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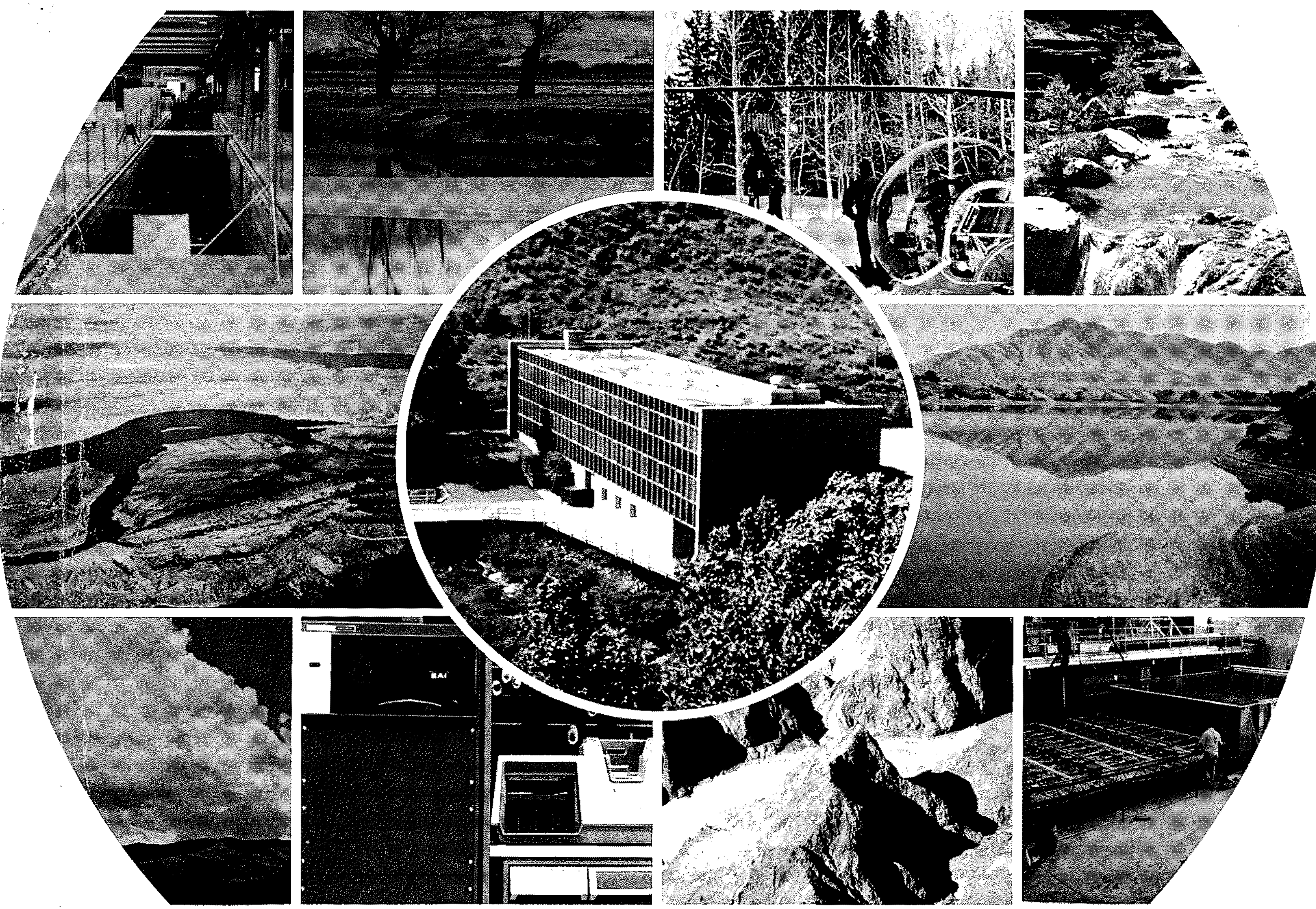

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Introduction

The impact on agriculture of a large coal-fired steam electric plant (such as the proposed Intermountain Power Project near Lynndyl, Utah) or a large nuclear electric plant (such as proposed for the Green River Site near Emery, Utah) depends on a large number of factors. Among the most important are the technology used in power plant design, the site-characteristics of the plant location, the availability of water resources in the vicinity of the plant, the quality of the available water, and the types of agricultural uses and their water requirements. Some of these factors can be defined by obtaining information for a given site, and others are determined by decisions made during plant design.

The agricultural impacts estimated here are based on the results of completed research and available site information. The results are given as a range from a minimum impact based on selection of a cooling technology requiring as little water as reasonable to a maximum impact based on selection of a technology using much more water. Both the minimum and maximum impacts estimated are probably on the high side because of very conservative assumptions made with respect to farmer reaction. The influence of the selected cooling technology on the impacts suggests the desirability of considering potential impacts during design so as to choose a technology having more 'favorable consequences'.

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Physical plant characteristics

The proposed coal-fired steam electric generating plant called the Intermountain Power Project (IPP) would construct four 750-MW units to produce 3000 megawatts of power, high voltage transmission lines to take the power to users, and provide systems to supply coal for fuel and water for cooling to the plant. The power plant site has been a controversial topic for a considerable length of time. Of the six possible sites, the Lynndyl site has been favored from political and environmental considerations. The power plant will be situated about 12 miles from Lynndyl, a small town in Milford County, Utah. The site is located in the Sevier River Basin at a location underlain with quarternary alluvial deposits. As to land use, the lower portion of the Sevier River Basin is largely used for dairy and feedlot operations. Cultivated agriculture and rangeland predominate near the Lynndyl area. About 600 permanent employees are expected (with more than 2000 during construction) and the induced increase in service industry employment is expected to be about 300 (a multiplier of 1.5 is assumed). The permanent population near Lynndyl could thus be expected to increase by 900 because of completion of the project. A temporary increase of 3000 is expected during construction. The output from the 4000-acre IPP complex provides for significant economic growth in Utah and supplies power to California and Nevada.

The concept of constructing a Nuclear Power Generation Complex on the Green River is still in its infancy. The Utah Power and Light Company was reported to have had nuclear intentions and to be looking for sites in Idaho and Utah. The Green River site in Emery, Utah, is found capable of sustaining a large nuclear complex. The proposed 10,000-13,000 MW capacity, about three or four times larger than any existing or other proposed nuclear plant in the country, could theoretically consume more than 20 percent of Utah's water. The Emery site is located along the Green River at a point where the basin has a drainage area of 40,600 square miles. The power produced at this site will be made available to Arizona and California. Little is known about plant designs, process water requirements, and associated population growth.

The location of the two proposed sites (Lynndyl and Green River) are shown in Figure 1.

Technological aspects of the power plants and water use

The IPP is a stream-electric power plant. Coal is used to heat incoming boiler water and produce steam. The steam passes from the boiler, gives up its energy by turning turbines to generate electricity, and condenses. In practice, powerplants fall short of the theoretical performance of the Rankine cycle in converting heated steam to electrical energy. The steam produced in the boiler must be superheated (above the saturation equilibrium temperature) to prevent excess condensation in the turbines. Condensers cannot be designed to condense the steam at ideal efficiency, and the condensate must be preheated before it is returned to the boiler.

The energy source for production of electricity in a nuclear plant is fission of nuclear material. The heat generated by fission is used to convert the boiler water to steam. About 35 percent of the thermal energy is converted into electricity. A smaller fraction (about 10 percent) escapes to the atmosphere by conduction and convection in the plant. The remaining 55 percent is discharged through the cooling system. The amount of water needed for cooling depends on a) the total amount of electricity

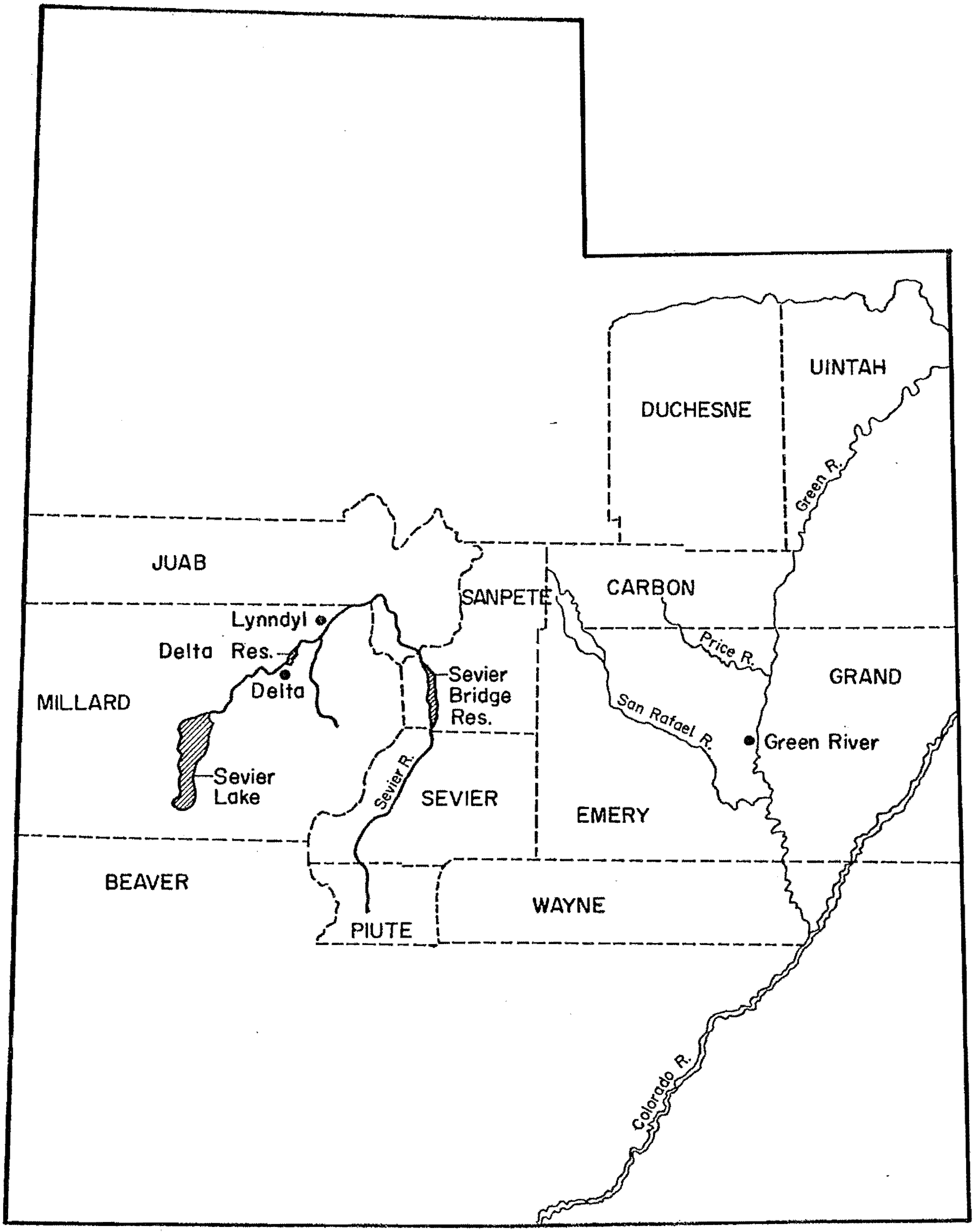

Figure 1. Lynndyl and Green River site location map.

produced, b) the type of cooling system employed, and 3) other environmental and plant design parameters.

Cooling water requirements

The type of cooling system selected depends on water cost and availability, the source as it affects water quality, in-plant circulation costs, environmental factors, storage costs, and other political and institutional considerations.

In once-through cooling, water is circulated through the steam condensers once and the heated water is discharged directly to a natural waterbody. This is probably the least expensive system. It has a large withdrawal requirement, but the consumptive use is relatively small. Restrictions in the Federal Water Pollution Act of 1972 against heated discharges make this system difficult to practice.

Closed cooling systems are, therefore, more advantageous. Here, water is recirculated through the condensers and cooled in towers or ponds through spraying or trickling. Cooling ponds serve for storage, and evaporation rates are largely a function of the pond design and environment (local climate). Evaporative cooling towers (mechanical or natural draft) consume more water and are also relatively more expensive. In these closed systems, the total water consumption consists of two parts. "Make-up water" is added to replace water lost through evaporation and drift, and additional water is added to replace a "blowdown requirement" of water removed from cooling recirculation to prevent excessive mineral build-up. The higher the influent in total dissolved solids, the higher will be the blowdown requirement.

The most expensive method is dry cooling. Dry systems require larger initial investments and operate at lower efficiencies, but their withdrawal requirements and consumptive use requirements are considerably lower as compared to other methods. The wet/dry system is a hybrid system designed to take advantage of the wet and the dry methods.

The estimates of cooling water requirements for nuclear plants are shown in Table 1 and estimates for coal-fired plants are shown in Table 2.

Table 1. Nuclear power plant water requirements.[1]

Reported Estimates \ Cooling Systems	Water Consumption AF/yr/1000 MWe			
	Once-through Cooling	Cooling Pond	Evaporative (wet) Cooling	Wet/Dry Cooling
Western States Water Council Report	4,000	12,000	17,000[2]	2,000
Giusti and Meyer-USGS[3]	13,000	15,200	21,000-22,000	-
Harte and El. Gasseir	-	-	10,000-16,000	-
Range	4,000-13,000	12,000-15,200	10,000-25,000[4]	2,000

1 The variation in water requirements quoted from these sources for a given cooling method is due to alternative designs. Site location and environmental factors also contribute to the variations.

2 Additional blowdown requirements range from 3,000-8,000 AF/yr depending on TDS levels of influents.

3 Indicated to be over-estimated due to not taking into account conduction and convection losses of about 20 percent.

4 The 25,000 AF estimate was obtained by adding the maximum blow-down requirement (8,000 AF) to the water requirement of 17,000 AF.

Table 2. Coal-fired steam electric power plant water requirements.[1]

Cooling Methods / Reported Estimates	Water Consumption AF/yr/1000 MWe			
	Once-through Cooling	Cooling Period	Evaporative (Wet) Cooling	Dry Cooling
Western States Water Council Report	3,600	10,000	15,000[2]	2,000
Harte and El. Gassier-USGS	3,600-7,200	9,000-26,900	7,200-10,800	-
Gold et. al. EPA Report	-	-	7,200-8,000	-
Range	3,600-7,200	9,000-26,900	7,200-23,000	2,000

[1]The variation in water requirements for a given cooling method is due to alternative designs. Site location and environmental factors also contribute to this variation.

[2]Additional blowdown requirements range from 3,000-8,000 AF/yr depending on TDS levels of influent.

Water resources alternatives

The Lynndyl site might obtain water from the Sevier River. The Sevier Basin along with the adjacent Cedar-Beaver Basin is rich in groundwater; however, the groundwater potential around Lynndyl is unknown. Another alternative is to acquire water from the Bonneville Unit of the Central Utah Project. The Sevier River water is high in total dissolved solids (above 3000 ppm), and use of water from that source will thus mean high blowdown requirements. Average flow near Lynndyl is estimated to be about 180 cfs and is regulated by Sevier Bridge Reservoir (2100 cfs - 0). The water is completely allocated (mostly to agriculture) and, therefore, any energy development will require that water be purchased from farmers. The amount of water that will be required and the estimated value of the consequent reduction in agricultural output are indicated in Table 3 and Table 4. The short-run impact indicates the immediate reduction in output. The long-run estimates allow for adjustments in farming practice and therefore less than in the short-run. These estimates were obtained by using a linear programming model to determine the value that the farmers in the area receive from irrigation water. The price estimates are minimum values for a given technology since such costs as those of negotiating the purchase, transferring the water rights, and continuing to make beneficial use of other local resources now used by agriculture are not included. The maximum price estimates in the table are probably more reasonable since they are larger.

Similar calculations for the nuclear plants are shown in Tables 5 and 6. The Green River flow at Green River varies from 1.5-6.7 million acre-feet annually with an average of about 4 million acre-feet. The TDS concentration varies from 0.5-0.8 tons/AF. Assuming no more water will be obtained from the Colorado River System (although an estimated 225,000 AF is still unappropriated) the nuclear plant will probably obtain water by purchasing water rights from farmers. Water must come from irrigated agriculture mainly in Emery, Wayne, Carbon, Duchesne, Grand and Uintah Counties. The resulting reductions in the value of agricultural output are shown in Table 5 and the values of the water that would be taken for the various cooling systems are shown in Table 6. Again, a range of values are given, and prices should be interpreted as minimum estimates. The maximum values in the table are recommended for use in policy decisions.

Table 3. Reduction in the value of agricultural output due to water withdrawal for production of coal-fired steam-electric power in Sevier Basin (3,000 Mwe Plant).[1]

Cooling Method \ Annual Amount[4]	Minimum[2]		Maximum[3]	
	$ X 1000	AF X 1000	$ X 1000	AF X 1000
Once-through Cooling	243	11	486	22
Cooling Pond	608	27	1818	81
Evaporative Cooling	486	22	1554	69
Dry Cooling	135	6	135	6

[1]Water is assumed to be taken from Sevier Basin (HSU 5).

[2]Based on a technology at the low end of the water-use range shown on Table 2

[3]Based on a technology at the high end of the water-use range shown on Table 2

[4]Short-run and long-run amounts are estimated to be the same since local farmers are not expected to be able to compensate for the water lost by converting to water-saving cropping practices.

Table 4. Water source and price for the IPP coal-fired plant.

Cooling Methods \ Price	Sevier River Water HSU 5	CUP Water
	Price[2] $/AF/yr	Price[3] $/AF/yr
All Systems	22.32	$21-30[3]

[1]HSU 5 includes Juab, Garfield, Millard, Sevier, Piute and Sanpete Counties.

[2]The prices are only rental (average annual) values. The purchase price is estimated by capitalizing the rental vaules by dividing by the interest rate and would thus be ten to twenty times as large as the rental values shown.

[3]The Bonneville unit water may not be competitive with local surface water used in present agriculture due to higher construction costs that may be incurred at the time of completion.

Table 5. Reduction in the value of agricultural output due to water withdrawal for production of nuclear power in the Colorado Basin (10,000 Mwe Plant).[1]

Annual Costs in $ / Cooling Method	Short-Runs[2]				Long-Runs[2]			
	Min[3]		Max[4]		Min[3]		Max[4]	
	$ X 1000	AF X 1000	$ X 1000	AF X 1000	$ X 1000	AF X 1000	$ X 1000	AF X 1000
Once-through cooling	281	40	1173	130	245	40	496	130
Cooling Pond	1036	120	1446	152	735	120	913	152
Evaporative Cooling	835	100	2924	250	613	100	1532	250
Wet/dry cooling	131	20	131	20	122	20	122	20

[1]Water is assumed to be taken from West Colorado and Uintah Basins (HSU 7&8 as defined on Table 6).

[2]The reductions in the long-run from the short-run economic impacts will be achieved only if the farmers will indeed be able to make the expected adjustments to compensate for water lost by converting to water-cropping practices. Short-run and long run water losses are the same.

[3]Based on a technology at the low end of the water-use range shown on Table 2.

[4]Based on a technology at the high end of the water-use range shown on Table 2.

Table 6. Water source and price for nuclear plant.

Cooling Methods \ Quantity and Price[3]	HSU 7[1]		HSU 8[2]	
	Quantity in AF	Price $/AF/yr	Quantity in AF	Price $/AF/yr
Once-through cooling - min	52,563	7.91	-12,563[4]	-
- max	117,768	11.92	12,231	11.92
Cooling pond - min	110,523	11.47	9,476	11.67
- max	133,708	12.90	18,292	12.90
Evaporative cooling - min	96,033	10.58	3,966	10.58
- max	204,708	17.27	45,291	17.27
Wet/dry cooling	38,073	7.01	-18,073[4]	-

[1]HSU 7 includes Duchesne, Uintah and Daggett Counties

[2]HSU 8 includes Carbon, Emery, Garfield, Grand and Wayne Counties.

[3]The prices are only rental (average annual) values. The purchase price is estimated by capitalizing the rental values by dividing by the interest rate and would thus be ten to twenty times as large as the rental values shown.

[4]Indicates that the agriculture sector will profit by transferring these amounts from HSU 7 to HSU 8 in agricultural use.

Land use impacts

Withdrawal of water for energy development would reduce the water available to irrigated agriculture. The reduction in available water will tend to reduce the land under irrigation, although it is not sure that there will actually be a reduction. Therefore the estimated reductions in Table 7 are maximum estimates that have very high error margin. By providing for possibilities of farmers substituting low water consuming crops, more reasonable estimates were derived; and they indicate that a reduction in irrigated acreages of 40 (rather than 69) percent will occur above Green River site and very small reductions in the Sevier Basin.

Table 7. Impact on agricultural land use.

Regions \ Acres	Presently Irrigated Land (acres)	Potentially Irrigable Land (acres)	*Estimates of land (acres) out of irrigation water[1]			
			Maximum[3]		Minimum[2]	
			Quantity	Percent	Quantity	Percent
HSU 5 (IPP)	298,000	976,000	32,780	11	2,980	1
HSU 7 (Nuclear Plant)	217,800	320,000	150,282	69	23,958	11
HSU 8 (Nuclear Plant)	94,900	304,300	38,909	41	4,745	5

1 The values are maximum estimates corresponding to the range of water requirements for all different types of cooling methods.

2 Based on a technology at the low end of the water use range shown on Table 2.

3 Based on a technology at the high end of the water-use range shown on Table 2.

Conclusions

With the results of this study, the following educated judgment can be made as to probable impacts of energy development. The IPP, if situated at the Lynndyl site, will consume about 45,000 AF of water, causing a reduction of $1,000,000 to $1,500,000 of output in irrigated agriculture. The necessary water can be purchased from the farmers for no less than $25 per acre-foot per year. The irrigated land may decrease 5 percent to 10 percent.

The nuclear plant in the Green River would have larger impacts. It probably will consume about 200,000 AF to 225,000 AF of water annually. It will cause a reduction of about $3,000,000 worth of agricultural output. Water can be purchased from the farmers at no less than $15 per acre-foot per year. The land taken out of irrigated agriculture may turn out to be as much as 50 percent of the total in the area.

Other studies are needed for a more complete picture of the water resources impacts of these power developments. Aspects not covered included the impact on water quality (particularly TDS and thermal pollution). The effect of these impacts on agriculture downstream, ecology and aquatic life will have to be given more thorough consideration. Air pollution effects of the IPP plant, nuclear waste disposal problems of the Green River plant, and other socio-economic aspects of growth also need further analysis.