COMMUNITIES

It is my understanding that the level of development of the coal-based synthetic fuels program presently being considered by the Congress is somewhat below that of the maximum development level analyzed in the Upper Missouri Water for Energy Assessment. As shown in table 4, this maximum level calls for high Btu coal gasification production of 1,750 mmcf/day by the year 1985 in the study area with no other synthetic fuels production forecast. By the year 2000, high Btu gasification was predicted to be 6,500 mmcf/day; low Btu gasification would total about 5,000 mmcf/day; and coal liquefaction in the study area would total about 400,000 bbls/day. Based upon unit-size plants (250,000 Btu's per day) as considered in the assessment, these levels of production translate to seven high Btu gasification plants by the year 1985; and 22 high Btu gasification plants, 2 low Btu gasification plants, and 9 liquefaction plants by the year 2000.

Qualitative threats exist with regard to the problems created by "boom town" development. These problems are addressed in the assessment, but this discussion considers only the question of water availability.

Based upon State estimates, the total amount of water required to be withdrawn for the coal conversion plant at the maximum development level in the year 2000 would be 275,000 acre-feet per year. Providing this amount of water to the conversion plants would entail deleting a minor amount (1,600 acres) of future irrigation identified in the recommended plan of the Yellowstone Level B Study unless additional water management structures and/or programs are developed for the Powder River Basin area of Wyoming.

Analysis indicates that flows in the Yellowstone River itself would be adequate during all months to meet maximum level synfuel water needs in the year 2000. Such would not be the case with respect to the Tongue and Powder Rivers where flows would be inadequate during numerous months without additional storage. The annual discharge of the Yellowstone River at Sidney, Montana, would be 99 percent of that expected without synfuel development, even with the maximum level of development considered in the assessment. The annual discharge of the Tongue and Powder Rivers would be reduced to approximately 75 percent of the level exepcted without synfuels development unless they are augmented by water delivery systems.

The analysis performed in the Upper Missouri Water for Energy Assessment indicates that few if any constraints to growth would be imposed upon the agri-

cultural economy or communities of the Northern Great Plains by the anticipated water requirements associated with the synfuels program presently being considered by Congress.

ADEQUACY FOR PRESENT LAWS AND POLICIES SAFEGUARDING NONENERGY WATER USE

Volume I of the Yellowstone River Basin and Adjacent Coal Area Level B Study contains several recommendations concerning laws and policies directly related to the development of energy and its impacts. Included among these are:

The Congress is urged to adopt a national energy conservation program designed to reduce current and projected energy demands, and provide additional funds for development of innovative renewable energy resources.

The States should pass legislation that would press for resolution of article X of the Yellowstone Compact, with a view toward permitting each State to use its allocated share of available water supplies outside the Yellowstone Basin hydrologic boundaries if it considers such action desirable; and take the lead in working with counties, cities, private interests, and Federal agencies in establishing utility corridors to serve as many service needs as practicable, and in providing legislative or administrative assurance that such corridors be used.

Recommendations were also made in the Yellowstone Level B Study concerning the environment. In recognition of the need for additional educational and research programs to address these concerns, the following recommendations were among those made:

The Congress is urged to enact laws and provide funding for accelerated programs in acquiring and publishing environmental base data on air and water quality, effects of interaction between man and his environment, environmentally sensitive areas, and beneficial effects on various elements of the environment; and expand funding for an air quality sampling network along with research on air quality modeling.

The States should provide for full disclosure of the environmental impacts of substantial actions other than federally funded developments when that action causes significant damage to the environment; is not already subject to the NEPA; and is subject to State funding or State administrative review.

WATER MANAGEMENT AND SYNFUEL DEVELOPMENT

The necessary amount of water management depends upon the selected level of development and the physical location of the synfuel plants. Based on the maximum level of development investigated for the Upper Missouri Water for Energy Assessment, it was concluded that "Several alternatives are available for providing energy-facility water supplies; however, new storage, interbasin transfers, changes in present water use, or ground-water development would be required to assure a water supply at desired locations." The total annual costs associated with the three alternative water delivery systems considered in the assessment ranged from $27 million to $47 million annually depending upon the complexity of the system. The cheapest alternative utilized the nearest available source of water while the more expensive alternatives in terms of dollars involved longer pipeline systems for supply water to the synfuel plants. Costs were estimated at the January 1975 level using a 6.625 percent interest rate.

ENVIRONMENT IMPACTS

The environmental impacts of the maximum level of synfuel development considered in the Water for Energy Assessment were broadly estimated. Such impacts would affect terrestrial ecosystems, fishery habitat, water quality, and air quality among others.

The water delivery systems would affect the lands across which they were built. At the maximum, approximately 32,000 to 37,000 acres would be so disturbed, depending upon the features of the system. Of this total, about 36 percent would be cropland and 32 percent would be grassland. The other 32 percent is brushlands, badlands, riparian habitat, etc.

Impacts upon fish habitat due to reduced streamflow would vary with the water supply source. Of the water supply alternatives considered, the most significant impact upon fisheries would occur in the reach of the Bighorn River downstream from the proposed aqueduct inlet near Hardin, Montana. Resident fishes such as the channel catfish would lose a large percentage of their spawning area below the aqueduct inlet.

Increased water pollutants could be expected from four sources. These sources are: (1) coal mining; (2) coal conversion; (3) population increases; and (4) noncoal-related industrial development.

Coal mining in the assessment area is not expected to result in significant acid-mine drainage because, regionally, the coal deposits have a low sulfur content. In addition, Federal and State effluent standards direct that water control facilities be provided during mining and reclamation so that most suspended solids would be removed from drainage water. Mine drainage, however, would be expected to carry high concentrates of dissolved solids. For purposes of the assessment the effluent standards for surface mine drainage that have been established by the Office of Surface Mining, Department of the Interior, were assumed to be in effect. Under these conditions, the major impact of coal mining on surface water quality would be an increase in total dissolved solids concentrations. Such an increase could affect the suitability of waters so affected for specific uses due to changes in hardness, color, taste, odor, alkalinity, acidity, Ph, and the like.

The affects upon ground-water quality from gasification and liquefaction plants are expected to be similar to those of conventional thermal-electric plants. Leaching of minerals from coal storage and from the liquid and solid waste disposal sites could be expected. However, the control of these leachates are expected to be closely regulated by Federal and/or State environmental control agencies. As a result of such strict control, only limited localized effects upon ground-water quality from synfuel plants are anticipated.

Assuming that current regulations are enforced, it does not appear that the overall environmental effects of the level of synfuel development being considered by the Congress would be "beyond mitigation."

POLICY ALTERNATIVES FOR CONFLICT MITIGATION

The issuance of State water rights under the prior appropriation doctrine is perhaps the strongest method of controlling and therefore mitigating potential conflicts between coal development and other nonenergy water uses. An additional opportunity for mitigation could come through recogntiion of the need for increased assistance to the affected region for educational, planning, and enforcement programs.

IMPLICATIONS OF MONTANA WATER RESERVATION PROGRAM

It is not believed that the Montana water reservation program will foreclose synfuel development in that State. Neither does this program threaten the water resources of other downstream States. Such a program does not entail water "consumption," but rather reserves water for use in the future. In this sense, it actually enhances the downstream States' water resources by assuring greater flows out of Montana.

While other States might certainly benefit from enacting a similar water reservation program, there are other approaches to the same end. For example, the development of a sound, comprehensive State water plan would be useful in protecting the States' interest in such matters. Also, a statutory provision considering certain instream flow requirements to be a "beneficial water use" could be an effective way of preserving recognized environmental values.

The Yellowstone Compact is more significant than the Montana Water Reservation Program in terms of its implications upon synfuel development. Article X of the compact prohibits the diversion of water from the Yellowstone River Basin without the unanimous consent of the States of Montana, Wyoming, and North Dakota. This provision of the compact has prevented Wyoming from diverting water—without the consent of Montana and North Dakota—from the Yellowstone Basin to the vicinity of Gillette for use in coal processing even though it is "Wyoming water."

WATER USE EFFICIENCY

Coal liquefaction and gasification are in their infancy as far as their technological development is concerned. Since no commercial plants are in operation in the United States, estimates of water requirement associated with these processes are largely theoretical. One might assume that as these processes are refined, the amount of water which they require may drop, thus, lessening their impact upon other water users. Conversely, greater efficiency in the use

of water by other users such as irrigators would provide more water for use by synfuel plants.

Incentives to encourage the use of more water-efficient technologies in all major areas of water use undoubtedly would promote conservation of water. However, the overall economic return on such incentives is unclear at this time.

CLOSING

In conclusion, my analysis of the situation is that the three major regional studies dealing with water supply needs and environmental quality concerns arising from proposed development of coal resources in the Upper Missouri River Basin provide adequate information at this time. Further, there is an adequate quantity of water to meet traditional demands in the region, as well as the new demands associated with the proposed level of coal development until at least the year 2000. However, changes in interstate compact agreements, alteration of State laws and regulations regarding transbasin diversion, and additional expenditures for water planning and management programs and structures are likely to be required to insure that this water is made to be at the appropriate time and place.

Present environmental regulations and programs undoubtedly will be useful in mitigating or preventing major environmental damages. However, additional research and educational and technical assistance likely will be required at the State and/or regional level to assure minimal environmental impact.

With these conclusions, I will be happy to answer any questions you may have. Let me add that I am grateful to be here representing the Missouri River Basin Commission today, and I hope that the Commission's contribution to your effort will prove helpful. Thank you.

TABLE 1.—ENERGY ACTIVITIES AND RESOURCE REQUIREMENTS, ALTERNATIVE REGIONAL ENERGY DEVELOPMENT SCENARIOS FOR THE YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREA, HIGH LEVEL

Resource	Tongue-Powder		Lower Yellowstone		North Dakota tributaries		Northeast Wyoming	
	1985	2000	1985	2000	1985	2000	1985	2000
Coal production (1,000 tons)	100,000	200,000	36,300	230,100	54,090	158,260	103,500	203,500
Exports (1,000 tons)	96,500	196,500	36,200	173,000	19,200	25,600	102,000	157,500
Conversion (1,000 tons)	3,110	3,110	120	57,120	34,900	132,600	1,500	46,000
Water requirements (total acre-feet)	45,800	55,607	3,397	163,326	115,987	224,779	34,145	92,320
Land requirements	5,340	9,780	1,702	13,527	13,064	24,724	4,292	10,662
Labor (number of employees):								
Operating	1,987	4,037	678	8,297	2,868	10,755	1,971	7,136
Construction	340	180	2,490	2,250	2,200	4,440	1,650	1,870
Capital requirements (millions of dollars)	446	1,016	170	7,221	3,733	13,362	515	6,337

Source: Yellowstone River Basin and Adjacent Coal Areas Level B Study; MRBC; 1978.

TABLE 2.—ENERGY ACTIVITIES AND RESOURCE REQUIREMENTS, ALTERNATIVE REGIONAL ENERGY DEVELOPMENT SCENARIOS FOR THE YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREA, LOW LEVEL

Resource	Tongue-Powder		Lower Yellowstone		North Dakota tributaries		Northeast Wyoming	
	1985	2000	1985	2000	1985	2000	1985	2000
Coal production (1,000 tons)	25,000	25,000	500	500	11,000	11,000	74,500	74,500
Exports (1,000 tons)	21,900	21,900	400	400	5,500	5,500	73,100	73,100
Conversion (1,000 tons)	3,100	3,100	100	100	5,500	5,500	1,400	1,400
Water requirements (total acre-feet)	15,702	15,702	822	822	20,592	20,592	9,586	9,586
Land requirements	2,106	2,106	69	69	2,137	2,137	3,197	3,197
Labor (number of employees):								
Operating	617	617	17	17	379	379	1,540	1,540
Construction	0	0	0	0	0	0	0	0
Capital requirements (millions of dollars)	0	0	0	0	26	26	295	295

Source: Yellowstone River Basin and Adjacent Coal Areas Level B Study; MRBC; 1978.

TABLE 3.—ENERGY ACTIVITIES AND RESOURCE REQUIREMENTS, ALTERNATIVE REGIONAL ENERGY DEVELOPMENT SCENARIOS FOR THE YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREA, MOST PROBABLE LEVEL

Resource	Tongue-Powder		Lower Yellowstone		North Dakota tributaries		Northeast Wyoming	
	1985	2000	1985	2000	1985	2000	1985	2000
Coal production (1,000 tons)	84,650	200,000	19,490	68,890	17,160	112,400	41,500	136,500
Exports (1,000 tons)	80,000	196,000	19,400	30,800	0	0	40,000	108,500
Conversion (1,000 tons)	4,600	4,000	90	90	17,160	112,400	1,500	28,000
Water requirements (total acre-feet)	27,437	32,742	2,532	46,689	35,879	203,872	8,184	44,115
Land requirements	5,127	10,250	1,083	5,374	4,592	20,880	1,986	6,929
Labor (number of employees):								
Operating	1,755	4,098	367	3,850	1,357	8,479	823	4,471
Construction	70	0	380	1,185	1,320	4,830	1,110	1,090
Capital requirements (millions of dollars)	517	1,170	74	4,215	1,603	11,158	197	3,821

Source: Yellowstone River Basin and Adjacent Coal Areas Level B Study; MRBC, 1978.

TABLE 4.—ENERGY SUPPLY DISAGGREGATIONS, STATE LEVEL FOR YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREA, DOE ACCELERATED SYNFUEL SCENARIO

State	1985 coal gasification (mmscf per day)		Coal liquefaction (barrels per day)	2000 coal gasification (mmscf per day)		Coal liquefaction (barrels per day)
	High Btu gasification	Low Btu gasification		High Btu gasification	Low Btu gasification	
Montana (total)	250	0	0	2,000	250	250,000
Upper Missouri ASA [1] 1001	0	0	0	[1] 1,000	0	[2] 50,000
Yellowstone ASA 1004	250	0	0	750	250	200,000
Upper Missouri ASA 1002	0	0	0	[3] 250	0	0
North Dakota	1,500	0	0	2,000	0	150,000
South Dakota	0	0	0	0	250	0
Wyoming (total)	0	0	0	2,500	0	0
Yellowstone ASA 1004	0	0	0	2,000	0	0
Platte ASA 1007	0	0	0	[4] 500	0	0

[1] ASA—Aggregated subarea.
[2] Because assessment subarea No. 4 (Lower Yellowstone) includes McCone County, which is in ASA 1001, these plants can be included if sited by the State in that county.
[3] ASA 1002 is outside of the assessment area; therefore, this plant will not be listed.
[4] Because assessment subarea No. 4 (northeastern Wyoming) includes Natrona and Converse Counties, which are in ASA 1007, these plants can be included if sited by the State in one or both of these counties.

Source: Department of Energy, reprinted in Upper Missouri River Basin Water Availability Assessment for Coal Technology Requirements; MRBC; 1978.

TABLE 5.—DOE ACCELERATED SYNFUEL SCENARIO, ESTIMATED WATER REQUIREMENTS FOR REMAINING STREAMFLOW AT SELECTED LOCATIONS, YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREA

Stream and location	Units DOE scenario, 2000		
	Estimated water requirement (acre-feet per year)	Remaining streamflow (acre-feet per year)	Percent reduction
Yellowstone River at Huntley, Mont	14,000	5,442,000	0.3
Bighorn River at Bighorn, Mont	1,000	2,430,000	.04
Missouri River near Culbertson, Mont	9,000	7,755,000	.2
Yellowstone River near Sidney, Mont	128,000	7,697,000	1.8
Cannonball River at Breien, N. Dak	124,000	174,000	3.3
Missouri River near Schmidt, N. Dak	6,000	15,472,000	1.9

Source: Upper Missouri River Basin Water Availability Assessment for Coal Technology Requirements, Water Quality Analysis, December, 1978.

Interbasin Transfers in the Missouri River Basin [1]

I. A GENERAL INTRODUCTION TO THE MISSOURI RIVER BASIN

The Missouri River Basin is vast and diverse. The basin covers 513,000 square miles—about one-sixth of the contiguous United States. This includes all of Nebraska, most of Montana, North Dakota, South Dakota, and Wyoming; about half of Kansas and Missouri; and smaller parts of Colorado, Iowa, and Minnesota. Land forms range from the slopes of the Rocky Mountains, across the semiarid plains, to the humid and wooded hills of Missouri.

With more than 50 percent of the total drainage area characterized as "semiarid," water is crucial to the Missouri River Basin. Average annual precipitation varies basinwide from over 40 inches in parts of the Rocky Mountains and extreme southeastern parts of the basin, to as little as 6 inches immediately east of the mountains. The basinwide pattern of monthly precipitation varies widely, and prolonged droughts and lesser periods of deficient moisture may be interspersed with periods of of abundant precipitation.

Runoff flowing into basin streams also varies widely, place to place, year to year. In parts—particularly the plains—the average annual runoff is less than one inch, while in southeastern and northwestern portions of the basin, the average annual runoff exceeds 10 inches.

Runoff and rivers flow irrespective of State boundaries. The upstream user affects the downstream user. Therefore, water needs and availability must be viewed in a "hydrologic context" acknowledging the central relationship between all users and the common supply. This flies in the face of traditional state control and brings into question the whole area of regional cooperation.

II. DEFINING FOCUS OF DISCUSSION AND TERMINOLOGY

In the western portions of the Missouri River Basin, the lack of water in the right place at the right time has met head-on with efforts to stimulate and maintain population and economic growth. This is a logical starting point for a discussion of interbasin transfer of water in the Missouri River Basin.

This discussion will concern itself with both intrastate and interstate interbasin water transfers as states may adopt different policies regarding interbasin transfers within a single state than they adopt in any type of interstate water transfer. Intrastate transfers involve water diverted from one basin to another within one state. Interstate transfer involve water diverted from one basin in one state to another basin in another state or water diverted from a basin in one state to the same basin in another state.

These different types of diversions will be examined in view of the Missouri River Basin Commission role, historical development of such transfers, examples of existing and proposed transfers in the basin, and the complex legal and institutional involvement in the simple concept of moving water from one place to another.

III. MISSOURI RIVER BASIN COMMISSION RELATIONSHIP TO ISSUE OF TRANSFERS

The Missouri River Basin Commission is one of six river basin commissions in the United States, authorized by the water resources planning act of 1965. These State-Federal entities exist principally as channels for coordinating water and related land resources planning within defined basins.

Membership of the Missouri River Basin Commission includes representatives of the ten basin states: two interstate compacts—the Yellowstone River Compact Commission and Big Blue River Compact Administration: and the Federal Departments of Agriculture, Army, Commerce, Energy, HEW, HUD, Interior, Transportation, the Environmental Protection Agency, and the Federal Emergency Management Agency. Canada is represented as an observer, and the basin's indian peoples have been voted observer status.

The commission was formed in 1972 at the request of the governors of the ten basin states. It is purposely neither a Federal nor a State agency, although it receives funds from both Federal and State sources. Ten reasons for the dis-

[1] Paper prepared by Millard W. Hall, Chairman, Missouri River Basin Commission, and J. David Aiken, Extension Water Law Specialist, University of Nebraska, Lincoln, Nebr., and presented before the American Society for Civil Engineers Fall Convention, Atlanta, Ga., Oct. 25, 1979.

tinction is to maintain an atmosphere where both State and Federal representatives have an equal opportunity to be heard. All decisions are made by consensus.

The commission chairman is a presidentially-appointed, Federal employee, but the commission staff of river basin planners and administrators are neither State nor Federal employees. A representative of the State members serves as vice chairman.

The MRBC role in interbasin transfers, consistent with its overall role, is that of planning and coordination. By law, the commission is the "principal agency for the coordination of Federal, State, interstate, local, and nongovernmental plans for the development of water and related land resources in its area." Its function is four-fold:

1. Continued, iterative development of an overall comprehensive, coordinated, joint plan;

2. Conduct of supplemental studies focusing on particular aspects of resource management;

3. Annual review and recommendation of priorities for water and related land resources management activities; and

4. A periodic review of Federal and State studies, research, data collection, and project implementation for water and related land resources in the Missouri River Basin.

Interbasin transfers come under the commission's scrutiny in the comprehensive planning area, and in the endorsement of priorities for Federal funding forwarded to the U.S. Water Resources Council and other Federal agencies. The commission plays a role in the early stages of these developments through its special studies function.

The crucial question in investigating problems and needs in water use in the basin and its subbasins is that of surplus—is there in fact surplus water—water to spare—for the needs of a neighboring basin or a neighboring state, or even for a state hundreds of slurry pipeline miles away? The commission is just now beginning a three-year basinwide hydrology study intended to provide baseline data on water availability and use, and devise a system for determining minimum need levels and surplus water availability relative to those needs in a given subbasin.

With this as background, we can proceed to look at some of the instances of interbasin transfer in the Missouri River basin.

IV. HISTORICAL OVERVIEW OF TRANSBASIN DIVERSION IN THE MISSOURI RIVER BASIN

A. Natural transfer

When we think of interbasin transfers, we usually think of man's role in diverting vast amounts of water from its natural course to the course of his convenience or need. It occurs to me, however, that in the Missouri basin long before men thought of retraining water flows, examples of diversion existed in nature.

I am referring here to movement of ground water through aquifers that connect one river system to another. In Nebraska, for example, water moves directly from the Platte River into an aquifer which discharges in the Kansas River drainage. Although not as evident, the general southward movement of water in the giant Ogallala aquifer, which extends from Nebraska to Texas, is also moving water from one surface drainage area to another.

B. Historical, man-made transfers

Historically, water needed for irrigation prompted the earliest man-made interbasin transfers in the basin. The 1860's saw the first significant irrigation developments. Such early diversions were usually one-man efforts to increase productivity of individual farms.

The Homestead Act of 1862—offering 160 acres to homesteaders working the land for five years—accelerated both the population growth of the area and the resultant expansion of irrigation practices.

Such practices were widely used in mountain valleys and along mountain fronts by 1890 and were further stimulated by the reclamation act of 1902. In the mid 1920's, Federal and state assistance to farmers in improving land and water practices was inaugurated. This assistance was strengthened and enhanced as a result of the drought of the 1930's, with local actions prompted by provisions of the watershed protection and flood prevention act of 1954. Irrigation diversions were beneficiaries of these aid programs.

Significant changes, including recognition of the multipurpose principles of water development, were made in the Reclamation Project Act of 1939 as an amendment to the 1902 act. Authorized functions now include the planning and construction of works for impounding and diverting water for irrigation, power generation, municipal and industrial uses, stream regulation and pollution control, and (where approved by Corps of Engineers) for navigation and flood control.

C. Diversions today

Today, agriculture is still the predominant industry in the Missouri River basin. The area produced about 33 percent of the nation's wheat, 25 percent of the sorghum, 22 percent of all corn grown for grain, and 20 percent of the livestock and poultry.

Irrigation is, at present, the principal consumer of the basin's water, although future needs for energy and municipal/industrial development could see this change quickly and dramatically.

The ten Missouri River basin states estimated that 11.5 million acres irrigated in 1975 consumed a total of about 16.1 million acre-feet of water, much of it from ground-water sources. By contrast, other water uses—municipal industrial, rural domestic, manufacturing, mining, livestock and steam-electric power generation—consumed only 1.5 million acre-feet.

It was estimated that total consumptive uses in 1975 depleted streamflows throughout the Missouri River basin (and ultimately the Missouri River) by 15.5 million acre-feet—about one-fourth of the river's historic average natural flow.

If there were only water enough—(in the right places)—there is a total of 64.2 million acres of suitable cropland with irrigation potential in the Missouri basin; 35.8 million acres—more than half the total suitable cropland with irrigation potential—is regarded as having essentially "no chance" of such development due to lack of readily available or economically transferable water.

Water use in development of the region's coal resources is perhaps the issue of greatest national significance in the Missouri basin today. Coal reserves in North Dakota, Montana, and Wyoming have been estimated at 165 billion tons. Coal production in the region was approximately 37.6 million tons in 1975 and increased to about 48.8 million tons by 1976. In a national context, these states could account for 36 percent of U.S. coal production by 1990, if U.S. Department of Energy projections are realized.

The amount of water required to support this development depends upon how the coal is processed and whether it is processed in the basin or shipped elsewhere. The amount of water locally available is questionable, due both to limited supply, and to further limitations imposed by intrastate and interstate water rights laws.

Municipal industrial water needs are also increasing, primarily in relation to the region's larger cities. M&I consumptive use in comparison to all other consumptive uses in the basin is small; however, the impact within some particular subbasins may be greater than for all other uses combined. For this reason, we might consider irrigation, energy production, and municipal industrial needs as the "Big Three" in terms of reasons for interbasin transfer of water in the Missouri River basin.

In the basin today, Colorado, Wyoming, Montana, Nebraska, and the Dakotas are all affected by various existing or proposed interbasin transfers. Minnesota, Missouri, Iowa, and Kansas have no existing transfers, nor is the Commission aware of any proposed for these states at this time.

Very briefly, there are ten existing interbasin transfers of significance in the Missouri River Basin—nine in Colorado, and one in Montana.

1. *Colorado*

The following diversions from the Colorado River Basin to the Missouri River Basin occur in Colorado:

a. Colorado-Big Thompson Project—collects runoff in the headwater of the Colorado River, storing it in Lake Granby and Willow Creek reservoirs. The Granby Pumping Plant and Granby Pump Canal deliver the water from Lake Granby to Shadow Mountain Lake and Grand Lake. From Grand Lake, the water flows by gravity through the Alva B. Adams Tunnel to the eastern (Missouri Basin) side of the Continental Divide. The water passes through a series of eastern slope conduits and power plants enroute to terminal storage in Horsetooth Reservoir and Carter Lake. Delivery of water is made from the terminal storage facilities.

The primary purpose of the project is to supply supplemental water to approximately 700,000 acres of irrigated land in the South Platte Basin of Northeastern Colorado. The secondary purpose is hydroelectric power production. Plans are being made to expand hydroelectric production of the project.

b. Grand River Ditch—diverts water from tributaries of the Colorado River to LaPoudre Pass Creek (Tributary to cache LaPoudre River) in the Platte River Basin. Water from this point is used for irrigation and municipal water supply.

Most of the water diverted by the next seven projects is used for municipal water supply in the Denver area.

c. Eureka Ditch—diverts water from tributaries of Tonahutu Creek in Colorado Basin to Spruce Creek (tributary to Big Thompson River) in Platte River Basin.

d. Berthoud Ditch—diverts water from tributaries of the Fraser River in Colorado Basin, to Hoop Creek in the Platte River Basin.

e. Moffat Tunnel—diverts water from tributaries of Williams Fork (via August P. Gunlich and Vasquez Tunnels), and from the main stem and tributaries of the Frazer River in the Colorado Basin to the South Boulder Creek in the Platte River Basin.

f. Hoosier Pass Tunnel—diverts water from tributaries of the Blue River in the Colorado Basin to Montgomery Reservoir on the Middle Fork of the South Platte River. This water is further diverted to South Catamount Creek in the Arkansas River Basin.

g. Boreas Pass Ditch—diverts water from tributaries of Blue River in the Colorado Basin to Tarryall Creek in the Platte River Basin.

h. Vidler Tunnel—diverts water from tributaries of Peru Creek in the Colorado Basin to Leavenworth Creek in the Platte River Basin.

i. Harold D. Roberts Tunnel—diverts water from Dillon Reservoir on the Blue River in the Colorado Basin to the North Fork of the South Platte River.

2. *Montana*

a. The St. Mary Canal diverts water from the St. Mary River of the Saskatchewan River Basin near Babb, Montana, and discharges into the North Fork Milk River (Missouri River Basin). The water flows in the natural channel of the Milk River through Canada and then back into Montana where it is used for irrigation in the Milk River Valley east of Havre. Diversions during the 1971 irrigation season totaled about 102,000 acre feet.

D. Potential

There continues to be interest in other subbasins for transbasin diversions. Four proposed projects are being discussed for subbasins in Wyoming, Colorado, and North Dakota. Another, an interstate coal slurry pipeline proposal, is being discussed among South Dakota, Wyoming, and Arkansas.

1. *Wyoming*

a. Diversion from Columbia or Colorado River Basins into Missouri River Basin—water needs in southern and eastern Wyoming are projected to exceed the locally available water supplies. Wyoming's compacted water supplies in the Snake (Columbia) and Green (Colorado) Rivers exceed the total projected water needs. The Snake and Green Rivers appear to be logical sources for at least a portion of the water needed elsewhere in Wyoming. Surplus Snake River compact water available for transbasin diversion in Wyoming has been estimated to be 150,000 acre-feet per year, while a corresponding surplus from the Colorado River compact in the Green River has been estimated as 104,000 to 272,000 acre-feet per year.

2. *North Dakota*

a. Garrison diversion unit—is an authorized bureau of reclamation project in North Dakota which was under construction when funding was temporarily stopped due to a controversy over environmental impacts. The Garrison Diversion Unit is designed to be a multipurpose project emphasizing the irrigation of 250,000 acres of land in eastern North Dakota using Missouri River water. Construction was approximately 20 percent complete when interrupted and is again underway, but at a slower rate. Return flows from irrigated lands would drain into the Nelson River drainage in Canada through the Souris River and the Red River of the north. The James River, a Missouri River tributary, would also receive return flows.

3. *South Dakota-Wyoming-Arkansas*

a. West River aqueduct.—Would be a pipeline diverting water from Lake Oahe in South Dakota for municipal and rural domestic use in South Dakota, municipal and industrial use in northeast Wyoming, and potentially for coal slurry out of the Missouri basin. (An aqueduct to Wyoming from Garrison Reservoir has been discussed as a possible alternative to this project.)

b. Coal slurry pipelines.—A coal slurry pipeline from the Gillette, Wyoming, vicinity to electrical generating facilities in the Little Rock, Arkansas, area has been proposed by industrial interests. A possible source of water would be the West River aqueduct mentioned above. This proposal has drawn vigorous opposition from the railroads. A major obstacle would be gaining permission to cross railroad rights-of-way with the pipeline.

E. In addition to the proposals receiving serious consideration at this time, there are three which for a variety of logistic, economic, legal, and political reasons are considered either unlikely or generally unthinkable.

1. The Beck plan.—First proposed by R. W. Beck & Associates in the late 1950's would divert water from the Missouri River below Fort Randall Dam to the Texas panhandle and beyond. Some 13 million acre-feet of water per year would be pumped up the Niobrara River in Nebraska through a series of reservoirs. A 940-mile canal from the Alliance, Nebraska vicinity would deliver the water through eastern Colorado, western Kansas, western Oklahoma, and western Texas to Mexico.

2. NAWAPA.—The north American water and power alliance was proposed in the mid-1960's by the Ralph M. Parsons Company. The concept involved diverting water from Alaska and western Canada to water-deficient areas of Canada, Mexico, and the United States. This enormous project would have cost $100 billion in the 1960's! The economic reality and the political problems of trying to persuade Canada to allow such a massive diversion of water made this a far-out dream from the start. (But, if . . .)

3. High Plains Import.—Is a proposal to import water, primarily for irrigation purposes, into the Ogallala Aquifier area of Nebraska, Kansas, Colorado, Oklahoma, New Mexico, and Texas. Following the general approach of the Beck plan, several alternatives have been laid out through the course of the economic development administration's ongoing high plains study. These alternatives include diverting Missouri River water from as far north as North Dakota or Montana to as far south as the lower Missouri River. The Corps of Engineers, and the study management, are now cooperatively studying the physical possibilities of such an import project.

V. LEGAL AND INSTITUTIONAL ASPECTS OF INTERBASIN AND INTERSTATE WATER TRANSFER IN THE MISSOURI RIVER BASIN

A. Legal: Interbasin transfers

The primary legal issue in moving water out of one basin or state into another is that of "who has the right to use the water and what are the limits of that right." This is not a simple issue in the Missouri River Basin, primarily because it is governed by a number of recognized doctrines with roots deep in the historical settlement of the area.

An oversimplified view of the situation (adequate to our purposes here, but I would urge additional reading) is that water rights doctrines in the Missouri basin emanate from two primary sources. Settlers from New England (the east) brought with them a tradition of law and order—civilization, if you will—that proceeded from England. Other settlers of Spanish or French heritage flowed in from California and Mexico, Louisiana and Canada, with diverse motives, exploring, adventuring, settling. Various other nationalities also settled at various times.

What they all found in the great plains was a land that suspended the rules—a land where survival was always at stake, and "civilization" was the occasional passing of a wagon train and the family Bible read by candlelight. Some clung to tradition, others abandoned tradition and relied on instinct to provide whatever it took to survive. From these two approaches to the new land, today's recognized water rights emerged.

1. The following general principles usually govern surface and ground-water transfers between basins within a state. (An exception in the Missouri River

Basin is Nebraska where it has been held illegal in several court cases to transfer water from one basin to another.)

A. THERE ARE TWO DOCTRINES IN THE MISSOURI RIVER BASIN GOVERNING RIGHTS TO USE OF SURFACE WATER

i. The Riparian Doctrine first employed in the east was borrowed from England where water was plentiful. It states simply that rights to water use accrue to whoever owns the land robbing the stream.

The Riparian owner's right is the same as all other Riparians on that stream and is not acquired by actual use nor lost by failure to use the water. There is no priority of right, although upstream domestic uses and watering of domestic livestock generally are considered preferential uses.

With the Riparian rights available only to lands contiguous to the stream, there usually is no basis for the transfer of rights to lands not contiguous, including those of another basin.

ii. The appropriation doctrine, more generally accepted throughout the west where water is in shorter supply and streams are fewer, allows that beneficial use is the basis, measure, and limit of water right. Often referred to as "first in time, first in right," appropriation means rights to water are appropriated by the state government, according to historical "beneficial" use. A definite rate of direct flow diversion or storage is stipulated, and use must be dedicated to the people of the state for beneficial purposes.

The appropriation right is sustained only by actual and continuous beneficial use, and generally, the right to divert is not denied except where in conflict with public interest. Waste is outlawed.

iii. Among Missouri Basin States, Minnesota and Missouri recognize the Riparian Doctrine, while Colorado, Montana, and Wyoming follow the appropriation doctrine. Kansas, Nebraska, and North and South Dakota depend on appropriation, but acknowledge Riparian Doctrine in varying degrees. Iowa, apart from the other basin states, makes substantially all uses of water in the state subject to permit and administrative regulation as to diversion, storage, or withdrawal, over some period of time not to exceed ten years.

B. GROUND WATER

Ground-water allocation is governed by similar principles. Appropriation rules apply in many Western States. In addition, three Riparian-like rules award water rights to owners of land located above ground water:

i. The English "absolute ownership" rule allows the landowner to draw according to his own needs without regard to others. No restrictions. Interstate or interbasin transfers are possible.

ii. The American "reasonable use" rule entitles the landowner to reasonable use of ground water related to the quantity withdrawn, and use is restricted to "overlying land."

iii. The California rule of correlative rights extends the reasonable use rule so that all ground water users share the available supply on a pro-rata basis. This would restrict ground-water transfers, and consequently is most often used in combination with other rules.

C. SPECIAL RESERVED RIGHTS

In addition to legal implications of doctrines applying to individual water rights in the basin, some 57 million acres of basin land are Federal or Indian lands for which rights to both surface and ground water have been reserved. Such reserved rights do not quantify the amount of water available to these lands nor do they qualify how it may be used.

Thus in the Missouri River Basin, any appropriation of rights to water shared with Federal or Indian lands poses serious problems in State, Federal, or local negotiation.

B. Legal: Interstate transfers

Introducing state boundaries immediately complicates the issues surrounding interbasin transfer of water.

1. Generally, States will follow the same principles for interstate as for intrastate transfer. Some States, however, establish separate rules for interstate transfers, posing the legal question of whether such rules are "restrictions on

interstate commerce" and invalid under the U.S. Constitution. Case law has so far invalidated attempts by states to have such separate rules.

2. The biggest question is the basin with regard to interstate transfers and water rights is how to resolve disputes and proceed with development.

a. Historically, some conflicting claims have been resolved in court—at local as well as Supreme Court levels. In cases of individuals, western courts have generally upheld "first in time, first in right."

b. In cases of State versus State, the U.S. Supreme Court has ruled on the basis of "equitable apportion," considering both priority of right and extenuating, recent circumstances—for example, protection of an established economy based upon a relatively recent water use.

c. Some states have acted to prevent disputes by negotiating compacts with neighboring states over interstate streams. State and Federal representatives get involved in such negotiations and the final compact must be signed by all State members and ratified by Congress.

There are two such compacts in the Missouri River Basin. The Yellowstone Compact involving Montana, Wyoming, and North Dakota; and the Big Blue Compact between Kansas and Nebraska.

The virtues of such a compact are that all parties have a common understanding and an equal voice in water use. The drawbacks are perhaps best illustrated by example:

In the Yellowstone Compact states local water supplies are frequently inadequate to support coal development, making necessary the importation of water from beyond the vicinity of the mine or plant. In Wyoming the coal fields straddle the Yellowstone Basin boundary, which causes problems due to provision of the Yellowstone River Compact.

The Yellowstone compact divides the waters of four tributaries of the Yellowstone River. These streams are the Clarke Fork, Bighorn, Tongue, and Powder Rivers. The compact was ratified by the States of Wyoming, Montana, and North Dakota, and the Federal Government in 1951. North Dakota has no share in the water supply. Article X of the Yellowstone compact prohibits diversion of water from the Yellowstone River Basin without the unanimous consent of all three signatory States. This provision of the compact has prevented Wyoming from diverting water from the Yellowstone Basin to the vicinity of Gillette for use in coal processing.

d. Finally, water rights have historically been apportioned by Congress for water stored in congressionally authorized storage projects. The U.S. Supreme Court has upheld this congressional authority when challenged.

In the case of the six main-stem dams of the upper Missouri's Pick Sloan project, Congress has authorized the Department of Interior to market surplus water from Federal reservoirs. The Pick-Sloan system was developed for flood control and water storage purposes, with irrigation contemplated as the major use.

Irrigation has not proven to require as much water as projected. However, coal development in the upper basin has resulted in increasing demands on the water supply.

C. Institutional involvement: Interbasin, intrastate, interstate

In any case, the underlying question in any transfer dispute is whether the area of origin—that is, the basin or State from which water is taken—will be better or worse off as a result of a transfer. Again, is there a surplus or water available; water to spare? water to share? and who—or what body—is the ultimate judge? Not surprisingly, the area of origin is likely to resist transfers which appear either detrimental or, simply, not beneficial in some way.

There are primarily three institutional alternatives for mediating these questions.

1. Some would suggest an economists approach. Basically, this means if the advantage to the area receiving the water is greater than the disadvantage to the area of origin, the receiving area should be able to compensate the area of origin and still be better off than if no transfer had been made. An advantage to this approach is that transfers would not occur unless a net economic gain would result.

There are also practical problems and disadvantages: deciding who compensates whom, for example. The major disadvantage of this suggestion is that it represents too radical of a change in thinking about water. Water has always been free—with users paying for costs of obtaining, treating and transporting it, but not for the water itself.

2. Congress has the power to allocate interstate waters developed by the Federal Government and to induce transfers by providing grants and public works funds for areas of origin. Congress also has the ability to force a compromise if it determines that the water transfer is in the national interest. However, such congressional action would need to be carefully weighed against the strong resistance of western States to such Federal intervention.

3. Finally, State-Federal river basin commissions can be helpful in negotiation of interstate transfers. The ongoing regional planning process, and the commission charge to coordinate cooperation among basin States and planners at all levels provide an existing forum where the entities involved in compact negotiations are likely already to be members.

Furthermore, the basin commission is familiar with water supply and needs in the area. And, finally, since the interstate nature of the compact can potentially involve Federal funds, the federally-employed commission chairman could be expected to have working knowledge and established channels within the Federal system.

The primary limitation to what the commission could offer would be imposed by the limitations of the information gathered and analytical capability available which might be brought to bear in any such situation.

In my opinion, the role of the basin commissions is changing. When these commissions first began, the structure dictated that the commissions implement water policy coming out of Washington. I think we have found that water policy designed for one region of the country is not likely to fit every other region.

I believe basin commissions are playing an increasing and appropriate role in policy development as well as implementation. If this is in fact the case, ultimately the planning process could supplant the litigation process in resolving issues of interstate transfer. If transfers are accepted as part of the regional plan to begin with, litigation becomes unnecessary.

VI. SUMMARY

In summary, interbasin transfer of water occurs in the Missouri River Basin against a backdrop of diverse needs, diverse altitudes, diverse precipitation, unique historical and sociological patterns, and legal constraints.

With over 64 million irrigable acres looking thirstily for water sources, and a Nation hungrily eyeing potential energy of the basin's coal fields—only a slurry pipeline away—such transfers are definitely among the issues of the future for the basin and for the Missouri River Basin Commission.

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Senator McGOVERN. Mr. McCormick, do you have any observations you want to make on anything that's been said here this morning before we go into some questions?

STATEMENT OF JOHN L. McCORMICK, WASHINGTON, D.C., REPRESENTATIVE, ENVIRONMENTAL POLICY CENTER

Mr. McCormick. Yes, I do, Senator. I would like to begin by saying it's a pleasure to be here before you and to testify on an issue that, as Assistant Secretary Guy Martin said, is a very critical issue regarding the Congress' recent action on the synthetic fuels program. I would like to associate my remarks with him and commend you for holding these hearings and hope that this is the beginning of a series of hearings on a component of the synthetic fuels program that I don't think has really been addressed adequately by the Congress.

I don't have a prepared statement, but I do have a position paper that was prepared by Jack Doyle for the Environmental Policy Center. It's entitled "Synthetic Fuels and Energy Mobilization—Impact on Agriculture." With your permission, I would like to submit that for the record.

Senator McGovern. We will be glad to have that as part of the hearing record.

Mr. McCormick. Thank you, Senator.

Just a few observations I would like to make in just a few moments. I have heard a great deal of testimony regarding resource availability, particularly water availability, and I can't say the statements are conflicting. I don't think they're complete because, as one gentleman said, we haven't really factored in the water demands of the several Indian tribes in the northern Great Plains, and without some estimate of the type of water demands they will have in the near future, any estimate on water availability for synthetic fuels or for agricultural or municipal or other industrial uses is going to be a wild guess.

While we are considering resource availability, and putting aside for a moment the question about whether the water does exist for the level of synthetic fuels development that President Carter's plan calls for, I would like to focus for a moment on the kinds of things that are going to occur in the northern Great Plains as we begin this level of development.

I think you are aware of this more than I am, but in my estimation, the real impact upon agriculture is not going to come from competition for the remaining resource base, but instead is going to come from the impact that industry has the capability of spending several thousands of dollars for an acre-foot of water to supply its needs for its production process and is going to inflate the cost of water in general. Where an agricultural interest would like to expand an operation and go out to lease or buy additional farmland, then have to negotiate for the lease of additional water rights, I think that person is going to find that the inflated cost of water has grown so rapidly that that person is probably going to be priced out of the water market. We are already beginning to see that in the Rifle, Colo., area where oil shale interests are buying up existing water rights for fantastic prices. That effect is causing some hardships on the existing agricultural industry in that area, and people are having to either curtail their plans to develop or, in some instances, are finding that there is a greater profit to be made in leasing the water for industrial use than to continue their agricultural endeavors.

Another impact that I see—and I have had lengthy discussions with environmental organizations in the northern plains regarding this—

they have a policy that they try to adhere to, that is, to recognize that demands for coal is of a national scale, and the likelihood that we can prevent coal production from occurring is pretty minimal. But we would rather that they take the coal and ship it out of the region.

Well, my response to that is, as more coal is developed in the northern Great Plains, the population begins to shift from an agriculturally based population to an agricultural and coal mining, synthetic fuels industry base. As this population shift occurs, the changes occur in the State legislatures as well, because those representatives and senators going to the Montana and Wyoming State Legislatures, some of them are going to be representing energy interests and no longer the agricultural interests, and therein lies another potential impact on agriculture.

In our efforts to try to bring to the attention of the Congress certain provisions within the coal slurry legislation, we find that there's a lot of talk given to drafting language that gives States ironclad protection of their water rights; but, as Governor Herschler pointed out, and you are aware, when a coal slurry pipeline interest has the powers of the Federal Government behind it and the State decides at some point during the course of the operation of that pipeline that the continued pumping of water to supply that pipeline—well, I'll give you one example of the problem.

The Etsi Slurry Pipeline from Gillette to White Gloves, Ark., would require water that would be pumped from the well field not too far from Edgemont, S. Dak. This has been pointed out to Congress and, in at least the estimation of one professor of the University of South Dakota School of Mines in Rapid City, it could mean a potential drawdown of the water supply in the Edgemont, S. Dak., area.

So one might say then that the Governor of Wyoming or South Dakota should try to effect some changes in the amount of water being pumped for slurry, or just to put an end to the pumping altogether because of the impact being so severe.

The slurry pipeline legislation purports to protect the States' water rights at that point, but given the power of the Federal Government behind that slurry pipeline project, the Governor of Wyoming and others feel certain that when the court finally—it would be the Supreme Court that would make the decision—finally hears the case, they're going to be weighing the interests of the citizens of Edgemont, S. Dak.—200 or 300 persons; maybe 5 or 6 or 10 farms—being the damaged party versus the benefits that the coal slurry pipeline provides to the economic health and well-being of the five or six Southern States.

Quite clearly, the Court is going to rule that while the interests of the persons being damaged in South Dakota have to be taken into account, when you weigh that with the many billions of dollars of economic goods that are generated by the coal interests—it turns into electricity and goes out in the market—it clearly overshadows the needs of those local people, and it's there that the courts have ruled that the Governors do not have the right to prevent the water from being shipped out because of the commerce clause of the Constitution.

So, while we talk about protection of State water rights, I see that

political changes within these communities affecting the State legislature somewhere down the road, then the powers of the Federal Government using the Energy Mobilization Board or President Carter's Synthetic Fuels Corp., those powers being in the national interest far outweigh the needs of the local communities—agriculture based communities. I think it's quite likely that some parts of the northern Great Plains are going to be considered national sacrifice areas in the name of creating more energy supplies for this nation.

I think I will conclude my statement there. Thank you.

[The paper referred to by Mr. McCormick follows:]

SYNTHETIC FUELS AND ENERGY MOBILIZATION—IMPACT ON AGRICULTURE

The Carter Administration has called for the creation of an Energy Security Corporation to "direct the development" of a 2.5 million barrel per day (BPD) synthetic fuels program and a three-member Energy Mobilization Board "empowered to expedite permitting and construction of critical energy facilities." [1] Several bills currently pending in the U.S. Congress have similar features, varying only in the nature and scope of energy siting powers, what constitutes a "priority energy project," and the range of synfuel subsidies, incentives and/or appropriations. A major national program to develop a synthetic fuels industry and/or priority energy projects, in combination with an Energy Mobilization Board empowered to expedite those projects and their supporting infrastructure, will have significant ramifications for agricultural resources, agricultural economies and small rural communities in several regions of the country.

SIZE AND LOCATION

While Carter Administration officials have used ballpark figures of "40 or 50 energy projects" for the entire program of new energy projects, and have specifically called for 16 coal liquefaction plants and 8 oil shale surface retorting facilities by 1990, some members of the business community have argued for a much larger commitment of a 6 million BPD synthetic fuels program. [2,3,4] Industry spokesmen and some engineers have talked optimistically about 20 synfuel plants by 1990, and possibly as many as 60 plants with refiners required by government to use an increasing percentage of synfuel product for their feedstock. [5]

In the early 1970s, the American Gas Association identified 176 sites for coal gasification plants. Such sites could also be considered for coal liquefaction plants. Last month, in a preliminary analysis using selective siting criteria, the U.S. Department of Energy found 41 counties in 8 states as potential locations for one or more synthetic fuels plants. DOE's list of counties included 3 in Colorado; 8 in Illinois; 10 in Montana; 7 in North Dakota; 1 in Pennsylvania; 1 in Texas; 5 in West Virginia; and 6 in Wyoming. [6] In a broader scoping process, DOE found that 159 counties in 22 states would have enough coal to feed a synthetic fuels plant for 25 years, but might otherwise be restricted because of potential air and/or water pollution. However, depending on the size of synfuel plant (whether 50,000 or 100,000 BPD), the degree of subsidies, and the extent of expedited treatment available to cut through red tape and environmental laws, over 150 project locations could become eligible for one or more coal-based synfuel projects. Many of these locations coincide with valuable agricultural resources in the west and midwest.

ENERGY FACILITIES AND AGRICULTURAL LAND

According to one estimate in Illinois, the site for a commercial-size coal gasification plant will require about 1,000 acres of land, and an additional 1,250 acres of land for the disposal of wastes generated at a rate of 5,000 tons per day. [7] Other synfuel facilities will require similar amounts of land for siting and operation.

Land needed to accommodate a coal/utility/synthetic fuels complex in the U.S. will also be required for the support facilities and infrastructure needed for energy processing and distribution. Pipelines, power lines, powerplants, reser-

voirs, and processing facilities will all require land, some of which will inevitably be productive cropland and rangeland. Fertile agricultural valleys and flat farmland are often the preferred types of terrain for building and locating new mines and energy facilities.

Five of the Illinois counties identified by DOE as possible locations for synthetic fuels plants contain high proportions of prime farmland. Vermillion, Shelby, Fayette, Franklin and Jefferson counties each have 63 percent or more of their cropland in SCS land capability classes I, II, and IIIw, generally considered to be prime farmland. [8] In North Dakota, a coal gasification plant proposed by the American Natural Resources Co. has been approved for a site in Mercer County containing 33 percent prime farmland. An adjacent powerplant built by the Basin Electric Power Cooperative would occupy a site with 36 percent prime farmland. Together, the two facilities would take about 600 acres of prime farmland centrally located in a large valley.

The U.S. Department of Energy has recently reported that the "conventional transportation infrastructure (i.e., pipeliens) is not consistent with likely oil shale and liquefaction siting patterns," noting that "(new) pipelines must be constructed." [6] In the oil shale region near Rifle and Meeker, Colorado, some 50 miles northeast of Grand Junction, a 100-mile pipeline will be needed to carry manufactured oil from ten 5,000-acre oil shale tracts northward to an existing pipeline network that runs into the midwest. [9] The Department of Energy has also reported that water pipelines may have to be constructed for coal liquefaction facilities since "coal fields are not always colocated with water resources." [6]

Coal slurry pipelines may also be in the offing for moving coal feedstock to distant coal liquefaction or coal gasification plants. A "hypothetical" coal slurry pipeline studied by the Congressional Office of Technology Assessment on a route from Wyoming to Texas would take about 11,000 acres of land through 40 rural counties. [10] Some coal slurry lines will take up to 15 acres per mile of right-of-way.

Coal-hauling, unit trains and new railroad spur lines can have a "Chinese wall" effect on ranching and farming operations. A proposed 126-mile railroad line from Douglas-to-Gillette in Wyoming needed to service new coal development will remove some grazing lands and hayland from production, will restrict access of cattle to stock water, and may adversely affect up to 3,000 acres of grazing land annually through rail-caused grass fires. [11]

Powerplants and powerlines will also require land. Depending on size, type, and extent of cooling facilities or reservoirs, electric generating plants can require as much as 10,000 acres of land. A 425-mile high-voltage transmission line recently built through Minnesota will cross at least 8,000 acres of good farmland. [12] About 1.5 million acres of land are required for every 100,000 miles of electric transmission line every 10 years.

Insofar as expedited treatment of "priority energy projects" includes expanded surface coal mining, coal gasification, coal liquefaction, and oil shale, facilities, tar sands development, coal slurry pipelines, product pipelines, water diversion projects, and additional coal-fired electric generating and transmission projects, the potential impact on the agricultural resource base could be quite significant, particularly at the local and regional levels.

COAL AND AGRICULTURAL LAND

Synthetic coal technologies, such as coal gasification and coal liquefaction, will require large amounts of coal feedstock; as much as 14 million tons per year, and ideally in 25-year blocks of 300 million to 500 million tons. [13,16] According to Business Week, replacing 10 percent of the nation's oil production with synthetic fuel could require new mining capacity equal to one-half the current U.S. coal production, or about 350 million tons. [14] About 70 million tons per year of new coal production will be needed for electric utilities ordered to convert oil and gas-fired boilers to coal. [15] New coal-fired electric generating capacity needed to provide electricity for a synthetic fuels industry will also add to coal production demands.

This huge demand for coal will inevitably translate into increased strip mining, primarily in the West, but also in other regions. Expanded coal demand will increase the pressure to strip mine alluvial valley floors in the west and prime farmlands in the midwest. Strip mining on alluvial valley and prime

farmland is presently restricted and/or subject to tough reclamation standards under the Surface Mining Control and Reclamation Act of 1977. Utility and mining interests have consistently challenged these provisions and would like nothing better than to open up these areas for strip mining under an energy mobilization mandate.

Illinois farmland is already being strip mined for coal, and good farmland in western Kentucky, Indiana, Missouri, North Dakota, and even in the Texas lignite fields stands to be impacted by increased, no-holds-barred coal development. About 12 million acres of Midwest farmland and thousands of acres of western alluvial valleys coincide with strippable coal reserves. [16] In a three-county area of Wyoming's Powder River Basin, for example, an alluvial valley network comprising approximately 135,00 acres of naturally sub-irrigated bottom land and feeder streams sustains ranching activity over some 7 million acres of open range. [17]

In a June 1977 study of coal mining and agricultural and loss in three counties of Wyoming, it was estimated that approximately 1,000 acres of irrigated land, 25,000 acres of dry cropland, and nearly 500,000 acres of range land would be impacted through the year 2000 by coal mines known at that time. It was further noted in the study that the land removed from crop production "would probably be returned as grazing land," adding the caveat, "it is not currently possible to estimate what productivity this land might have for grazing purposes." [11]

FAST-TRACK SITING AND AGRICULTURE

Given broad Energy Mobilization Board powers to determine "priority energy projects," to make interpretations of state and local laws, to tailor and/or compress certain, state, local and federal procedures and requirements, and in the extreme case, to waive state, local and federal laws that are deemed "impediments" to the construction of certain designated projects, agricultural land, water rights, and landowner due process could all be directly and indirectly threatened.

New de facto eminent domain powers could be granted to builders of priority energy projects for everything from coal mines to power lines and existing procedures and hearings under state condemnation laws could be shortened. Under some of the proposed legislation, federal laws and procedures which protect agricultural resources and landowner rights might also be affected. Laws such as the Uniform Relocation and Assistance Act and those which govern mining, leasing and the use of the public lands could be waived or adjusted for energy projects of national importance. Agricultural District laws and other agricultural protection laws at the state level could also be overriden by priority energy projects. In states where siting laws and eminent domain practices have been bridled to take account of agricultural resources, such requirements could also be waived.

In addition to synfuels fast-tracking, individual energy projects or classes of projects not directly associated with synfuels may come under their own forms of fast-track siting and licensing. The U.S. Department of Energy, for example, is currently studying high-voltage transmission lines to determine their potential for "coal-by-wire" and "fast-track" siting and construction. DOE may offer fast-track legislation for transmission lines similar to that being considered for synthetic fuels. [18]

Projects accorded "fast-track" siting and permitting could circumvent the time-consuming process of negotiation with landowners to secure approvals, easements and settlements for land, water and/or rights-of-way. Court-determined compensation at "fair market value" could be applied to land and water taken for priority energy projects; projects which in normal times would be regarded as private and strictly commercial.

Montana, for example, has a law which prohibits changing an agricultural water use to an industrial use. This law could be overriden or waived for a priority energy project given fast-track sanction by an Energy Mobilization Board. Moreover, large corporate coal owners and lease holders in the Northern Plains states, such as Utah International, Tenneco, Gulf Oil, Sun Oil and the Burlington Northern Railroad, are very interested in the economic advantages of using regional water resources to develop regional coal. Utah International and Tenneco are fighting the state of Montana for water claims of about 120,000 acre feet annually. [19] Their fight, and others like it, would be made easier

by projects designated for federal synfuels development and fast-track consideration. Some of these corporations may throw their political weight behind centralized energy mobilization board policies at the federal level, while encouraging state legislatures to adopt similar policies.

ENERGY, WATER AND AGRICULTURE

Synthetic fuels development and associated coal development, power generation and coal transportation will require large volumes of water for cleaning, processing and cooling as well as for reclamation, spent shale stabilization and for use in coal slurry pipelines.

According to Business Week, synfuel plants will consume about four times as much water as the amount of oil they produce. [14] For every barrel of oil extracted from shale, 2 to 5 barrels of water are required for cleaning, processing and cooling. For every barrel of synfuel derived through coal liquefaction or coal gasification, 4 to 13 barrels of water are required. [20]

A one million barrel per day oil shale industry could require as much as 295,000 acre feet of water per year for oil shale mining, processing and power generation. [21] The U.S. Department of Energy has estimated water use for cooling, dust suppression, reclamation and steam generation for a 100,000 BPD syncrude plant at 26,000 to 29,000 acre feet per year. [6] Coal gasifiers, depending on type, use 8,000 to 17,000 gallons of water per minute for process water and 30,000 to 170,000 gallons per minute for cooling purposes. [22] Some estimates for coal gasification plants have placed total water use at 40,000 acre feet per year.[23]

Coal slurry pipelines require about one ton of water, or 250 gallons, to move one ton of coal. One coal slurry pipeline could consume as much as 6 billion gallons of water per year—an amount of water equivalent to the needs of a town of about 65,000 people. Three coal slurry pipelines each requiring 25,000 acre feet of water per year, would exceed the "replacement flow" that replenishes the 3-state Madison Formation in the Northern Plains. [24]

In order for a synthetic fuels program to overcome certain water supply and other related problems such as state prohibitions on impoundments, interbasin transfers and seasonal low-flow problems for streams in the west, the U.S. Department of Energy has suggested using groundwater, transferring water rights, building reservoirs "large enough to supplement instream flow in late summer and winter," and importing water from other regions. [6]

In some regions—such as the Upper Missouri River Basin area, which has been mentioned as a possible source for 1.7 million BPD of coal liquefaction—DOE explains that the water problem is a problem of distribution rather than quantity and suggests that "new storage, interbasin transfers, changes in present use, or use of groundwater would be necessary to some extent." [6]

However, where water supply becomes an obstacle for a "priority energy project," energy mobilization powers might be used to circumvent existing prohibitions and limitations. Moreover, according to one account, DOE might require abrogating existing interstate water compacts, state and local water arrangements, Indian water rights, and even treaty obligations with Mexico. [25]

Traditionally, America has always assumed that more foodstuffs could be produced simply by developing more irrigated farmland. Irrigation, however, is rapidly becoming a more expensive and complicated proposition. Falling water tables, expensive electric irrigation technologies, and grandiose capital-intensive water diversion projects place irrigated agriculture in the arena of corporate management and government subsidy.

Further, the regions where irrigated agriculture could most profitably expand will be precisely in those areas where large energy industries and expanding western metropolitan areas will also be growing and needing water. For example, the Western States Water Council has noted that new energy developments in an 11-state region could require an additional 2.3 million acre feet of water by 1990; enough water to irrigate about 1 million acres of farmland. [26] Only large projects and large irrigators able to throw as much political and economic weight around as metropolitan and energy interests will be able to compete for water under these circumstances. Small irrigators will not survive in this kind of competition.

Large corporate irrigators who dominate western water planning and western agriculture may develop political alliances with big energy interests to effect large-scale water diversion and interbasin transfers as local resources are

exceeded and exhausted. In order to insure "certainty" in meeting U.S. production goals which are tied to international markets, even midwestern agriculture could be pressured into large-scale irrigation policies. Pressures of this sort on a limited agricultural resource base will eventually lead to lower production and gradual resource exhaustion.

TAR SANDS

An estimated 450 tar sand "occurrences are found in scattered and concentrated deposits in 22 states. Some of these occurrences are estimated to have a total synthetic crude oil potential of about 33 billion barrels." [27] Some strippable tar sand deposits are found in all 22 states, placed variously at about 20 percent of the total reserve.

Other estimates have placed the total national reserve of tar sands at about 200 billion barrels, with an estimated 26 billion barrels reachable by strip mining. The remainder is found deep underground, to depths of 2,000 feet, currently out of reach with existing technologies. [28]

Significant deposits of tar sands, including strippable tar sands, are found in eastern Utah, south Texas, New Mexico, west-central Kentucky, and California. An estimated 25 billion barrels of potential syncrude is found in 6 deposits of tar sands in eastern Utah. In south Texas, another 3 billion barrel deposit is found in Uvalde County, west of San Antonio. New Mexico has about 1 billion barrels in potential syncrude from the Santa Rosa tar sand deposit in Guadeloupe County. California has "million of barrels" of potential syncrude in tar sand deposits found in the San Joaquin and Salinas Valleys in Santa Barbara County, San Luis Obispo County, Kern County and Mendicino County. Significant tar sand deposits are also found in the Kentucky counties of Breckinridge, Grayson, Edmonson, Logan and Warren. The tri-state area of Kansas, Missouri and Oklahoma also contains tar sands. [27]

Tar sands are cleaned by a mixture of hot water, steam and air, then chemically treated to remove carbon, sulfur and nitrogen, yielding synthetic crude oil.

SULFUR DIOXIDE AND AGRICULTURAL PRODUCTIVITY

Synthetic fuels production, coal-fired electric generation and electric utility fuel conversion to coal will all contribute to increased sulfur dioxide emissions as well as a longer-term carbon dioxide build-up in the earth's atmosphere. At certain levels of emission, sulfur dioxide pollutants have been found to damage leafy green vegetables, cotton, alfalfa, pine trees, grapes, citrus fruits and rye grass. Some irrigated crops are especially sensitive to sulfur dioxide pollution.

In 1976, the House Interstate and Foreign Commerce Committee reported that the National Ambient Air Quality Standards may not be adequate for protecting crops and agricultural productivity:

There is evidence that pollutants may have damaging effects on crops at levels below the national standards. For example, studies show that important agricultural crops suffer leaf damage, growth inhibition or increased mortality resulting from sulfur dioxide levels lower than the national ambient air quality standards.

At SO_2 levels below the national standard, and measured over one growing season, the Committee reported, for example, that some varieties of wheat had a "15 percent decrease in grain yield weight"; that oranges had a "decrease in yield quality and in thickness growth," and that potatoes were found to have a "decrease in tuber yield weight." [29]

EPA air pollution standards are designed primarily to protect people from respiratory illness and are geared to local health, and do not necessarily take account of crop damage thresholds or synergistic impacts on agriculture such as acid rain over large regions. [30]

Pressure to relax SO_2 standards for fast-track energy development could exacerbate pollutant damage to agricultural crops and livestock.

MORE POWER PLANTS: IT TAKES ENERGY TO GET ENERGY

A synthetic fuels industry is a very energy-intensive proposition. The "energy-in, energy-out" ratio for domestic oil production is currently about 50 BTUs returned for every 1 BTU used in production. For synthetic fuels produced from coal, the ratio falls to about 17 to 1; and for oil shale to about 6.5 to 1. [31] Two electric draglines used in strip mining could require as much as 1.9 million kwh of electricity per month, enough to supply the needs of about 1,000 average size farms. [32]

New electric generating plants—with all their attendant resource demands for coal, land and water—will be required to power oil shale, coal gasification, coal liquefaction, strip mining, and other energy processing and distribution activities. Electric generating facilities used to power synthetic fuels plants and mining are themselves inefficient energy converters, typically delivering less than 40 percent of the in-ground resource for power use.

In the nation's rural areas, REA electric cooperatives will supply much of the electricity needed for mining and synthetic fuels production. For example, the Basin Electric Power Cooperative of North Dakota is planning to supply 170 megawatts, or 20 percent, of its new Antelope Valley generating station to the ANG Coal Gasification Co. for lignite gasification. [33] Another Basin Electric power plant being planned for Montana will require approximately 22,400 acre feet of water annually for cooling purposes. [34] Other rural electric cooperatives in Colorado, Utah, Wyoming, Missouri, Kentucky, Illinois and Indiana have planned to supply power for mining, gasification, oil shale, liquefaction, and pipeline pumping.

CHANGING STATE ENERGY POLICIES

Following the lead of the White House and the U.S. Congress, state governors and state legislatures may move to design their own energy mobilization laws and boards to lure certain energy and synfuels industries to their states. Again, in many states, agricultural interests may wind up taking a back seat to favored energy projects. Using the national model, the most insignificant intra-state and local energy projects may be given the same expeditious treatment that major federal programs and new technologies are given, simply because they meet some popular conception of energy action or energy independence. State laws containing agricultural protections may be overturned or waived in the process or new laws pre-empting agriculture may be enacted.

In the summer of 1974, for example, the Illinois legislature passed a bill, subsequently signed into law by Governor Dan Walker, which amended the Illinois Eminent Domain Act of 1872, allowing the state's Department of Business and Economic Development, and private corporations acting in concert with the state, to condemn land, water and mineral rights for coal resource development purposes. [35] Through the efforts of some Illinois citizen groups, the law was changed in 1975 to remove the provisions for condemning mineral or water rights.

Moreover, with energy mobilization policies in the making, and politicians at all levels thinking about "priority energy projects" and fast-track approvals, agricultural interests are likely to receive the kind of treatment accorded local ranchers and farmers a few years ago when the Wyoming Industrial Siting Council was reviewing a large coal-fired power plant that held impacts for agricultural interests in Platte County. According to one account of that review:

The Council glossed over .... water conflicts and other ways the plant would hurt the agricultural community. Instead they reasoned that a farmer or rancher who was forced out of business or lost income because of the plant, could go to work at the plant and make more money that way. And if the plant ran out of water and went shopping for more agricultural water or infringed on a prior user, again the Council saw no problems. They noted that the agricultural water user could sell out or sue.

Although agriculture is the economic backbone of Platte County (where the plant would be sited), the Council gave little consideration to its continued vitality. They wrote agriculture off, concluding that an industrial economic base created by the plant would probably improve the area's overall economic condition—a bigger tax base, higher wages, more sales. They chose not to worry about agriculture and its meager returns, and refused to even give the impacts of the plant on agriculture a good hard look.

Not only did the (Siting) Council refuse to give agriculture the benefit of a second stage evaluation, they did not even attempt to impose any conditions on Basin which might offer some protection to the agricultural community ... [36]

ENERGY ECONOMICS: PRICING AGRICULTURE OFF THE LAND

A congressionally-sanctioned synfuels and energy mobilization program will signal speculators in several agricultural regions to begin buying up land and water rights for prospective energy and mining projects. Given a major push for a synthetic fuels program and expanded coal development, agricultural land and water in targeted areas will increase sharply in value, encouraging farmers and ranchers to sell out for quick profits.

More seriously, however, is the fact that energy speculation and inflated land values will eventually undermine the willingness of farmers and ranchers to invest in their future as agricultural producers. One study of farmers and ranchers in northwest Colorado found that energy speculation, concern for condemnation, interference and property damage from energy development and exploration, and general uncertainty about the future of the area, influenced farmers' and ranchers' investment decisions, retirement plans and general morale. [37] Once local farmers and ranchers begin to cut back on investments in their own operations, it isn't long before local agricultural businesses and suppliers begin to feel the loss, and before long, overall regional investment in agriculture declines, encouraging all but the most tenacious of farmers to give up their land.

In 1976, a study of 300 farmers and ranchers in a four-county area of northwest Colorado revealed that 77 percent had been made an offer for their land by a developer, speculator, utility, coal, or oil company. [37] In Wyoming, Exxon, Reynolds Metals, Texaco, and Pacific Power & Light Co. have already purchased entire ranches solely to obtain water rights. A southern California utility recently paid local farmers in south central Utah $1,750 per acre foot for water needed to operate a large coal-fired power plant. [26]

A study comparing synthetic fuels production with crop production in competition for water resources in the 17 western states indicated that "crop production cannot compete with synthetic fuels production for water resources on an economic basis." [38] Considering only the allocation of water resources under competitive market conditions, and evaluating projected export values, the study noted, "synthetic fuel production appears likely to supplant agricultural crop production in some areas of the 17 western states." The estimated economic return for synthetic fuels production per 100,000 gallons of water was as much as 10 times that of agriculture.

In an analysis of how prime farmland would fare in a marketplace that wanted the coal beneath that land rather than the crops the soil would produce, a Carter Administration task force studying strip mining on prime farmland in 1977 made the following observation:

The fact that some prime farmland will be taken out of production for a period of time, or will be able to support diminished production levels for an additional period, should be balanced against the social utility of mining the strippable coal reserves underlying that land. As a practical matter, the economic balance is not really at issue. If one assumes that the market price of a given commodity bears some relationship to its economic and social value to society, the social investment decision for most of the Nation's coal fields will almost always favor the coal. In the most simple terms, the fact is that the price utility and other major coal users are willing to pay for the resource will normally far exceed the long term income potential of a given plot of land for agricultural production. [39]

AGRICULTURAL RESOURCES: BALANCE OF PAYMENTS VALUES

In order to offset an OPEC price increase of 60 percent, the U.S. must export an additional $25 billion worth of goods abroad. [40] Agriculture already contributes nearly $30 billion worth of commodities to the Nation's balance of payments, and with the recent announcement by Secretary of Agriculture Bob Bergland that the U.S. will remove acreage restrictions on wheat due to an expected grain deal with the Soviet Union, the U.S. will add an estimated $1.4 billion to its agricultural export earnings.

For the last 2 years or so, the Carter Administration has been aggressively promoting U.S. agricultural commodities abroad. In order to meet expanding export markets and large orders like that of the Soviet Union, more "set aside" acreage for wheat and other crops will eventually be brought into production. This means that there will be less of a "margin" or excess of agricultural resources in the U.S. as domestic and world needs continue to expand.

As agricultural land is pre-empted for energy production and other encroachments, more pressure will be placed on the remaining agricultural resource base. For example, thousands of AUMs (Animal Units per Month) in grazing capacity will be lost in the Northern Plains and Rocky Mountain states as coal mining and synthetic fuels development occur. The demand for beef is rising, and so grazing land is in demand. Currently, much of the range land in the west controlled by government is overgrazed, and needs a rest to repair itself. [41] However, these lands are precisely those that will feel more pressure for grazing and beef production as mining and coal development remove western grazing lands from production.

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As demand for U.S. food and fiber increases at home and abroad, there will be new demand for agricultural land and water. Given a major synthetic fuels program and favorable energy mobilization policies, energy and mining interests will be granted priority over farmers and ranchers for limited land and water, precisely at a time when agricultural resources should be preserved for economic and humanitarian purposes.

Due to a shrinking agricultural resource base, every pre-emptive inroad made on productive land and water by energy and mining interests is a direct balance-of-payment loss to the U.S. productive agricultural resources, if husbanded properly, have renewable and long-term balance-of-payment potential, and will not require the degree of subsidization and price guarantees that synthetic fuels projects will need.

AGRICULTURE NEEDS PROTECTION AND LOCALIZED ENERGY INCENTIVES

Given the potential impact that expedited energy developments could have on agriculture, and the apparent fact that existing protections for agriculture would not hold up under fast-track, priority energy siting and permitting, agricultural interests need to make a lot of political noise in order to secure protection for land and water resources.

Within the framework of the existing legislative debate shaping up this fall, amendments, separate legislation and oversight hearings need be readied and organized, specifically drawn to publicize the potential impact of energy development on agriculture. If major synthetic fuels and energy mobilization programs are to go through Congress this year, then the public ought to be made aware of all the potential ramifications, and especially those concerning agriculture.

The expensive nature of a synthetic fuels industry means that money and political momentum will flow toward the energy industry; money and political leverage that will be used to subdue agriculture when land and water conflicts emerge. The most constructive alternative to an impecunious synthetic fuels spending spree would be a serious energy conservation and solarization program. For farmers and ranchers, such a program could be initiated and funded through the U.S. Rural Electrification Administration and pushed by the nation's 1,000 local rural electric cooperatives. This may not be easy since many rural electric systems are themselves eyeing the potential electric growth that would come to their service areas with a crash synfuels program.

Nevertheless, rural electric service territories occupy 75 percent of the land area of the U.S. and are found in 46 states. They are in an ideal position to demonstrate the economic and environmental advantages of solar, conservation, wind, methane, etc. An estimated 50 percent of existing homes in rural electric service territories areas are under-insulated. Potential energy savings of 40 percent in existing rural homes and 60 percent in new rural homes could cut back on the need for expensive, new rural electric generating facilities, bringing economic savings to farmers and ranchers who use REA systems. Moreover, REA could make an all-out effort to bring solar, wind, and methane technologies to farmers and ranches through special subsidized programs, further helping ameliorate agricultural production costs.

By calling for an REA-sponsored program of alternatives and energy conservation, agricultural interests will be seen in a constructive light by Congress. By offering such a practical approach to rural energy needs, a synthetic fuels/energy mobilization program that is destructive of agriculture will appear even more ludicrous and wasteful.

Notes

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(4) Why the U.S. Needs a Synthetic Fuels Industry", *Business Week*, July 16, 1979.

(5) Hoyt C. Hottel & Carroll L. Wilson, "Clearing The Way for Synthetic Fuels", *Washington Post*, June 18, 1979.

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(16) Hon. Charles Percy, U.S. Senate, *Congressional Record*, May 20, 1977.
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Senator McGOVERN. Just on that point, it might not be quite on target with what we're talking about here today, but I would hope that in addition to those 200 or 300 people in southwestern South Dakota that do not want to lose their underground water in order to turn it into sludge to float coal to the South, that they'd also be joined with the railroads and other interests that are perfectly capable of moving coal. There are various ways you can move coal from the North to the South. It doesn't all have to be done by pipeline.

But I share your concern that water users in those Great Plains States are going to be vastly outnumbered by others who are going to be eager to see as much energy developed as possible without regard to what it does to the local people.

Your point regarding the possibility of pricing the farmer out of the water market, I think, is well taken. It's one that hasn't been made before, at least in a public hearing, to my knowledge.

Do you see any way this problem can be prevented if we continue to pursue synfuels under the recently passed legislation?

Mr. McCORMICK. In fact, Senator, I see the problem being exacerbated because what we are discussing in this legislation is a variety of incentives, given the synfuels interest, to spur on their development plans, to hurry these projects into operation. And one particular form of incentive would be the guaranteed price, where the difference between the world oil price and the production costs of synfuels would be subsidized by the Federal Treasury. And it's there that the project managers no longer have to consider the economics of the capitalization of their project.

When it comes to their looking for the purchase of water rights, the price will be no object then, because the high cost of their water will be factored into the cost of the product, and that will be subsidized at the back end by a guaranteed price provided by the Synthetic Fuels Corporation.

So I see the direction that we're going is just, in a sense, encouraging that this water speculation occur, and it already has occurred in the oil shale regions of Colorado. And that's just beginning to come in right now, and I can see it being played out equally as rapidly in the northern Plains States as those synfuel projects become closer to reality.

Mr. CLARK. May I add a word?

Senator McGOVERN. Yes; I was going to ask both you and Mr. Hall to comment on the same problem.

Mr. CLARK. Under Montana water laws, it is actually impossible for large agricultural water rights to be transferred to industry, period. That is, you can't have an industrial corporation acquire agricultural water rights by purchase.

Senator McGOVERN. You're protected by State law.

Mr. CLARK. Yes; State law prevents the transfer of agricultural water to industry.

Senator McGOVERN. Would that be true, as you understand it, under the authority of the new Energy Mobilization Board, as that stands with the power that it now has in recently passed legislation?

Mr. CLARK. Well, I'm not familiar in detail with that legislation, but this, as you well know, is the concern that western and northern Plains States have—that any of the Federal laws do not just steamroller the State water laws.

Senator McGOVERN. Well, as I remember, we did bring in some protections there to protect State laws, but I think that's a matter we need to research a little more carefully.

Mr. HALL. This is a tremendously complex issue. When people think about water rights and their salability, it's true that many Western States can't sell surface water rights. In Nebraska, for example, you have a surface water right that you obtain from the State. You either use it or you lose it. You have to use it for some beneficial and stated purpose. And when you stop doing that, the water right reverts back to the State. It's not salable.

What is overlooked is that many of the States' water doctrines do not apply to ground water, and, in fact, this is the major issue in Colorado now in terms of salability of water. Ground water is inadequately protected in my opinion against this kind of effort in most of the Western States.

Certainly included in those would be those of the upper Great Plains.

Senator McGOVERN. Mr. Clark, in your testimony, you mentioned the fact that Indian water rights claims regarding the Yellowstone are still pending. Despite the fact that a complete set of water reservations for the river in Montana have already been established, how much of an impact could Indian water claims have on existing reservations and, more particularly, on water that would be available for synfuels development if these claims are upheld?

Mr. CLARK. Of course, one hears all sorts of claims, as you well know, all the way from all the water that flows through and falls on to various quantities less than that. The problem is that the Big Horn River, which comes in from Wyoming and is the major tributary of the Yellowstone and is subject to the Yellowstone compact, plus the Rosebud, plus the Tongue—all three of those are affected by the potential Indian water claims.

Now the Tongue is a stream that has a pretty minimal inflow. It gets down to the point where we play with 75-cubic-feet-per-second flow as a minimum instream flow on that thing, and that's pretty ridiculously low. There are times when it darn near approaches that on the natural flow.

But if the Indian water claims are granted through the Federal courts, there's no question that we will have to go back to the drawing board on these water reservations. There's absolutely no question. We could not prejudge the thing because we had no quantities to work with at all.

Senator McGOVERN. Mr. Hall, in your prepared statement, you suggest that there's enough water in the aggregate for a major synfuel

development program in the northern Plains but that substantial changes in water management policies will be necessary.

Given your experience bridging the gap between Federal and State decisionmaking on water issues, how likely is it that these changes are going to be forthcoming in time to meet the President's synfuel production goals?

Mr. HALL. I think it's highly unlikely they will be forthcoming without the impetus of the Federal Government. I think the States themselves are unlikely to get together to work out arrangements that would facilitate interbasin, transbasin, and trans-State agreements, without Federal stimulation.

Senator MCGOVERN. Well, just to take that specific case that you referred to, the article X of the Yellowstone compact, if that proposal fails, what constraints would its failure impose on the synfuel development program?

Mr. HALL. I don't think it will impose any particular constraint on the total program. What it will do is impose additional costs on the management of water, on getting water to the right place at the right time, and it will impose some constraints on the site selection for synfuel facilities.

All I'm suggesting in my prepared statement is that article X of that compact does, in fact, come into play in a material way in the whole question of siting and water management.

Senator MCGOVERN. Mr. Clark, earlier today Ms. Clusen testified that interbasin transfers of Yellowstone River water supplies may be necessary to facilitate coal-based synthetic fuel development. Would those transfers be allowed under existing Montana law?

Mr. CLARK. Well, they are subject to the compact, obviously. Yes, in that respect, they would be allowed, but they would be subject to ratification under the Yellowstone compact.

Senator MCGOVERN. But might it mean amending that compact to permit those transfers?

Mr. CLARK. I'm not sure I get the drift of what you're shooting at, sir.

Senator MCGOVERN. Well, she, as I understand it, said that you might have to work out transfers of water—the Yellowstone River water. What I'm asking is, does the existing Yellowstone compact prevent that, and, if so, can it be amended? Can it be modified, and what is your feeling as to how this would be resolved?

Mr. CLARK. Well, I think Mr. Hall is probably better qualified than I to deal with that. My understanding is that it is possible under the compact, if the signatories agree to it. Now, is that correct, Mr. Hall?

Mr. HALL. That's right.

Mr. CLARK. And the reservation I would have relative to the interstate transfer of water from the Yellowstone system is that in low water years, the water isn't there to transfer, unless you transfer from an offstream storage reservoir.

Senator MCGOVERN. Are those offstream storage facilities generally more environmentally acceptable than instream storage projects?

Mr. CLARK. In Montana, I think that's true. On the main stem of the Yellowstone up near Livingston/Paradise Valley, there's tremendous opposition to that as an onstream dam. These offstream

dams are on fairly small, almost intermittent tributary streams where the terrrain is such that you could build a dam and pump it full during high water flow and then draw down during low water periods.

Senator McGOVERN. Well, the hour of 12 has come, and we have to adjourn this hearing at this time. But I would like, if I may, to reserve the right to submit some questions to you gentlemen in writing.

Thank you very much for your testimony here today.

The hearing is adjourned.

[Whereupon, at 12:05 p.m., the subcommittee adjourned, subject to the call of the Chair.]

[The following questions and answers were subsequently supplied for the record:]

RESPONSE OF RUTH C. CLUSEN TO ADDITIONAL WRITTEN QUESTIONS POSED BY SENATOR MCGOVERN

Question 1. It is my understanding that energy companies are already purchasing water rights to large amounts of water presently being used by farmers and ranchers. Clearly, the energy companies can afford to pay more for water than our agriculture producers. Do you see this development as a threat to our region's agricultural economy? If not, why not?

Answer. Any transfer or sale of water rights from irrigated agriculture to energy companies in any western state requires approval by State, not Federal, authorities. Indeed each state has its own system of prioritization of beneficial uses, which the state engineer will take into account in approving or denying any request for transfer of water use from agriculture to energy.

It is also our understanding that some purchases of water rights by energy companies have already occurred. The following table, from a briefing package prepared by the University of Oklahoma, based upon their study "Energy From The West" which was sponsored by EPA, shows the estimated quantities of existing rights owned by various oil shale developers, many of which were obtained as early as the 1940s.

TABLE 1

Existing rights:	*Estimated quantity (acre-feet per year)*
Colony development	171,274
Union Oil Co	85,770
Sohio Petroleum Co	72,380
TOSCO	39,000
Mobil	36,190
Superior	17,370

It should be noted that the recent water-for-energy assessments for the Upper Colorado and Upper Missouri River Basins, which I mentioned in my testimony, both concluded that high levels of energy development could be accomodated in those regions without drawing upon any existing water rights, provided appropriate water management policies are undertaken.

Question 2. Your prepared statement suggested that the average coal-based synthetic fuels plant uses only about 8,000 acre feet of water per year, and that this amount can be reduced dramatically for only a fraction of the cost of a plant. Why aren't we requiring all plants to use this more water efficient technology? Are there other incentives that might encourage private companies to use water efficient technologies?

Answer. The type of water-efficient processes and practices which can further reduce water use by synthetic fuel facilities, especially increased use of dry cooling and recycling of process waters, has not yet been practiced extensively, but is beginning to be reflected in new designs for these synfuel facilities.

Certainly, on a Federal level, the President's national water policy encourages water conservation in all sectors. In addition, EPA Region 8 has recently proposed an environmental/energy policy for that region which would, among other things, require developers to assess the feasibility of maximizing methods for conserving water. I would suggest, however, that the real key to industrial decisionmaking on water conservation is whether scarcity of water and the

requirements of state permiting mechanisms will together encourage private industry to conserve water as much as practicable.

Question 3. As I listened to the testimony of the witnesses, it struck me that our synfuels development program directly depends on the cooperation of states and regions to make adequate amounts of water available for the various plants which will be established, yet little has been done at this point to establish hard agreements for this purpose with various state and regional water resource agencies. It seems to me that the success of the synfuels program largely hinges on such agreements. Would you comment on this point?

Answer. I would agree that synfuels development in the West depends to a great degree on the cooperation of states, regions, and the Federal Government to ensure sufficient water is available. The studies which have assessed these issues to date and which I mentioned in my testimony indicate that surface water supplies can be made available in the West for synfuels development without impacting other non-energy uses, provided the appropriate water resource management and development decisions are made by all parties concerned. For example, the Bureau of Reclamation has set aside industrial allocations of water in many of its reservoirs, and has also offered states the authority to market much of the unallocated water in its reservoirs.

As I stated in my testimony, greater attention must now be paid by both the Federal Government and the states to integrating and coordinating energy policy and water policy, at both the national and local levels. The linking together of these two critical concerns will do much to resolve the remaining uncertainties regarding water and energy, and ensure that adequate water supply is available to meet vital needs within these regions.

RESPONSE OF MILLARD W. HALL TO ADDITIONAL WRITTEN QUESTIONS POSED BY SENATOR MCGOVERN

Question 1. Your prepared testimony suggested that further research aimed at developing "procedures and policies needed for the expression and integration of national, regional, State, and local needs and interests would be appropriate." I could not agree more.

Could you elaborate further on who might conduct this research and how they might go about it?

Answer. Research aimed at developing "procedures and policies needed for the expression and integration of national, regional, State, and local needs and interests" could be conducted by any number of competent entities. However, I generally find that the most effective research is that which is done as close as possible to the problem area, by those having the greatest familiarity with the problem and all of its possible alternate solutions. Thus, I suspect the research itself can probably be conducted most effectively by the universities in the Missouri River Basin. However, much effort will be needed at the regional level to channel the interest of researchers in these universities toward such investigations and to coordinate them so the results can be integrated into a regional and national whole. To this end, the Missouri River Basin Commission, in cooperation with the Department of Energy, the Environmental Protection Agency, various offices of the Department of the Interior including the Office of Water Research and Technology, and the U.S. Water Resources Council, could assist. I feel that the Commission has shown through its work on Section 13(a) of the Federal Non-Nuclear Research and Development Act of 1974, the 1975 National Water Assessment, and other cooperative programs, that we are well suited for orienting research and data collection at the regional level and for helping to get meaningful results from such efforts organized into a national result.

While new research systems could be devised for conducting and coordinating research and related activities in the States and regions, I firmly believe in using existing, proven mechanisms for these tasks insofar as possible. In this case I believe that the Water Resources Research Institutes in each State, as well as the Agricultural Experiment Station and the Cooperative Extension Service in each State, with strong coordination from a regional body such as the Commission, could well be used in this effort.

Question 2. In your statement, you noted that interbasin transfer of water may be necessary to adequately meet synfuel plant needs.

What incentives are there for one basin system to allow transfer of water to another?

Answer. At present, I am not aware of any incentives for one river basin to allow transfer of surplus water to another basin. As I understand it, such incentives are being explored to some degree in the studies now being conducted with regard to the Ogallala Aquifer under the auspices of the High Plains Study Council. This study, of course, is being funded by the Economic Development Administration in the Department of Commerce.

A potential incentive which comes to mind, would be the possible construction of storage or transfer facilities in and/or through the basin of origin which could also be used to benefit the basin of origin. This is, I think, illustrated very well by the proposed West River Aqueduct from Oahe Reservoir in South Dakota to Gillette, Wyoming; from the mainstem Missouri drainage into the Belle Fourche Basin. This project would have as its primary function the supply of water to a coal slurry pipeline. However, a secondary purpose might well be supplying water to numerous small municipalities and farms along the nearly 200 miles that the pipeline would traverse. These seems to be little possibility of providing additional water to the municipalities along this route without the delivery of water for energy development.

Similar opportunities probably will arise for synfuel developments where the value of the water at the synfuel processing site is great, and the cost of water is a small percentage of the total operational expense for the synfuel facility. In such cases, the synfuel operation might well be used to assist in financing water supply to rural or urban areas.

At any rate, it is clear that the basin of origin will have to be assured that a) there is surplus water within its borders, b) there is a great need for that water outside its borders, and c) that the basin of origin is being adequately compensated for giving up its rights to that water. It must also be made clear to all concerned that the basin of origin, or at least the State of origin, will continue to play the controlling role in deciding on the fate of its water resources.

Keeping and utilizing water in the basin where it originates is a well ingrained principle in the western United States. Although there have been large interbasin transfers of water in this century, the adverse effects of some of those transfers in the basin of origin, either real or imagined, has even more firmly established the general principles of "keep the water where it falls." Some States have incorporated this concept into interstate water allocation compacts, and into State legislation. States like Nebraska have laws which have been interpreted to mean that water cannot be transferred from one basin to another, even within the borders of the State. I presume that appropriate incentives can be found. However, I expect them to vary widely, depending on the State and local area. Regional, organizations, such as the river basin commissions should be helpful in determining the necessary incentives and conditions which would permit the interbasin transfer of water. In support of this argument, I am enclosing a copy of a paper on interbasin water transfers which I gave recently at a national meeting of the American Society of Civil Engineers.

Question 3. As I listened to the testimony of the witnesses, it struck me that our synfuels development program directly depends on the cooperation of States and regions to make adequate amounts of water available for the various plants which will be established, yet little has been done at this point to establish hard agreements for this purpose with various State and regional water resource agencies. It seems to me that the success of the synfuels program largely hinges on such agreements.

Would you comment on this point?

Answer. You are very perceptive in recognizing that the Federal Synfuel Development Program directly depends on the cooperation of the States and the region to make an adequate amount of water available for the various plants which will be established. At the same time, these States and the region must be protective of their individual economic and social needs. You are also correct to note that little has been done at this point to establish hard agreements regarding such matters with various State and regional water resources agencies. This will probably necessitate individual State and interstate agreements requiring additional and strengthened programs for State and regional planning and coordination efforts.

With States having the right to issue permits for the use of their water, it is imperative that they become full partners in synfuel development. Even

though there may be negative environmental and social impacts from synfuel plants there certainly should be social and economic incentives for States to cooperate in synfuel development. In some instances this likely will require providing tradeoff such as nonenergy related projects or activities being fulfilled in part or subsidized by the synfuel development, thus providing synfuel to meet national needs and objectives and also accommodating State and regional needs and desires for economic, social, and environmental enhancement in nonenergy related areas.

In addition, the States wherein synfuel development is likely to be most intense, or have the greatest impact, will require additional assistance with funding of water resources planning. Such funding is available through the Public Law 89-90 Title III Program. However, special studies that are undertaken by the Federal Government outside of, or in addition to, planning activities require active participation by the States as well. In many cases, some additional funding from the Federal Government to the States for such activities would allow this necessary participation as a full partner, in a timely fashion. This would be considered at the time that such studies are being formulated.

The MRBC is in a strong position to facilitate cooperation between the States in the region and the Federal Government to assure the availability of adequate water supplies for the synfuel program. Through its planning program, the Commission is responsible for coordinating not only Federal and State water and related developments, but those of private entities as well. Up to this point we have had little involvement in private development. However, we recognize that in some instances, such as in the case of the planned ANG Coal Gasification Company Plant in Mercer County, North Dakota, private developments can have major impacts on the areas' water and related resources. In fact, in this regard, we are now negotiating with the U.S. Water Resources Council, pursuant to authority granted under Section 13(c) of the Federal Non-Nuclear Research and Development Act of 1974, to lead the (initial) site specific study of the impact of a synthetic fuel plant on the water resources of the area. Clearly, State and regional water resources planning programs must be fully utilized to coordinate allocation of water to synfuel uses as well as to the more traditional uses to which water must be put in the basin.

RESPONSE OF WILSON F. CLARK TO ADDITIONAL WRITTEN QUESTIONS POSED BY SENATOR MCGOVERN

Question 1. Ms. Clusen testified that the relations between the Federal Government and State governments pertaining to the authority to allocate water in federal water storage projects needs some clarification.

Could you describe this issue as you see it, and offer any suggestions you might have for clarification of this relationship?

Answer. I am not familiar with the legal intricacies of storage projects. However, as I understand it, at least in Montana certain memoranda of understanding have been made whereby the State is specifically given authority over a certain volume of water, such as some 300,000 Afy I believe from Fort Peck reservoir. This certainly is a constructive avenue of cooperation.

The basic problem is, I feel, one of uncertainty about jurisdiction and about the quantities of water that are available, and even more uncertainty of the actual totals of legitimate water filings and adjudicated water rights. Because of these uncertainties, neither part (state, or federal agency) is very sure of the magnitude of the water resource or the actual claims against it. Consequently each tends (quite understandably) to hedge its bets and get as large a share as possible.

The present Montana Constitution gives full authority to the State over the total water resources of the state. I realize that this doctrine is not necessarily palatable to the federal agencies, particularly to those already having impoundments and water contracts. It would seem to me (in my non-legalistic view) that each Federal agency claiming water should literally file on that water and establish clear water rights under state laws.

For instance, the Bureau of Reclamation (now re-named the Water and Power Resources Service) can readily document the flow histories, storage histories, and firm sale contracts on its reservoirs: It can document long-range commitments and plans for water. Amounts over those quantities could then be recog-

nized as clearly available for filing or reservation under state law—with due regard to any interstate aspects of a particular stream.

Those Federal agencies that do not have major impoundments such as BLM and USFS, still need to be assured of certain water rights. The BLM entered the Yellowstone Water Reservations case to establish a right to water for stock directly from streams, for water for small ranch ponds, and for some amount of water for irrigation development. In large measure those reservation requests were granted, and as a result I see one less area of contention between the state and federal agencies.

On the other hand, the USFS did not make any applications for water reservations within the Yellowstone Basin even though a significant part of the higher elevation watershed is Forest Service land. Merely being the owner of land, the Forest Service is entitled to use of water—for recreational sites (actual water supply at campgrounds), water needs of forest industries, water for oil and gas activities, etc. As a minimum, there should be a clear determination and establishment under State water law of a quantity of the water that "belongs to the Forest Service." It would not be reasonable to say this quantity is all of the water that falls on the FS lands (for FS land is largely the snow-catchment area that supplies a major part of total flows). But it would be equally unreasonable to deny water for the development of National Forest resources.

In summary, I feel sincere efforts should be made by both the state and the federal agencies in the state to quantify the present water quantities, uses, needs, claims, and long-range commitments of each agency (whether or not it has major impoundments), and nail down such items under existing state laws. This would indeed "clear the air." It would reassure the states (particularly irrigation states) that those nasty ol' Feds would not pre-empt water by fiat or merely because the majority of Congressional voting strength is not cognizant of western water problems and limitations.

Question 2. Your testimony states that the Montana Board of Natural Resources and Conservation had little information from the Yellowstone Compact as to inflows of water from Wyoming to Montana.

I recognize the difficulty of making judgment based on little information, but do you have any estimate of the amount of water that Wyoming could consume for energy development without disrupting the Yellowstone Compact or the Yellowstone Water Reservation Program?

Answer. As I know you are aware, and as I stated in my testimony to your subcommittee on November 14, the State Board of Natural Resources was restricted entirely "to the record," in making its water reservation decisions. There was in the record some small amount of data on the Yellowstone Compact (primarily in relation to the Big Horn River), but there was little clear agreement or clarification of quantities of water or even of percents of flows which "belonged" to Wyoming and to Montana. The Big Horn water is also that which is claimed by the Crow Tribe. Thus, on that river we had very large areas of ignorance of claims, rights, and uses.

As the single largest tributary of the Yellowstone, the Big Horn contributes an average of over 2 million Afy to the Yellowstone under present uses. The diversion reservations we approved were not large. The largest reservation was for in-stream flows. But we realized that both the Crow Water case (if and when settled) and the Yellowstone Compact (if and when clarified and quantified) could and probably would force a major revision of not only reservations on the Big Horn, but of reservations on the main-Yellowstone below the Big Horn.

The Tongue River has identical problems (Northern Cheyenne water claims, Yellowstone Compact) but with a much less volume of water involved.

Question 3. As I listened to the testimony of the witnesses, it struck me that our synfuels development program directly depends on the cooperation of states and regions to make adequate amounts of water available for the various plants which will be established, yet little has been done at this point to establish hard agreements for this purpose with various state and regional water resource agencies. It seems to me that the success of the synfuels program largely hinges on such agreements.

Would you comment on this point?

Answer. I feel your question hits on a major point, and that it identifies an essential cornerstone for any synfuel program. The cooperation of the state is indeed absolutely necessary. As a person in a neighboring semi-arid state, I know you are well aware of how fervent are the feelings on water. In addition, at

least in Montana, there are very strong feelings of the state having a major deciding role in plant siting, and a real fear that the Montana Major Facilities Siting Act will be ignored.

You'll recall that all of the five people who testified Novembre 14 stated that there was a significant amount of water available for energy development. Mr. Guy Martin quantified this in relation to federal impoundments. But the federal people dealt in gross quantities and averages. On the other hand, in my testimony (restricted to the Yellowstone Basin) I made the point strongly that there was a lot of water unallocated, un-reserved, and not filed on in years of 60 percentile flows or better. But in lower flow years, these excess quantities were not there. I advised that any future industrial user of water (who would hold a right junior to existing rights and reservations) would have to either build his own off-stream storage to tide him over the dry years, or would need to sign long-range purchase contracts with the Bureau of Reclamation for water out of the three Bureau of Reclamation off-stream storage dams for which our Board approved reservations. Those off-stream dams, under stipulated conditions of their respective reservations, would be filled by pumping from the main Yellowstone River only in periods of better than average flows. The same situation applies to the Tongue River Dam belonging to the State Department of Natural Resources. That dam exists now, but with a fairly small storage capacity. Our Board approved a reservation of Tongue River water that would allow a very considerable expansion of the storage capacity, for the Department of Natural Resources proposes to raise the level of the dam materially, or build a higher dam just downstream and breach the present dam. A further possibility being studied is the feasibility of draining the present dam, and while the new dam is being built, of mining the considerable amount of coal now below the impounded water. By not backfilling, the storage quantity of the new dam would increase considerably over what it would be with only a new and higher dam.

As to a suggestion to solve the business of nailing down water for energy or any other industrial development, I think the appropriate agency (or agencies, or corporate bodies) should file now for the quantities of water they need, and should go through the regular State water rights procedure. But in such a filing, the applicant would need to show clearly how it planned to live through the years of less than average or possibly 60 percentile flows.

I do not see this as a large problem—unless the Federal agencies feel that by applying to the State and going through the State system they would some how be discounting the sometimes-made claim to paramount water jurisdiction. To feel that way is downright silly. To go the road of the State system, and do it rationally, carefully, thoroughly, and in good faith would go a long way to allaying State fears of a federal steam-roller job.

A further advantage of federal agencies fully cooperating with State water law and water procedures would be that at least there would be a single repository and central data bank on the waters of a state. Such a thing most certainly does not now exist; and the absence of solid data was one of the most frustrating aspects of the State Board of Natural Resources efforts to make reasonable decisions on the Yellowstone Water Reservations case.

CONCLUSION

I hope these few thoughts are of help to you. Under Answer No. 2 I made reference to a Mr. Gary Fritz. He's the head of the Water Resources Division, State Department of Natural Resources, 32 S. Ewing Street, Helena, Montana 59601. Mr. Fritz is without a doubt one of the best informed people on the water resources of Montana, and particularly on the Yellowstone Basin. I'm sure he could shed considerable light on your question No. 2 dealing with the Yellowstone Compact.

APPENDIX

Work Group Report for the National Agriculture Research and Extension Users Advisory Board

Water and Agriculture

A meeting of the work group was held at the BARC-West, Beltsville, Maryland, on August 28, 1979. The discussions and presentations were directed primarily to the water problems of the irrigated lands of the 17 Western States, and specifically, to the potential impacts that a massive energy development program may have on the future of western agriculture. The proposed subject areas recommended for increased attention and action should be considered as "first cut" proposals and not an all inclusive list of concerns and problems requiring attention.

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RECOMMENDATIONS

Water is the single most limiting resource in crop production. Hence, policy changes and/or technological developments that have a major impact on water must be carefully examined and the possible direct and indirect effects on agriculture determined. Likewise, the potential for increasing crop production through improved, water management policies and the development of innovative technology is tremendous.

The massive energy program that is contemplated to reduce the Nation's dependence on OPEC will have a major impact on agricultural water supplies, quantity and quality. Problems concerning water and agricultures future must be realistically identified and imaginative, innovative solutions found. Present policies or the lack of policies regarding water management must be reexamined in view of rapidly changing conditions. New policies on a local, regional, and national level may be required as the energy impact unfolds. Alternatives to and improvements in irrigated agriculture are urgently needed.

POLICIES AND PROGRAMS

Future Use of Irrigated Lands in Western States.—Agricultural problems that are likely to be encountered in the event that energy costs and water supplies are altered to the deteriment of agriculture must be identified and alternative solutions to these problems developed. For example: Improved gravity or low pressure irrigation systems may have to replace high pressure systems. Land use guidelines may be required wherein crops, soil and water are simultaneously considered in determining what crops will be grown where. Alfalfa may have to be produced in humid areas and scarce irrigation water in the West

used, for high valued fruits and vegetables. Consequently, there may have to be a relocation of associated cattle feeding operations now located throughout the arid West. Higher yielding cropping systems will have to be developed if irrigated acreage is to be materially reduced and food supplies are to be maintained. The possible damaging effects of salinity associated wtih oil shale development must be minimized.

Ground Water Utilization—Techniques and procedures must be developed to improve the management of surface and subsurface water supplies. Areas must be identified where excess water resources during the non-crop season can be stored as ground water for subsequent use.

Water Zoning.—Develop methods for making wide management of water for irrigation and/or other feasible uses. There is little effective basin wide management at this time. In the past, water management has been generally very haphazard with static use patterns dictated by existing State water right laws.

Rural Electric Associations and Energy Conservation Programs.—The REA's appear to be in an excellent position to serve as a focal point for energy conservation programs. It is recommended that the Department use REA and Extension, working together, as leaders of a new major thrust to conserve energy in agriculture production systems and rural communities. Conservation probably represents the most immediate approach to solving the energy crisis.

The Nationwide Water Situation.—Policies for the most effective management of water resources on a national, regional, and local basis need be formulated. East vs. West interrelationships need to be determined as supplemental irrigation in some of the humid East may be more desirable from a national food production standpoint than expanding or continuing irrigation in the arid or semiarid West.

Synfuel Production and Agricutlural Implications.—Although many studies have been made regarding the use of water in large scale energy developments, detailed analysis of water requirements for synfuel production are not adequate. Social impacts have to date been largely ignored. This is especially so regarding the social consequences of saline water that are likely to be an horrendous byproduct of oil shale and synfuel production.

Location of Energy Plants versus Agricultural Needs and Concerns.—A critical technical/sociological evalution of DOE inventory sites for energy plants is needed as these, if developed, will impact on agricultural water, production. and people. Agriculture may be able to do wtih less water but not less land.

Federal Energy Mobilization Board.—Hearings related to responsibilities, authorities, and function are to be held in the near future. Decisions made by Congress now regarding this Board will materially impact Western agriculture. The Users Advisory Board should be in a position to play a major role in assuring that all of agriculture is considered before the legal structure and authority of the Board (EMB) is finalized.

RESEARCH AND EXTENSION

Transfer of Technology with Emphasis on Irrigated Farming.— Develop more effective transfer systems to advance the rate of adaption of new technology. New institutional approaches for improved technological transfer need to be explored, as well as the possible use of new economic incentives and/or penalties. SCS and Extension should be involved.

Models.—Models to describe effects of various trade-off are needed, including such major components as energy, water, food supply, and food prices. For example, should irrigated agriculture in Wyoming or Colorado be abandoned for energy? What effect will energy production in Colorado and Wyoming have on water supplies in the Lower Colorado and Platte rivers? How much water is needed to export slurried coal versus production of electrical energy on-site?

Nonirrigated Lands.—Technology must be developed to better manage water on nonirrigated lands as an alternative to irrigation. An intensified effort is needed by the most competent scientists available to find practical ways to increase infiltration and reduce evaporation. Crop yield in much of the semi arid Great Plains could easily be increased two fold without irrigation if such improved water management practices could be developed. Irrigation water in some areas could then be allocated for high valued specialty crops.

Water Management.—1. Develop long-range management strategies for agricultural water supplies under increasing competing water demands during the crop season and offseason use.

2. Conservation and management of water supplies on agricultural lands including conjunctive use of surface and ground water, use of lower quality water and effluents, increased capture and retention of precipitation and evaporation control on land and water.

3. Develop more efficient agricultural water control systems to achieve water and energy conservation objectives.

4. Develop better understanding of plant response to controlled soil water levels and crop water requirements for subhumid areas.

Background Notes

Overview:

The Second National Water Assessment[1] study concluded in 1978 "that in the past decade significant achievements have been made in preserving water and harvesting its power." Their report recognized that interest in water conservation and environmental protection continues to grow; but the report also indicated that greater efforts in this area were needed.

Furthermore, this intensive and comprehensive study concluded that the United States "has an ample supply of water from both surface and underground sources." It was recognized that there can be regional or local shortages of water because of uneven distribution of precipitation. The report listed 10 critical problems related to the Nation's water (Table 1).

This report was published in December 1978 prior to the *energy crisis* and the unanticipated demand on water that a massive energy program (synfuel, oil, slurry pipelines, etc.) now may conceivably produce. In addition to an energy crisis, we may also be approaching a water crisis.

Present Situation:

Forbes,[2] one of the Nation's leading business magazines, carried in their August 20, 1979, issue an article titled "The Water Crisis: It's Almost Here." According to Forbes, the U.S. has a dependable supply of fresh water equal to about 600 billion gallons of water a day (about 3 percent of the world's total). Up until today, this has been adequate. Agriculture has been the prime user and has been adequately and perhaps sometimes overly supplied.

In 1960, according to this article, we used about 270 billion gallons per day (bgd); in 1970, this further reached 370 bgd. By 1985, total daily use will grow to at least 422 bgd—without the massive energy program that has been proposed. From this day on, choices are going to be required by local, State, and Federal officials responsible for the Nation's water resources.

Nowhere will the conflict over water be more serious than in the irrigated West. Unfortunately, most of our irrigated land lies in close proximity to the most easily developed energy alternatives—coal, lignites, oil shale, and geothermal. Without careful planning, as Governor Lamm of Colorado pointed out, energy may usurp agriculture in the economy of many Western States. Careful but imaginative planning is now necessary to prevent an undue negative impact on western irrigated agriculture, environment, and the Nation's future food supply. More energy, especially liquid fuel, is obviously needed and there is strong public pressure to develop alternative sources of fuel—to remove or limit our dependence on OPEC. Western irrigated agriculture can expect to be subjected to continuous and unexpected requests to "share" its water.

Energy—Demand on Water:

There are many studies or reports delineating the water requirements of a massive energy program and the potential impact on agriculture. A recent report,[3] prepared by Jack Doyle of the Environmental Policy Center, is attached in the appendix as a supplement to this brief discussion. An in-depth study has been undertaken by the Council of Agricultural Science and Technology and should be available in the immediate future. Recently, the Soil Conservation Service has been asked to prepare a report (deadline December 15, 1979) on the impact on agriculture of using water for energy development. The Resource Conservation Act also provides for an inventory of resources and identification

[1] The Nation's Water Resources 1975–2000, Volume 1: Summary, Second National Water Assessment by the U.S. Water Resources Council, U.S. Government Printing Office, December 1978.

[2] The Water Crisis: It's Almost Here. Kathleen K. Wiegner, *Forbes* 57–63. Aug. 20, 1979.

[3] Synthetic Fuels and Energy Mobilization—The Impact on Agriculture. Jack Doyle. Environmental Policy Center, Washington, D.C., August 1979.

of potential problem areas, including water. The needs for conservation practices in future agriculture area are also to be identified.

It is generally concluded that if a massive alternative energy program is undertaken, it will require a large amount of scarce western water. Constraints of fresh water on the expansion rate of particular energy options have been examined in detail by John Harte and Mohammed El-Gassier.[4] The authors conclude that the availability of fresh water is the paramount factor to be considered in setting energy policy. Decisions pertaining to the limits of water use for energy will require a greatly improved understanding of irrigated and nonirrigated agriculture, rivers, lakes, estuaries, and climatic variability.

Irrigated Agriculture:

Irrigated agriculture accounts for nearly 80 percent of all water consumed in the U.S. However, irrigated acreage in the United States constitutes only 10 percent of the total cropland. The production from irrigated land accounts for more than 25 percent of total farm sales. The 17 western States have about 90 percent of the 57 million acres irrigated in the United States. Over 80 percent of the crops produced in California, Arizona, New Mexico, Nevada, Utah, Wyoming, and Idaho, are produced with irrigation. Hence, these western States that are also "fortunate" enough to have vast alternative energy resources also play a very essential role in the food and fiber production of the Nation. The problems associated with both energy and the future of irrigated agriculture in the West are, therefore, especially important to the USDA, and more specifically, to SEA.

Research and Development—Funding:

Water supply, irrigation, drainage salinity, and energy consumption are the principal areas of technological concern by several Federal agencies and many States involved in water resource research. In fiscal year 1979, it is estimated that about $322 million was spent on water resource research by the State and Federal Governments (see appendix Table 1). It is expected that this figure will exceed $330 million in fiscal year 1980. In fiscal year 1979, it is estimated that SEA spent about $37 million on water-related research. Working with CR, the States spent about $18 million on cooperative water-related research. The Forest Service in fiscal year 1979 spent $9.6 million on water-related research while the ESCS spent $800 thousand on economic aspects of water. It is interesting to note that there are eight other Federal agencies in addition to the U.S. Department of Agriculture that are involved in Research and Development (R. & D.) related to water resources and use. The Department of Interior and the EPA accounts for a major portion of this effort.

The current expenditures of funds for water-related R&D by SEA in the 17 western States are shown in Table 2. For projects directly involved with irrigated and nonirrigated water, AR had a total budget of $18,570 thousand in fiscal year 1979. CR had a budget of $2,279 thousand, and the States contributed $16,692 thousand. This level of effort is expected to be of the same order of magnitude in fiscal year 1980. It should be noted that discrepancies in total funds expended for various agencies as shown by different reference sources can be attributed to a variation in program coding, interpretation, and yearly changes.

The scope of SEA–AR/CR water-related research is shown in Table 3. Not all components receive equal emphasis. Of major concern is the handling of irrigation water supplies to minimize the adverse effect of degradation that are associated with the evapotranspiration for crop production. There is also a major effort addressing the broad questions of water supply and energy consumption.

It should be pointed out that SEA/AR and CR also conduct an extensive research program related to water conservation, runoff control, an water use efficiency on nonirrigated soils. This research could conceivably become even more important if because of pressures from energy development or because of actual shortage of water from overdraft of groundwaters, it becomes necessary to find alternatives to irrigation, which will not reduce food and fiber production.

Water Policy:

Complexity of National Water Programs.—The diversity and scope of the National Water Programs and the added complexity that the proposed massive energy program will produce dictates that the National Water Research Pro-

[4] Energy and Water. John Harte and Mohammed El-Gasseir, Science, Volume 199, pp. 623–634, Feb. 10, 1978.

gram be coordinated. The Department of Energy, the EPA, and the USDA, for all essential purposes, have been formulating their own water programs independent of one another and often independent of the States and areas which are to be impacted. Continued actions of this type can result in the inefficient use of all scarce resources, especially water.

The recent proposal wherein a Federal Energy Mobilization Board may have authority to nullify State laws or regulatory decisions pertaining to energy projects could severely and adversely affect western irrigated agriculture if improperly or hastily implemented. This so-called "fast track" approach to solving the Nation's energy problems is adamantly opposed by most, if not all western governors and organizations representing city and county governments.

The USDA, under Public Law 96–113, September 29, 1977, has the responsibility [Sec. 1405(3)] to "coordinate all agricultural research, extension, and teaching activity conducted or financed by the Department of Agriculture and, to the maximum extent practicable, by other agencies of the executive branch of the United States Government;" and [sec. 1405(4)] to "take the initiative in establishing research, extension, and teaching programs, funded in whole or in part by the Department of Agriculture in each State, through the administrative heads of land-grant colleges and universities and the State directors of agricultural experiment stations and cooperative extension services, and other appropriate program administrators."

Agriculture is the largest user of water. Two crises, energy and water combined, and occurring almost simultaneously, could prove catastropic to agriculture, particularly in the West, if positive and technologically sound coordination is lacking.

The USDA has the authority and responsibility to assume the leadership of all programs and policies directly or indirectly related to water use and water resource development.

Water Technology:

There can be little doubt that solutions to the present energy crisis and, therefore, a possible water crisis will be found. However, any major reduction in irrigated acreage in the 17 western States will materially impact on the Nation's food and fiber prduction unless alternatives are developed.

But recognizing that oil shale will be developed, coal will be mined, and slurry pipelines will be built, it is imperative that R. & D. programs to develop alternatives to present irrigation practices be intensified and expanded. New, novel concepts must be examined for crop production systems under both irrigated and nonirrigated agriculture.

Special emphasis needs to be given to evaporation control. A significant technical breakthrough in this area of soil-plant-water relationships could significantly affect irrigated and nonirrigated crop production. It conceivably could, in future years, offer an alternative to irrigated agriculture or greatly reduce irrigations demand for water.

There are a host of other technological problems related to water resources and water use in agriculture, including such items as solar energy for pumping, management practices to reduce salinity and pollution, new low energy demanding irrigation systems, techniques to increase infiltration, water recycling, and development of crops that use water more efficiently. Irrigated agriculture uses water on a massive scale. We know that water management can be materially improved through innovative technology and new effective public policies. In fact, there conceivably may be enough water for both energy and agriculture if matters, political and technical, are carefully but imaginatively used together for the benefit of all.

TABLE 1. CRITICAL PROBLEMS—NATIONWIDE

Inadequate surface-water supply.
Overdraft of ground water.
Pollution of surface water.
Pollution of ground water.
Quality of drinking water.
Flooding.
Erosion and sedimentation.
Dredging and disposal of dredged material.
Wet-soils drainage and wetlands.
Degradation of bay, estuary, and coastal water.

Source: The Nation's Water Resources 1975–2000 Volume 1: Summary.

TABLE 2.—WATER RELATED RESEARCH AND DEVELOPMENT—17 WESTERN STATES

	Amount	SY's
ESCS	$1,801,000	33.6
FS	10,923,000	117.2
SEA/CR	2,279,000	
State Funds	16,692,000	193.2
SEA/AR	18,570,000	156.4

Source: 1977 Computer data for CR: 1979 data for AR.

TABLE 3. SEA-AR/CR WATER RELATED RESEARCH

Water harvesting and hydrology.
Irrigation and hydraulics.
Soil-Water-Atmosphere Systems.
Subsurface Water Management.
Sedimentation.
Crop and Forage Production:
Soil fertility crop/water interactions.
Water quality (pollution):
chemicals
soil
salt
Salinity control.
Water use efficiency.
Strip mine reclamation.
Snow hydrology.
Runoff control.
Watershed modeling.
Channel hydraulics.
Irrigation/Energy.
Irrigation techniques:
sprinkler
surface
trickle/drip
Irrigation scheduling.
Channel improvements.
Recharge of soil profiles.
Weed control.
Cropping practices/water use.
Residue management.

APPENDIX TO TABLE 1

CURRENT RESEARCH—WATER RESOURCES, NATIONWIDE

	Fiscal year 1979	Fiscal year 1980 (estimated)
USDA:		
ESCS	$800,000	$800,000
Forest Service	9,640,000	9,726,000
SEA-AR:		
Land and water resources	22,947,000	24,677,000
Watersheds	10,555,900	12,095,700
SEA-CR land and water resources:		
Federal	4,200,000	4,200,000
State	18,000,000	18,000,000
SEA-EXT	(1)	
NOAA:		
Cloud seeding—Florida	1,431,000	1,509,000
Hydrology	1,052,000	1,092,000
DOE:		
Energy impact	1,000,000	1,000,000
Environmental impacts	500,000	500,000
Movement of tranuranic elements in the environment	1,301,000	1,295,000
Ecological effects of cooling systems	1,017,000	923,000
Other water related studies (reservoir ecology, waste management, modeling, cooling, etc.)	3,401,000	
Coal—all aspects related to water	1,785,000	1,775,000
Oil shale	600,000	450,000
Petroleum and gas	880,000	2,120,000
Solar/conservation/geothermal	248,000	202,000
DOI:		
Atmospheric water resourced management (seeding)	9,090,000	7,871,000
Planning and engineering	2,297,000	2,962,000
Dam safety (to start in 1981)	(2)	(2)
Energy	376,000	502,000
Phreatophyte control, sedimentation environment, fish and wildlife	290,000	180,000
Outer Continental Shelf—submerged lands	26,500,000	34,800,000
Bureau of Mines	4,800,000	4,100,000
Office of Surface Mining	476,000	500,000
Office of Water Research and Technology	28,400,000	30,700,000
Non-Federal	8,600,000	
Fish and Wildlife Service	200,000	250,000
Geological Survey	29,900,000	31,300,000

	Fiscal year 1979	Fiscal year 1980 (estimated)
DOT:		
U.S. Coast Guard:		
Marine environmental protection (oil)	$5,500,000	$6,000,000
Ice operations	380,000	150,000
Federal Highway Administration, hydology, water quality	1,150,000	1,160,000
St. Lawrence Seaway Development Corporation:		
Ice, locks, navigation systems	812,000	935,800
Shore erosion	75,000	20,000
EPA:		
Water quality	66,616,000	63,659,000
Drinking water	18,017,000	23,669,000
NASA:		
Remote sensing for water management	1,000,000	1,500,000
Water quality	900,000	1,700,000
Technology transfer	1,700,000	2,000,000
NSF:		
Water cycle, quality management and protection	4,860,000	5,010,000
U.S. Corps of Engineers:		
Civil Works R. & D	17,280,000	21,370,000
Environmental water quality	5,000,000	5,730,000
Navigation—St. Lawrence Seaway	4,000,000	
Aquatic plant control	1,000,000	1,080,000
Fish engineering and protection	3,218,000	2,743,000
Grand total	321,794,900	330,256,500

[1] No dollar level available. 5 FTE's involved in irrigation, salinity, etc. 25 FTE's involved in water quality. These inputs generally matched or exceeded by States.
[2] $6,950,000 for 5 yr.

Source: Water Research Priorities for the 1980's. Office of Water Research and Technology, Department of Interior (revised May 1, 1979).

Effect of the Proposed ETSI Coal Slurry Pipeline on Water Resources in Wyoming, South Dakota, and Nebraska[1]

(By Perry H. Rahn, Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, Rapid City, S. Dak.)

ABSTRACT

In 1974 the State of Wyoming gave permission to Energy Transportation Systems Incorporated (ETSI) to develop a well field in Niobrara County, Wyoming. The anticipated withdrawal of 15,000 acre-ft/yr (equivalent to 20.7 cfs or 9,300 gpm) is to be obtained from about 40 wells in the Madison Limestone. The water would be sent in a 38 inch pipeline to the Gillette area, mixed with crushed coal, and the coal slurry pumped 1,038 miles to Arkansas.

ETSI drilled three test holes in the Madison Limestone, and they were test pumped at 57 to 180 gpm. Using values of transmissivity and storage derived from the acquifer pumping test, a predicted drawdown in the piezometric surface which would ultimately develop after the 45 year life of the project can be made. A study by University of Wyoming geologists shows, for instance, that a cone of depression would spread over 50 miles from the ETSI site, and may cause a drawdown of 1,100 feet at the town of Edgemont, South Dakota. A report by the U.S. Geological Survey supports these predictions and includes data showing that Cascade Spring, South Dakota could be reduced 4 cfs in its discharge.

INTRODUCTION

In 1974 ETSI secured water rights from the State of Wyoming for the withdrawal of up to 20,000 acre-feet/year of ground water from the Madison Limestone in Niobara County, Wyoming. The water would be used to move about 25

[1] Paper published in the 1979 Proceedings of the South Dakota Academy of Science.

million tons of coal per year in a 38 inch diameter pipeline from Gillette, Wyoming to White Bluff, Arkansas. The anticipated water requirement for the coal slurry pipeline is 15,000 acre-feet/year, which is equivalent to a continuous discharge of 9,300 gpm (or 20.7 cfs). It is anticipated that 40 wells would be required to supply the 15,000 acre-ft/year. The area selected for the well field is in eastern Niobara County, Wyoming (Fig. 1).

The purpose of this paper is to review literature which describes ground water impacts from the ETSI well field. The writer wishes to thank Jack A. Redden for his review of an earlier draft of this paper.

HYDROGEOLOGY

The Madison Limestone (technically the Madison Group) is an interstate aquifer, extending throughout a large part of Wyoming, Montana, South Dakota, North Dakota, and northwestern Nebraska (Fig. 1). The Madison crops out along most Laramide up lifts in these states, but locally has different names. For instance in the Black Hills it is called the Pahasapa Limestone and near Guernsey Reservoir it is called the Guernsey Limestone. The top of the Madison is at a depth of 16,000 ft in the deepest part of the Powder River Basin near Gillette, and lies almost 3,000 ft below the land surface at the ETSI well field area. The Madison is about 300 ft thick in Niobara County. The Madison is cavernous at many places, and is the host rock for numerous large caves, such as Jewel Cave and Wind Cave in the Black Hills.

The Madison is recognized as an aquifer with great potential (U.S. Geol. Survey, 1975). Municipal supplies from flowing artesian wells are found at Edgemont, Provo, Philip, Midland, and Eagle Butte, South Dakota, and Upton, Osage, and Newcastle, Wyoming. Numerous springs in the Black Hills, such as Cascade Spring and Hot Springs, originate from the Madison Limestone and the overlying Minnelusa Formation, with which the Madison is hydraulically connected (Rahn and Gries, 1973).

The quality of water in the Madison is typically good near the outcrop areas, but becomes brackish to saline deep in the basins. At the ETSI well site the total dissolved solids was reported to be 530 ppm after continuous pumping of a test well for three weeks (Anderson and Kelly, 1976). This is reasonably good drinking water for this area; almost 90 percent of the municipal water supplies in South Dakota exceed 500 ppm TDS (S.D. Dept. Envir. Prot., 1976). ETSI well water has nearly the same quality as Missouri River water in the Dakotas for which massive diversion schemes such as the Garrison and Oahe Irrigation Projects and the West River Aqueduct have been proposed.

GROUND WATER RECHARGE

Most, if not all, of the water recharged to the Madison in the three state area near the ETSI unit comes from precipitation that falls on outcrops around the Black Hills, Bighorn Mountains and Hartville uplift. The ground water moves roughly perpendicular to the piezometric surface shown in Figure 2. At the ETSI well site, the water in the Madison would be moving easterly toward South Dakota.

Attempts have been made to quantify the recharge rate. The Wyoming State Engineer (Bishop, 1974, p. 7) stated that "Estimates of recharge to the Madison indicate something like 150,000 acre-feet per year being added to the Madison aquifer within the area involved in the ETSI project." The same figure was used on a 1975 ETSI "Fact Sheet": "The annual recharge to the Madison Formation is estimated to be 150,000 acre-feet, so ETSI will be pumping an amount equal to one-tenth of the new water each year." The validity of the calculation of 150,000 acre-ft/yr, supplies in a report by the Wyoming State Engineer (1974), was questioned by Rahn (1975). More recently the Wyoming Engineers Office revised the stimated recharge down to 75,000 acre-ft/year (Anon, 1978).

Recharge rate calculations involve assumptions about precipitation, evapotranspiration, hydraulic conductivity, aquifer thickness, piezometric surface, and other parameters. Reliable quantitative data on these parameters are lacking for the Wyoming-South Dakota area. In a study of spring discharge in the Black Hills area by the author, the deep recharge rate to the Madison had to be considered an unknown quantity (Rahn and Gries, 1973, p. 17).

Therefore, it seems premature at the present status of knowledge to make firm statements as to the amount of recharge which could influence the ETSI

well field. Certainly the recharge rate is very low; in many semi-arid basins in western United States recharge is negligible in contrast to withdrawal rates (Baski, 1979). Published figures tend to be taken by laypeople as being unquestionably accurate; a layperson could, for instance, compare the most recent recharge rate suggested by the Wyoming State Engineer (75,000 acre-ft/year) with the planned ETSI withdrawal (15,000 acre-ft/year), and deduce that there is five times as much recharge as the withdrawal, and there would hence be no need to worry about ground water "mining."

In addition to questions pertaining to the reliability of recharge calculations, it should be emphasized that recharge is a process involving geologic time. The water in the Madison at Philip and Midland, for example, is almost 30,000 years old (Fig. 2). Far more critical to evaluating the impacts of the ETSI project is the determination of the decline in pressure in the artesian aquifer, which is an almost instantaneous response to pumping from an aquifer.

DRAWDOWN

The piezometric (or potentiometric) surface of an artesian aquifer is the elevation to which water will rise in wells drilled to the aquifer. The piezometric surface of the Madison (Fig. 2) is above the land surface in many of the low-lying areas of Wyoming and South Dakota. Artesian aquifers with very low coefficients of storage are highly susceptible to drawdown from ground water withdrawals (Walton, 1970).

During 1974 and 1975 ETSI spokesmen assured the public as well as Wyoming and South Dakota officials that there would be no drawdown beyond the limits of the ETSI well site itself. According to a report by ETSI consultants (Anderson and Kelly, 1974, p. 12). "The effect of the project development will be essentially limited to the area of the well field." Mr. Floyd Bishop, formerly Wyoming State Engineer, testified before the U.S. House Interior and Insular Affairs Committees on November 14, 1975, (p. 819) that "Another important fact is that the area of drawdown around the ETSI well field is not predicted to extend more than a mile beyond the outer perimeter of that field. . ." No quantitative predictive techniques for the size and shape of the ultimate cone of depression were given to support these statements, despite the fact that analytical techniques are available and widely used to predict the cone of depression which dvelops around a pumping center (for example, see Walton, 1970; or Bouwer, 1978).

At the request of concerned South Dakota officials I used a conventional Theis nonequilibrium method to predict the cone of depression resulting from pumping 9,000 gpm for 45 years, and presented my findings to the U.S. House Committee on Interior and Insular Affairs (Rahn, 1975). The Theis method requires that the aquifer constants transmissivity (T) and storage (S) be known. In order to determine T and S, I used aquifer pump test data supplied by ETSI for their well field area.

The three ETSI test holes to the Madison and the two other test holes are described by Anderson and Kelly (1976) and Rahn (1975). The wells were test pumped in 1974, and produced 57 to 180 gpm for 2 to 24 days. Figure 3 shows a typical time-drawdown plot. After about 1,000 minutes a reduction of the rate of drawdown occurred; this phenomena could be attributed to a recharge boundary, or, more likely, to leakage from the overlying Minnelusa Formation. Leaky conditions are fairly common in unconfined aquifers, where a temporary slowing of the rate of drawdown is caused by vertical leakage due to delayed release of water from storage (see Bouwer, 1978, p. 107–113 for a more detailed explanation). Eventually the rate of drawdown increases once more, and follows a new Type Curve. The flattening of the time-drawdown data from the test pumping does not demonstrate that all drawdown has henceforth ceased, or that drawdown is limited in areal extent in the same way. Rather, this time-drawdown data simply follows a pattern typical of an aquifer being pumped adjacent to a leaking aquifer of lower permeability. Ideally a much longer aquifer test should be run to get a better estimate of aquifer parameters, e.g. the coeffiicent of leakage and storage. While the aquifer constants are not known with certainly, it is believed that they can be used to give an indication of the range of the predicted long-term drawdown.

Using a match point solution (see Fig. 3 for example), I determined that T is about 6,400 gpd/ft and S is about 0.000,065 as average values for time and distance drawdown calculations from several ETSI pump tests (see Rahn, 1975, for more

complete analysis). These values of T and S are within the range determined for the Madison in other places (Wyoming State Eng. Office, 1974), including the Midwest, Wyoming area where large withdrawals are used for the secondary recovery of petroleum in Cretaceous sandstones (Swenson, 1974). The impacts of 9,000 gpm withdrawals over 45 years can be determined and show a drawdown theoretically extending over 50 miles from the ETSI well field (Rahn, 1975).

SUBSEQUENT STUDIES

In late 1975, the University of Wyoming published a geologic report which predicts the ground water decline after 20 years of pumping at 15,000 acre-ft/yr from the ETSI well field (Huntoon and Womack, 1975). This study utilized conventional analytical techniques, but also took into account structural complexities such as a fault through the Old Woman Anticline located a few miles west of the ETSI well field. The map of the drawdown (Fig. 4) is very similar to my 1975 prediction. The cone of depression as shown in Figure 4 extends 50 miles from the ETSI site, well into South Dakota and Nebraska. The decline at Edgemont, South Dakota, for example, would be 1,100 ft.

In early 1976, the U.S. Geological Survey (USGS) issued a report on the effects of a hypothetical well field in Niobrara County from which 20 cfs would be withdrawn for 100 years (Korikow, 1976). The report utilizes a digital (finite difference) computer model to predict drawdown under several different hydrogeologic possibilities. The drawdowns as shown on plates 5 and 6 of the USGS report are very similar in pattern but not as severe as the earlier predictions by Rahn (1975) and Huntoon and Womack (1975); however, plate 5 of the USGS report shows the drawdown would be about 350 ft at Edgemont. The USGS study also examined the effects of the ground water withdrawals on springs. Figure 5 shows that Cascade Spring could be expected to lose between 1 and 4 cfs in its discharge (the range in these values is due to a range in S used in the model, from 0.000,25 to 0.000,01). Cascade Spring, probably South Dakota's largest spring, presently has an average discharge of about 24 cfs (Rahn and Gries, 1973), and flows into the Cheyenne River. It is not known to what degree the ETSI project would affect other springs in the area, some of which discharge into the Platte and Niobrara Rivers which drain into Nebraska.

In 1976 the U.S. Geological Survey began a test drilling project which included the drilling of three test holes in the Madison. Well No. 1 is about 50 miles northwest of Belle Fourche, South Dakota, and was drilled to Precambrian basement rocks at 4,341 ft (Blankennagel, et al, 1977). Is it capable of being pumped at 1600 gpm from a pumping level of about 300 ft below the land surface; taking into account the intial artesian pressure, the specific capacity is about 4 gpm/ft drawdown.

Well No. 2 in the USGS test program is about 35 miles northeast of Broadus, Montana. The well bottomed 94 ft below the top of the Precambrian rocks at 9,378 ft below the land surface on March 23, 1977. This well was much less productive; the specific capacity was estimated at 0.06 gpm/ft drawdown (Brown, et al, 1977).

Well No. 3, the last well in the USGS program, is about 15 miles east of Billings, Montana. It was drilled 7,714 ft to basement rocks in December, 1978. Pumping data is not available at this time.

In summary, the three USGS test wells provide useful information on the depth, thickness, porosity, and water quality in the Madison. They are, however, quite far from the ETSI site and the information they provide does not significantly affect the calculations or conclusions of this report.

CONCLUSIONS

Despite claims by ETSI spokesmen that the ETSI project will have no adverse environmental impacts to ground water, studies by Wyoming, South Dakota and federal agencies show that the project will have wide-ranging impacts on the ground water in South Dakota and Wyoming, and to a lesser extent, northwestern Nebraska. The main impact will be a lowering of the piezometric surface in the Madison Limestone. Figure 4 is a prediction by University of Wyoming geologists, and shows, for example, a decrease in the piezometric surface of 1,100 ft at Edgemont. This would mean that the flowing artesian wells in the Madison at Edgemont would cease flowing. Since the shut-in (artesian) pressure is about 100 ft at Edgemont, the static level would be lowered to 1,000 ft

below the ground surface. Pumping costs may make utilization of this water uneconomic, or at least will considerably increase the cost of utilization of water.

It has been determined that springs will also be effected by the project. The reduction in discharge of Cascade Spring and Hot Springs (Evans Plunge), South Dakota, over 35 miles from the ETSI site, has been calculated by the USGS. Frank Visher, a USGS hydrologist, said that "Ultimately, we think that the pumping of a lot of wells by ETSI and others who will follow them will have a wide-ranging effect on the surface water all over the Powder River Basin" (Boeckman, 1976). Oddly, these predictions by USGS people were not supported by another federal agency report (Office of Technology Assessment, 1978, p. 89), which states that ". . . there is no evidence that local or regional subsidence or reduced surface stremflow would occur."

The loss of artesian pressure may ultimately have effects on overlying aquifers, because studies by several geologists show that the Madison is a source of recharge to the Lakota Formation (Gott, et al, 1974) and the Dakota Sandstone (Swenson, 1968).

At the time of the writing of this paper (April, 1979), ETSI plans to proceed with the project as soon as questions of pipeline right-of-way in Nebraska and Kansas have been settled via either state or federal eminent domain bills. ETSI officials have proposed to install observation wells at the Nebraska or South Dakota border to monitor drawdown. This may be an unnecessary expense because there would be virtually no way to stop the project once in operation. Concern over the ETSI project has been expressed by other geologists, including the Wyoming State Geologist (Miller, 1975) and the South Dakota State Geologist (McGregor, 1976).

Because of the predicted adverse effects on the water resources of the states affected, the U.S. Congress Office of Technology Assessment suggested that slurry pipeline companies should seek alternative sources of water. Alternative sources suggested by the Office of Technology Assessment (1978) include sewage effluent, irrigation return flows and saline ground water. Saline ground water does exist in the Madison in the deep basin areas; in fact brackish water occurs in the Madison right below the city of Gillette.

In summary, independent studies by myself and other hydrogeologists from state and federal agencies confirm that the amount of water withdrawn from the proposed ETSI well field will adversely affect water supplies in adjacent states. Adequate provisions should be made to protect the water in areas affected by this project. Water from the Madison Limestone has considerable potential for local use (including geothermal energy) even though the depth prohibits its full usage in some areas due to high drilling costs. The main issue that needs to be addressed at this time is whether a coal-slurry pipeline is the wisest use of an exhaustible resource. Should water be reserved for local use or exported to Arkansas?

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Figures

Figure 1. Thickness and areal extent of the Madison Limestone (from Wyoming State Engr. Office, 1974). The location of the ETSI well field is shown.

Figure 2. Potentiometric map of the Madison Limestone and carbon-14 and tritium data for selected sites (from Hanshaw, et al, 1977).

Figure 3. Time-drawdown plot for ETSI test well #ETSI–O–1.

Figure 4. The predicted cone of depression from pumping 9,000 gpm for 50 years using no recharge boundary (modified slightly from Huntoon and Womack, 1976).

Figure 5. Predicted decrease in the discharge of Cascade Spring, South Dakota, using nonleaky aquifer conditions (from Konikow, 1976).

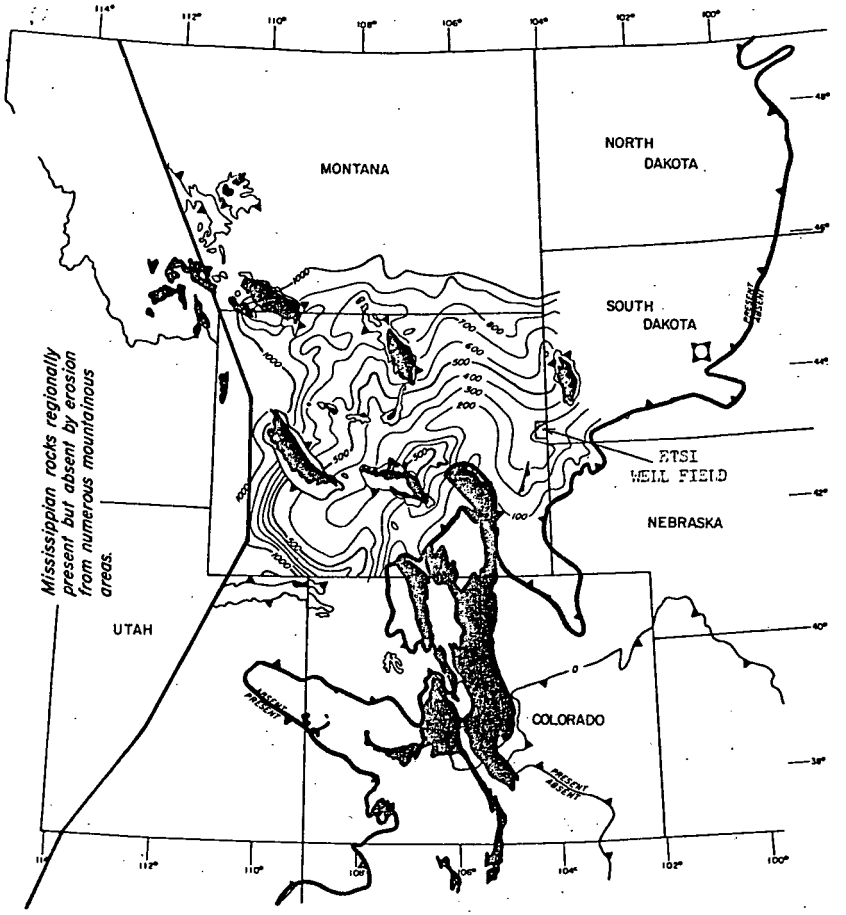
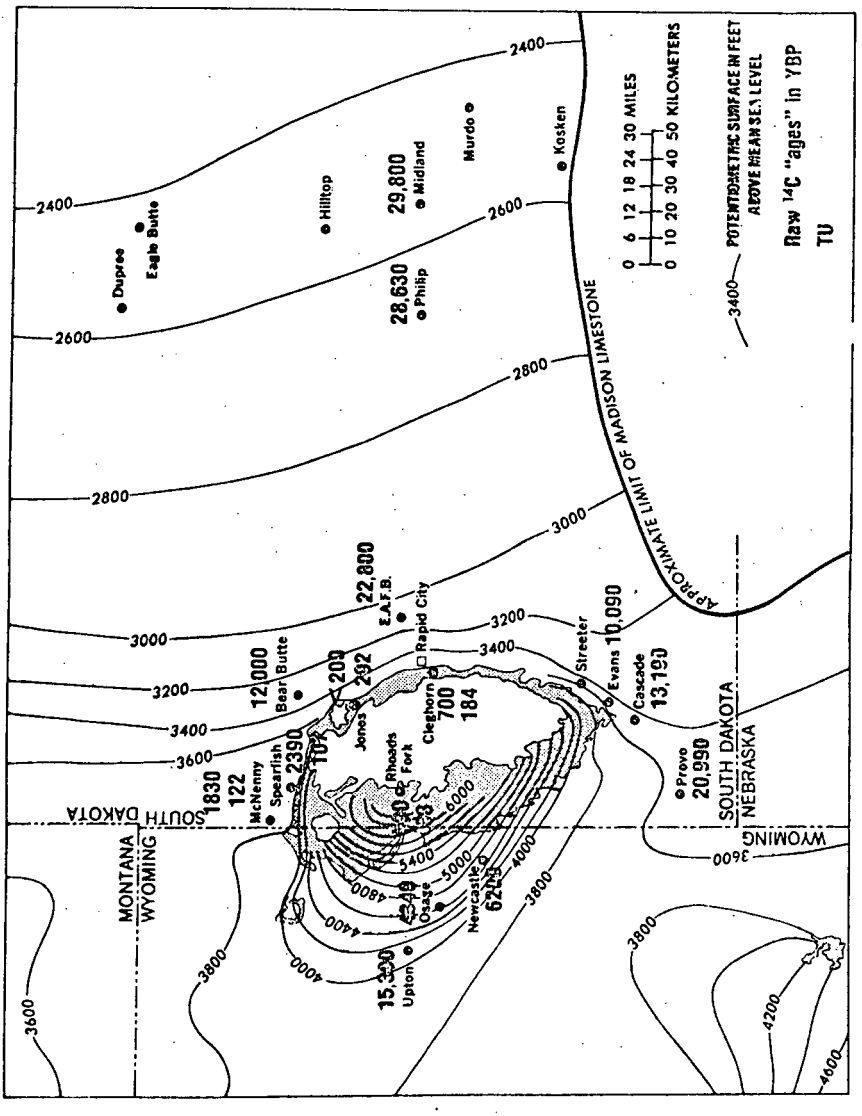
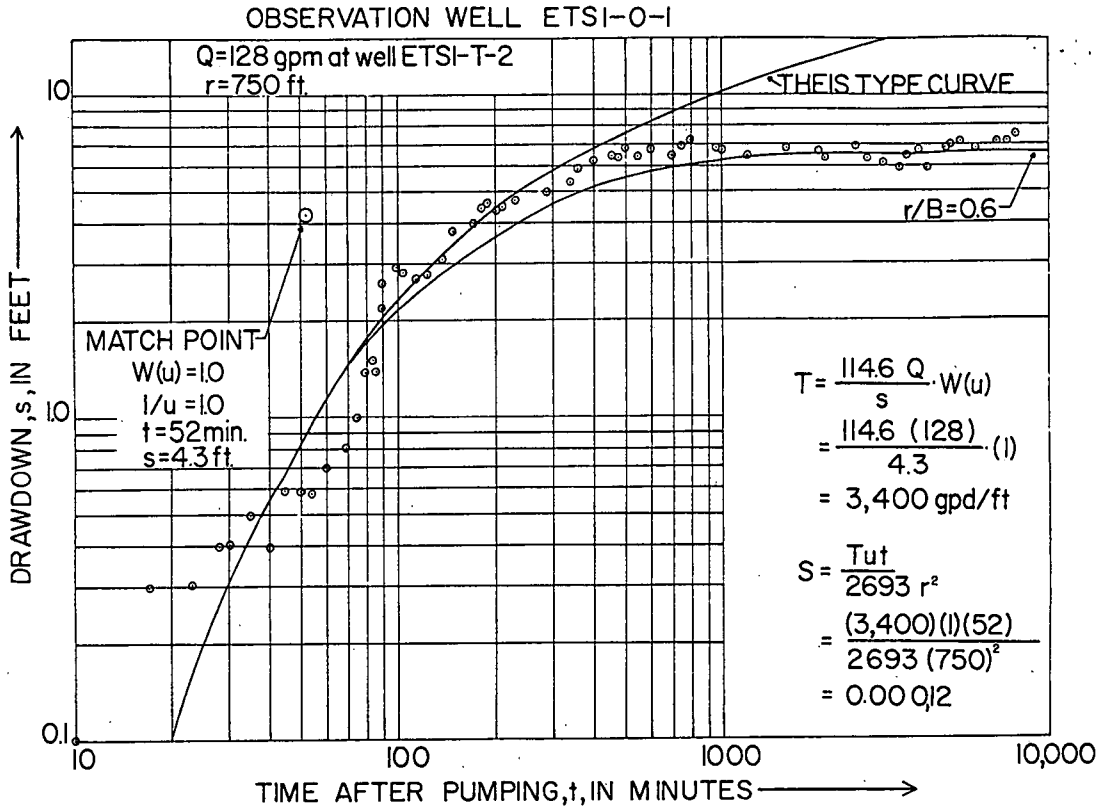


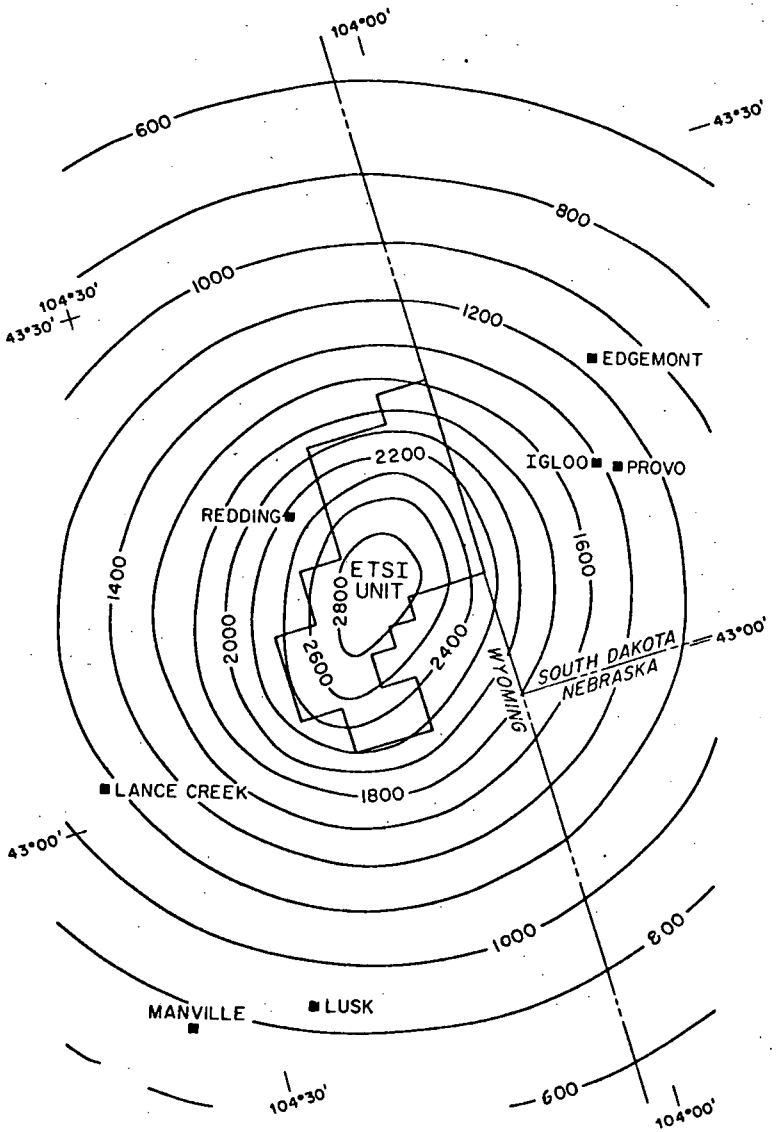
Figure 1
Thickness of Madison Limestone in Wyoming and its regional limits

LEGEND
200 Isopach line and thickness Contour interval = 100'
Limit of Madison and Mississippian rocks
Precambrian crystalline rocks exposed

From: Geologic Atlas of the Rocky Mountain Region, by Rocky Mountain Association of Geologists, Denver, Colo., 1972


Dupree
Eagle Butte
Hilltop
29,800
Midland
Murdo
Kosken
28,630
Philip
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4800
5000
5400
6000
0 6 12 18 24 30 MILES
0 10 20 30 40 50 KILOMETERS
POTENTIOMETRIC SURFACE IN FEET ABOVE MEAN SEA LEVEL
Raw 14C "ages" in YBP
TU
APPROXIMATE LIMIT OF MADISON LIMESTONE
22,800
E.A.F.B.
Rapid City
Streeter
10,090
Evans
Cascade
13,190
12,000
Bear Butte
209
292
Jones
Rhoads Fork
Elephorn
700
184
Prove
20,990
1830
122
McNenny
Spearfish
2390
104
SOUTH DAKOTA
NEBRASKA
WYOMING
MONTANA
WYOMING
Osage
Newcastle
6200
15,300
Upton


OBSERVATION WELL ETSI-O-I
Q=128 gpm at well ETSI-T-2
r=750 ft.
THEIS TYPE CURVE
r/B=0.6
MATCH POINT
W(u)=1.0
1/u=1.0
t=52min.
s=4.3 ft.
$T = \frac{114.6\ Q}{s} \cdot W(u)$
$= \frac{114.6\ (128)}{4.3} \cdot (1)$
$= 3,400$ gpd/ft
$S = \frac{Tut}{2693\ r^2}$
$= \frac{(3,400)(1)(52)}{2693\ (750)^2}$
$= 0.00012$
DRAWDOWN, s, IN FEET
10
1.0
0.1
10
100
1000
10,000
TIME AFTER PUMPING, t, IN MINUTES



EXPLANATION

600

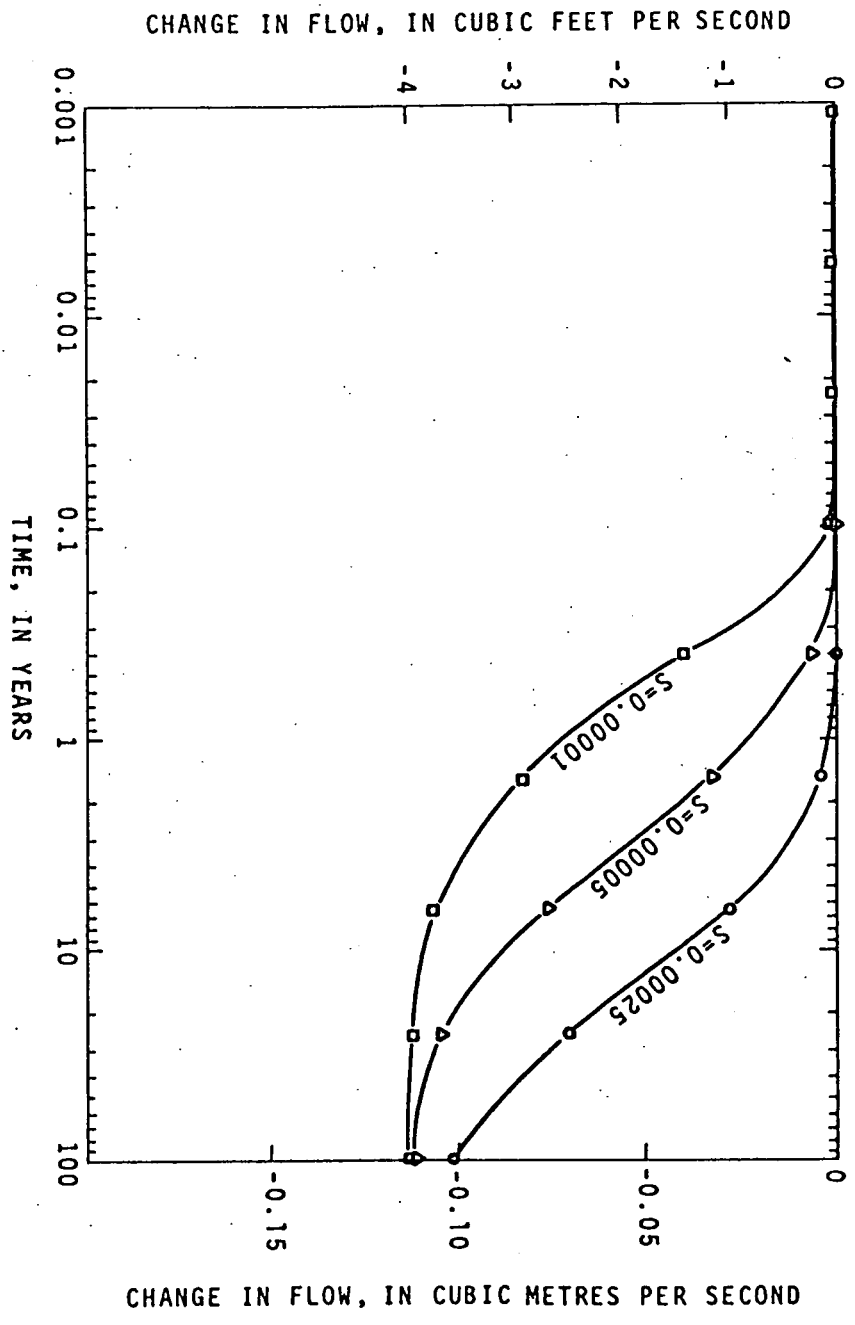
LINE OF EQUAL CALCULATED WATER LEVEL DECLINE IN FEET

0 5 10 15 MILES

N

SCALE

0 5 10 15 KILOMETERS


CHANGE IN FLOW, IN CUBIC FEET PER SECOND
0
-1
-2
-3
-4
0.001
0.01
0.1
1
10
100
TIME, IN YEARS
S=0.00001
S=0.00005
S=0.00025
0
-0.05
-0.10
-0.15
CHANGE IN FLOW, IN CUBIC METRES PER SECOND