VI. Environmental and Social Impacts

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INTRODUCTION

The following discussion of the environmental and natural resource impacts of transportation of coal, by railroad unit trains or coal slurry pipelines, recognizes the inherent differences between the two modes of transportation The form of the product transported differs, the physical environment under which the products are transported differs and therefore, the environmental impacts differ. Coal slurry pipelines use substantial amounts of water, whereas railroads require essentially no water for the transportation of coal. The major environmental impacts of railroads are the delay, noise, and inconvenience caused by trains traversing populated communities. Both modes of transportation will cause some environmental impacts from construction and facility improvement. Slurry pipelines and increased unit train operations are directly comparable only in the areas of air pollution, safety and health, noise, and energy and materials resource depletion Even these areas present analytical problems: diesel locomotives emit pollutants along a linear path, while the emissions due to power generation for coal slurry pipelines would be concentrated at several point sources. A large percentage of the occupational accidents due to pipelines would occur during construction, but the present study anticipates only a nominal amount of new rail construction. Additionally, many if not al I the impacts are interrelated For example, noise pollution has an effect upon land use, as does the diversion of water to a slurry pipeline from an existing or projected future alternative use

The discussion is limited to the incremental impacts of moving the estimated amounts of coal. That is, analysis of all railroad impacts is not attempted, but rather those impacts attributable to the estimated increased coal transportation. The incremental impacts due to moving comparable amounts of coal by coal slurry pipeline are analyzed, but because of the necessary pipeline construction and the fixed origin, destination, and volume of pipelines, the incremental and total impacts are nearly the same.

The discussion is also limited to the differential impacts of coal slurry pipelines and railroads. It is assumed that the coal will be transported and not, for example, burned at the mine site. Other modes of transmission, while admittedly possible, are not analyzed here.

The people adversely impacted by coal transportation are not necessarily the same people who will benefit from the power generated by the coal. The study is concerned with the nature, extent, and duration of the examined impacts. Railroads and oil and gas pipelines have been on the American scene for many years. Many of their environmental impacts are well known and it is relatively easy to compare them with other aspects of human experience.

Three kinds of impacts were selected for study:

1. Those which have been historically significant, such as air pollution,
2. Those which, from a scientific standpoint, appeared to have the potential for significance; e.g., the interactions between coal and water in the slurry pipeline, and
3. Those which initially appeared to be insignificant but which, due to their frequent appearance in the public debate, required an objective, thorough examination; e.g., the potential for coal dust being blown off of coal hopper cars.

The following section discusses the most important environmental issue associated with coal slurry pipelines — the availability of water. The major environmental impacts associated with increased railroad unit train operation — noise, traffic, delay, and inconvenience — are discussed in the next section. Longer term impacts, chiefly those resulting from pipeline operations, and shorter term impacts, chiefly associated with construction, are reported in later sections. Some of the construction and operation impacts have actually been observed, while other impacts may not have yet been observed but were either deemed likely to occur or subject to enough public debate to be included.

WATER USE BY PIPELINES

As illustrated in figure 20, water requirements for transmission of coal as a slurry are substantial and dependent upon coal-moisture content. The four hypothetical pipelines discussed earlier in this report would require a total of from 35,000 to 47,000 acre-feet per year (AF/yr) of water. These aggregate figures, which are presented by hypothetical pipeline route in table 25, do not reveal much about either the impacts of such water use upon the areas which would supply the water, or the source of the necessary water. To place the consumptive use of water in perspective, the water supply potential of four hypothetical pipeline origins was evaluated. In two source locations, Wyoming and Montana, the Bighorn River would supply water by aqueducts to the slurry pipeline origin. Ground water from the Madison Limestone Formation was also considered as a water source for the pipeline **from Wyoming.** The Tennessee River would supply the pipeline from Tennessee and the Green Rive would be the water source for the pipe ine from Utah.

Figure 20–Transmission Water Requirements as a Function of Coal Throughput Moisture Content

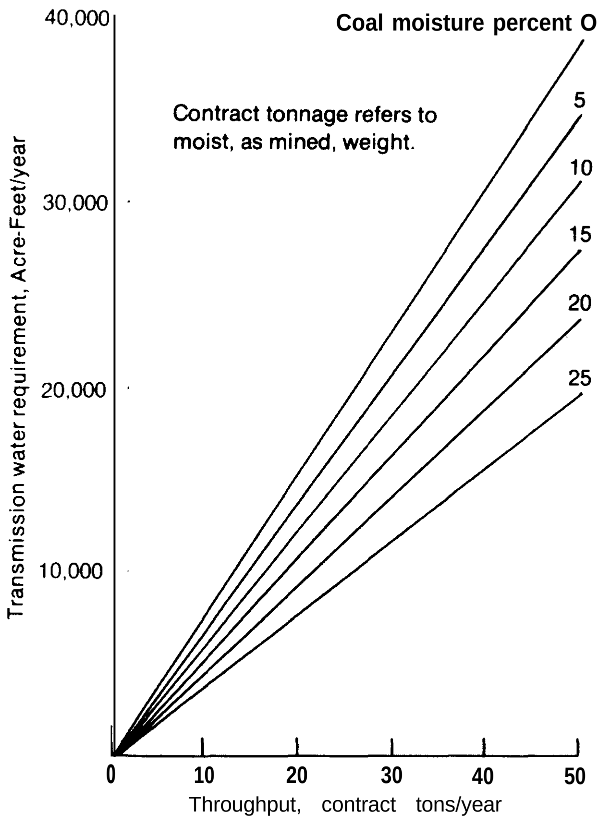

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Table 25. Water Requirements for Hypothetical Coal Slurry Pipelines

Route	Million tons of coal per year	Range of annual requirements AF/yr
Wyoming-Texas	**35.0**	**13,000-20,000**
Montana-Minnesota/ Wisconsin	**13.5**	**6,000-8,000**
Tennessee-Florida.	**16.0**	**10,000-12,000**
Utah-California.	**10.0**	**6,000-7,000**

[a] Includes water for transmission and emergency flushing reservoir replenishment. Minimum is for high-moisture coal and no spills. Maximum is for low-moisture coal and a worst case of one spill per year.

Although the four pipieline routes and destinations are hypothetical, the general location of the source of the routes is plausible because of the abundance of coal at the selected locations. Most of the water required for a given pipeline must be available near the pipeline origin. The generalizations from the four specific cases are therefore of widespread importance with respect to water usage and availability.

Two types of potential impacts from the water use were investigated: those upon the immediate, surrounding environment, i.e., streams and aquifers, and those upon alternative water uses, The first category, environmental impacts, are minor for the following reasons:

- Withdrawals of surface water for coal slurry pipeline use would constitute a very small fraction of the physically available flows in supply source streams or rivers. If one ignores other uses of water as a resource, effects upon flow rate, dissolved oxygen concentration, salinity, waste assimilative capacity, and other water quality parameters would probably not be measurable. For example, a group of pipelines moving 125 million tons of coal per year from Wyoming would use a maximum of **3 percent of the Bighorn River's average depleted flow at the Wyoming-**Montana State line. Agricultural uses downstream from the nearby Boysen Reservoir are more likely to deplete flows to a point where water quality seriously declines. Pipelines from Tennessee carrying 31 million tons per year would remove at most O 1 percent of the flow of the Tennessee River. **I n** both cases flows are regulated by reservoirs.
- Although increased pumping of ground water from the Madison Formation in Wyoming could result in declines in potentiometric head at some distance from well fields, there is no evidence that local or regional subsidence or reduced surface streamflow would occur.

The other category of environmentally related impacts from water use by coal slurry pipelines is a reduction in some present or future alternative water uses. In each of the four hypothetical cases studied, the physical supply of water is sufficient to transport the coal even with substantial future expansion of pipeline volumes. However, three legal factors limit the actual water available:

1. Interstate compacts, State legislative restrictions on use, Indian rights, and the possible exercise of Federal reserve rights all place a practical limit upon quantity of water that may be used in a given river basin or State. Ironically, the greater the hydrologic area considered, the more restricted the water supply.
2. The prior appropriation doctrine, based upon the concept of earliest beneficial use of water, dominates the water rights system in the coal-producing areas of the West. In most Western States, including Wyoming and Colorado, the user who is "first in time is first in right. " The holder of a relatively recent right which is subordinate to older claims may be allowed to appropriate or divert little or no water in times of drought.
3. Water rights systems in the West are administered by the States, usually through the State engineer. Obtaining water rights is often a time-consuming, complicated affair, and the would-be appropriator must often "stand in line behind a series of prior applications."[1]

The current drought is dramatizing the scarcity of water in the West at the same time that plans for increased energy development, including mining, electric power generation, coal gasification and liquefaction, and shale oil exploitation, all would require relatively large increases in consumption of the region's

[1] W Gertsch, **"Utah** Water Supply," *Study of Alternative Locations of Coal-Fired Electric Generating Plants to Supply Energy From Western Coal to the* Department *of Water Resources*,. University **of California at** Los **Angeles, Institute of** Geophysics **and Planetary** Physics **and** Office of Environmental Science and Engineering, pp 6-45 to 6-53, March 1977

water.[2,3] **In each of the potential coal slurry pipeline origin areas except Tennessee, demand projected for the 1985-2000 period exceeds the legally available supply. In the case of the Bighorn River** in Montana, for example, the combination of present uses, signed contracts for U.S. Bureau of Reclamation water, and applications for future appropriations exceeds the State's compact share of the river's flow by over 450,000 AF/yr. Demands in the entire Montana portion of the Yellowstone River Basin (to which the Bighorn is tributary) will reach the legally available supply by the year 2000.[4] Similarly, according to some projections, the area around Gillette would have (without a slurry pipeline) a deficit of over 100,000 AF/yr by 2000, unless water were imported.[5]

The significance of these deficits is that a coal slurry pipeline could use surface water only at the expense of growth in the existing and new uses. Ground water could in some cases reduce the deficit, but not the competition. For example, water from parts of the Madison Formation is chemically suitable for most municipal, industrial, and agricultural uses, in addition to coal transportation. Furthermore, assuming it were physically possible and economical to withdraw enough water to overcome the projected deficit, withdrawals would **exceed the present estimate of recharge, so that the consequences of groundwater mining would have to be considered.**

It is impossible to predict which specific future water uses would be precluded by coal slurry pipelines. The major types of competing uses would be energy-related industry and agriculture. Rather than speculate upon the myriad of possible futures, "water-use equivalents" of a given slurry pipeline demand were estimated. Table 26 lists the total water-use equivalents for the four pipelines examined in the case studies. For example, the pipeline from Tennessee would consume about the same amount of water as one to three coal gasification plants using the Lurgi process. Similarly, the Montana pipeline would take enough water to revegetate about 3,000 acres of surface-mined land in the Colstrip area in 1985. If all the water for the four pipelines carrying 74.5 million tons of coal per year were redirected, it could be used to mine 160 to 220 million tons of coal, reclaim 16,000 to 21,000 acres of surface-mined land, serve up to 10 coal gasification plants or up to 5 coal

[2] R Nehring, B Zycher, and J Wharton, *Coal Development in the Northern Great Plains A Preliminary Report,* R-1 981 -N SF/RC, prepared by Rand Corp , for National Science Foundation, August 1976

[3] *Report on Water for Energy in the Northern Great Plains Area With Emphasis on the Yellowstone River Basin,* U S Department of the Interior, Water for Energy Management Team, January 1975

[4] Ibid

[5] *The Wyoming Framework Water Plan,* State of Wyoming, State Engineer's Office, Laramie, Wyo , May 1973

Table 26. Water-Use[a] Equivalents for Hypothetical Pipelines

Alternative use	Wyoming-Texas	Montana-Minnesota/Wisconsin	Tennessee-Florida	Utah-California
Coal mining (10^6 tons/yr)	60-90	30-40	50-60	30-40
Mine reclamation (10^3 acres)[b]	6-9	3	5	3
Coal gasification[c] (plants)				
—Lurgi	1-4	0-2	1-3	0-2
—CO_2 Acceptor	1-4	1-2	1-3	1-2
Coal Liquefaction (plants)[d]	1-2	0-1	1	0-1
Electric power generation (plants)[e]	1-2	0-1	0-1	0-1
Municipal (10^3 people)[f]	65-130	50-60	100-120	20-25

[a] Net consumptive use for all categories except municipal. [b] For 2 years. [c] 250 million scf/day. [d] 100,000 bbl/day. [e] 1,000-MWe plant at 35-percent efficiency, 70-percent load factor, wet cooling tower. [f] Based upon projected withdrawal rates for 1990. Also based on total withdrawal and not net consumptive use.

liquefaction facilties, or provide cooling for 2 to 4 powerplants. To process 1 ton of coal, an electric powerplant requires roughly seven times as much water as a slurry pipeline does, and about twice as much water is needed to gasify the same amount of coal, Mining, on the other hand requires approximately half as much water per ton of coal as slurry transportation.

The nature, magnitude, and probability of impacts upon agricultural alternative uses depend entirely upon local conditions. In Tennessee, where only 65 acres are irrigated in the coal source area, the impacts upon agriculture would be minimal, Farming is reportedly marginal in parts of Carbon and Emery counties in Utah, so that some farmers may be willing to sell their water rights and thus eliminate some agricultural uses. Alfalfa, hay, and corn are the main irrigated crops in the Wyoming, Montana, and Utah source areas. Sugar beets are fairly important in Montana, as is irrigated pasture in Utah. Vegetable and fruit crops are not irrigated to as significant an extent as grains. Because of the large present use of irrigation water (about 200,000 AF/yr) and the projected demand for Bighorn River water, agriculture in the Bighorn River Basin is, of all the cases studied here, most **likely to face a conflict with other uses, including coal slurry pipelines,**

The remainder of this section discusses in more detail water availability and the impact **upon future water uses for each of the pipelines.**

Water for the Wyoming Pipeline

The hypothetical 35 million-ton-per-year pipeline from Wyoming would require 12,640 to 19,300 AF/yr of water in Wyoming. Additional water for emergency replenishment could be obtained along the pipeline route in the States of Nebraska, Colorado, Kansas, and Texas, and local sources would be sufficient. Flows in surface streams in the **Powder** River Basin area are low and irregular and therefore are not a reliable water source for coal slurry pipelines. Additionally, the water demands of the pipeline would exceed the available water by 1985 if the Little Missouri, Belle Fourche, and Cheyenne Rivers were relied upon. The Bighorn River Basin in northcentral Wyoming is a reasonable source of water supply for a coal slurry pipeline originating near Gillette. It is estimated that 1.8 million AF/yr are now available to Wyoming from the Bighorn River Basin for new beneficial uses. '

The Madison Formation was analyzed as a potential water source because of the projected future" competition for surface water and the controversy associated with ground water sources in Wyoming. The Madison aquifer consists principally of carbonate rocks of Mississippian age (about 310- to 345-million years old) underlying northeastern Wyoming, southeastern Montana, northwestern Nebraska, and western North and South Dakota. Figure 21 shows the outcrops and subsurface extent of these rocks. The Madison is composed chiefly of limestone ($CaCO_3$) and dolomite ($CaMg(C0,)_2$). Because these carbonate rocks are relatively soluble in water, the development of karst, or solution-cavity features, is common. [7]

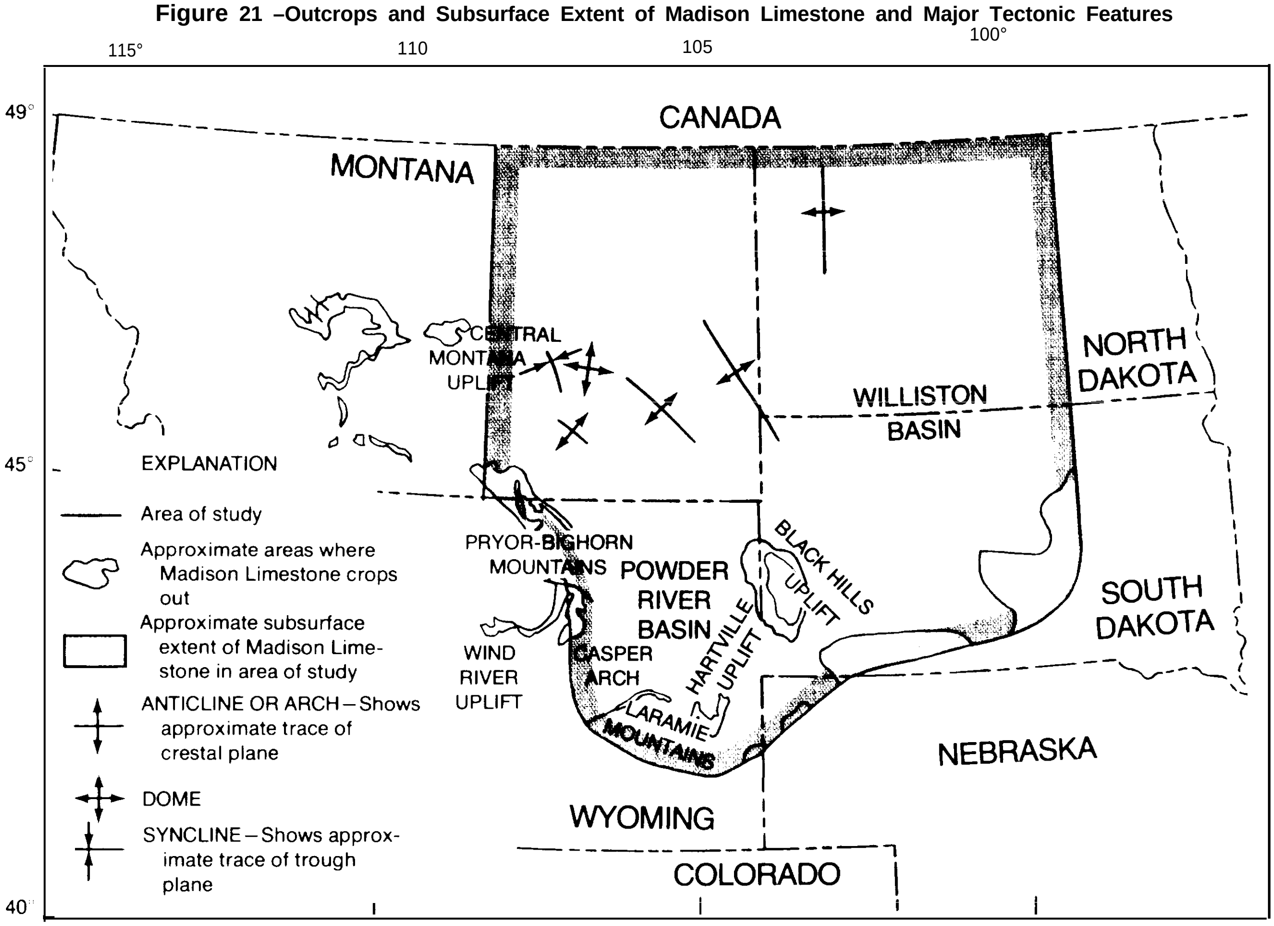
The water-bearing and transmitting capability of the Madison is highly variable because of its primary structure, the karst features, and the filling of the latter. As the Wyoming State Engineer notes, "No rock differs more radically with respect to water yield than limestone. Limestone can rank among the most productive aquifers, or can be as unproductive as shale."[8] The Madison's primary porosity, i.e., that due to open spaces between carbonate grains, appears to be low and to vary spatially. Dolomite beds seem to be more

[6] Ibid

[7] L F Konikow, *Preliminary Digital Model* **of** *Ground Water Flows in the Mad/son Group, Powder River Basin and Adjacent Areas, Wyoming,* **Montana,** *South Dakota, North Dakota, and Nebraska,* **U S** Geological Survey Water Resource Investigations 63-75, January 1976

[8] *Investigation of Recharge to Ground Water Reservoirs of Northeastern W yoming (The Powder* **River** *Basin),* State of Wyoming, State E ngineer's Off Ice, June **1976**

Figure 21 –Outcrops and Subsurface Extent of Madison Limestone and Major Tectonic Features



Base U S Geological Survey
1 7500,000 1970

Source U S Geological Survey, 1975

porous than limestone beds in this aquifer. ' water is stored mainly in and transmitted through secondary openings such as fractures, joints, and solution cavities. The occurrence of these secondary openings is quite variable and difficult to predict, which may explain the wide range in yields of water wells drilled into the Madison. [0]

Certain structural features greatly influence the hydrologic characteristics of the Madison. Several areas of folding and faulting have been identified, **while others** have been inferred. Folding and faulting probably have fractured **the rocks and increased their permeability.**[11] Faults often also act either as barriers to lateral movement of ground water or as conduits, although the role of faults in the Madison has not been conclusively determined. The U.S. Geological Survey is testing a hypothesis that the Madison is actually several discontinuous hydrologically isolated aquifers rather than a single continuous one. [2]

Figure 22 shows the configuration of the top

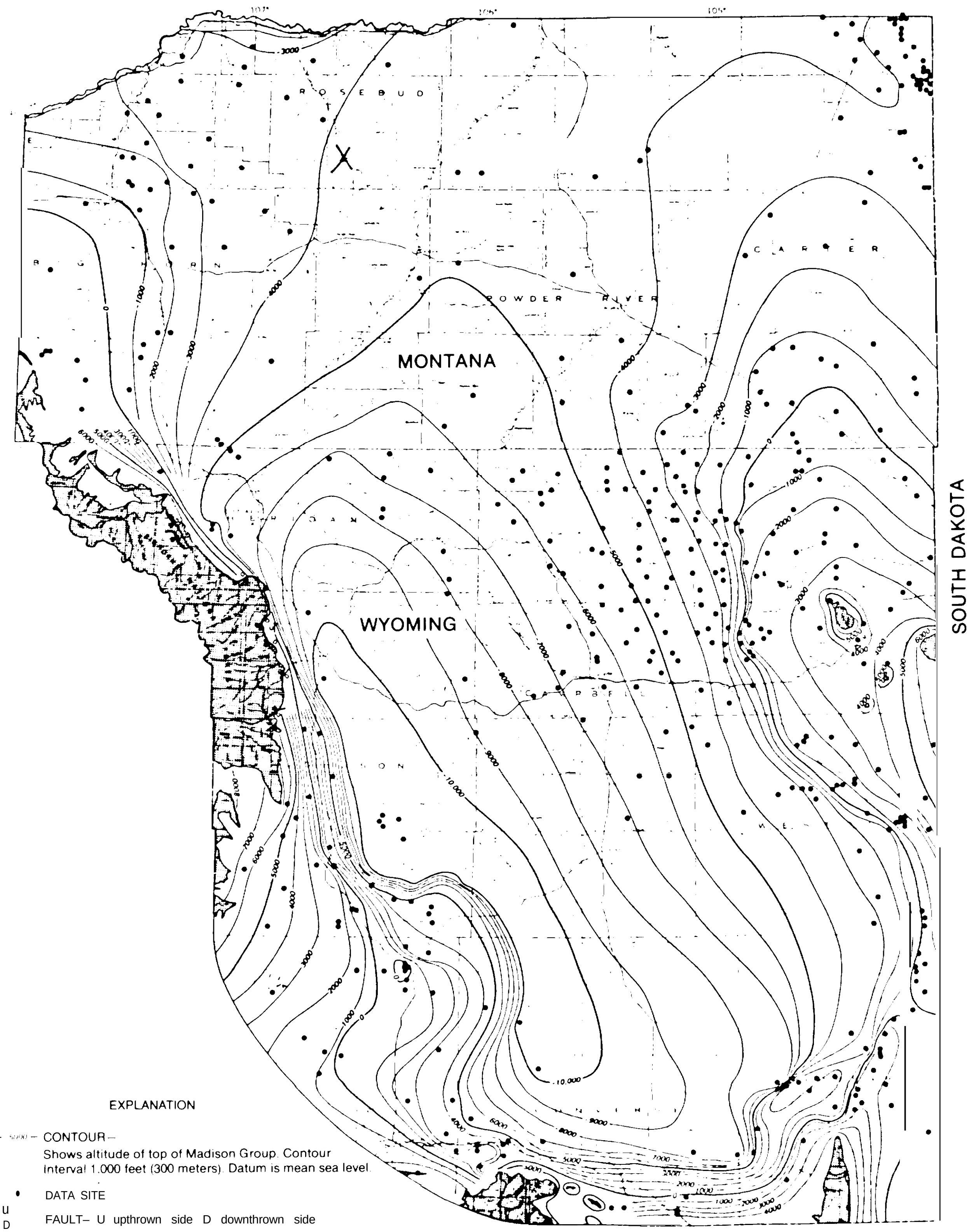
[9] **Leonard Konikow, U S Geological Survey,** Lakewood,Colo, personal communication, **Sept 14, 1977**

[10] **L F** Konikow, *Preliminary Digital Model of Ground Water Flows in the Mad/son Group, Powder River Basin and Adjacent Areas, Wyoming, Montana, South Dakota, North Dakota, and Nebraska,* U S Geological Survey Water Resource Invest igations 63-75, January 1976

[1] *'Plan of Study on the Hydrology of the Mad/son Limestone and Associated Rocks in Parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming,* U S Geological **Survey, Open File Report 75-631, Denver,** Colo **, December 1975**

[12] **E** lliot Cushing, **U S Geological Survey,** Lakewood,Colo **, personal** communication,Aug **22, 1977**

Figure 22-Configuration of the Top of the Madison Group



EXPLANATION

— CONTOUR —
Shows altitude of top of Madison Group. Contour interval 1,000 feet (300 meters). Datum is mean sea level.

• DATA SITE

U
D FAULT– U upthrown side D downthrown side

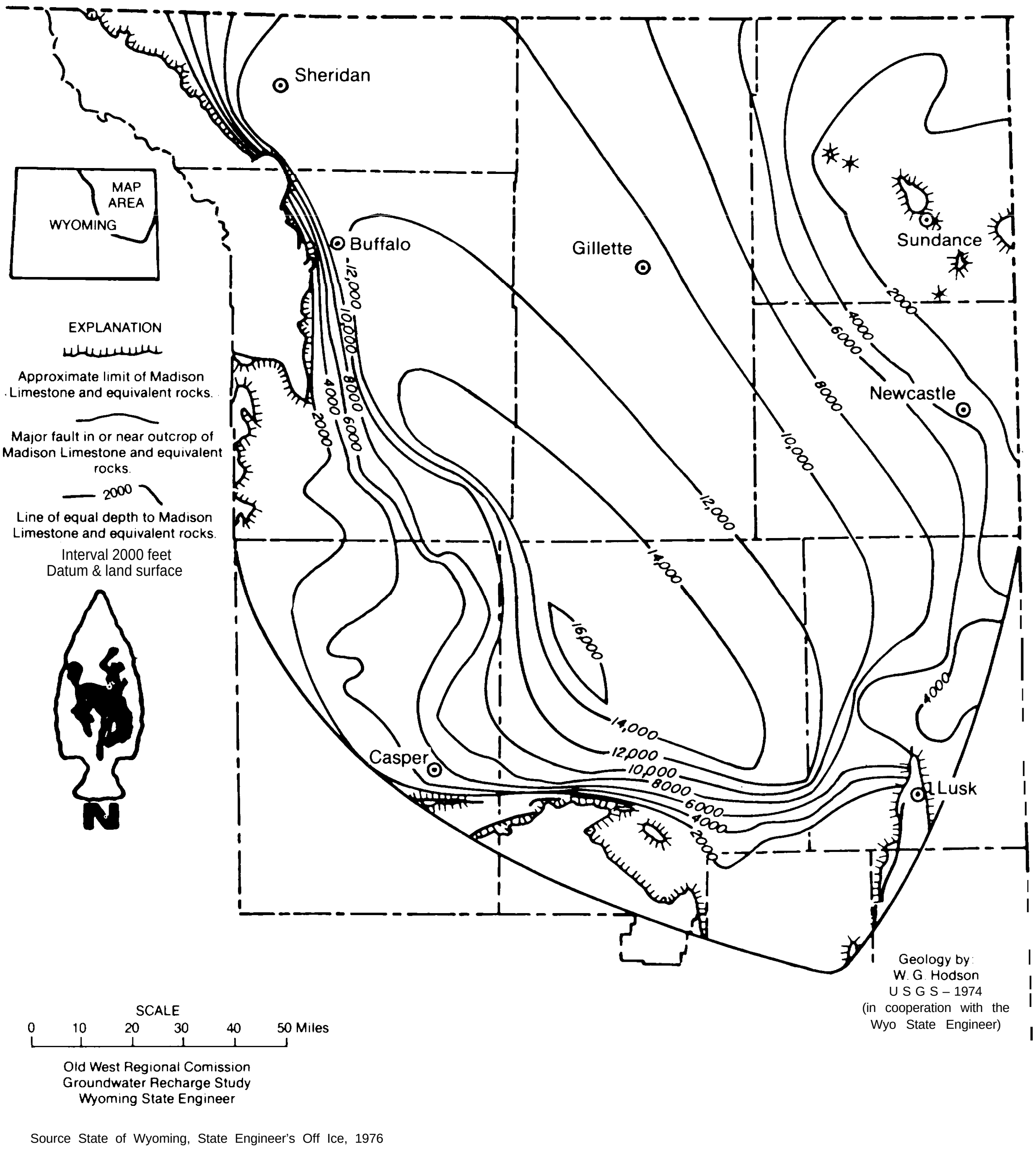
AREA WHERE MADISON GROUP IS ABSENT

Source U S Geological Survey 1976

Contours by F A Swenson W R Miller
W G Hodson and F N Visher 1975

of the Madison Group in northeastern Wyoming and southeastern Montana; contour lines show the elevation above mean sea level. Depths to the Madison from the land surface are shown in figure 23. At its deepest portion, which appears to be in Converse County, Wyo., it is about 10,000 feet below sea level and 16,000 feet below the land surface. In the

Figure 23–Depth From Land Surface to the Madison Limestone and Equivalent Rocks in the Powder River Basin and Adjacent Areas



Source State of Wyoming, State Engineer's Off Ice, 1976

Table 27. Selected Data From Madison Formation Wells and Springs, Powder River Basin, Wyo.

No[a]	Location T	Location R	Use[b]	Well depth (feet)	Test date(s)	Discharge (9pm)	Drawdown (feet)	Penetrated thickness (feet[c])	Specific capacity (gpm/ft)
1	33N	75W	OFW	8,591	1963	510	800	235/250	0.64
2	33N	75W		9,337	1951	ND[d]	ND	ND	ND
3	33N	76W	OFW	8,770	1962	75-320	16-92	240/250	3.5-4.7
4	33N	76W	In	6,954	1964	195	ND	ND	ND
5	33N	77W	In	7,615	1966	65	ND	ND	ND
6	36N	62W	T	3,116	1974	104,180	217-386	250/250	0.47,0.48
7	39N	61W	T	2,889	1962	30	36	81/300	0.83
8	40N	61N	OFW	7,467	1971-2	297-359	274-298	350/350	1.0-1.2
9	40N	61N	OFW	5,049	1971-2	491-726	100-133	350/350	4.4-7.1
10: : : : : : :	40N	61N	OFW	4,889	1971-2	4,121-5,599	152-202	214/350	25-31
11	40N	61N	OFW	4,975	1971-2	1,700-7,200	35-418	281/310	17-49
12.	40N	61N	OFW	4,968	1971-2	482-650	11-25	291/310	26-44
13........	41 N	84W	s	424	1963	15	60	200/200	0.25
14.	42N	81W		4,246	ND	1,080	ND	ND	ND
15.	43N	80W	OFW	9,300	1973	170,315	139,219	340/340	1.2,1.4
16.	44N	63W	u	6,881	1967	250	175	400/400	1.4
17.	45N	61W	M	2,638	ND	600-1,500	173-462	26/400	3.2-3.6
18.	45N	61W	M	2,872	1966	460	200	400/400	1.4
19.	45N	61W	c	2,738	1965	176	18	43/400	15
20.	45N	61W	s	2,728	ND	1,200	ND	ND	ND
21.	45N	61W	In	3,073	ND	117	ND	ND	ND
22.	45N	61W		3,028	1960	650	ND	ND	ND
23.	45N	61W	OFW	3,596	1960	290	ND	ND	ND
24.	46N	60W	S.I	1,178	ND	35	ND	ND	ND
25.	46N	62W	S	2,677	ND	30	ND	ND	ND
26.	46N	63W	In	2,592	ND	580	ND	ND	ND
27.	46N	64W	A	7,542	1956(?)	280	80	428/450	3.5
28.	46N	64W	u	5,125	1965,1972	70,308	65,293	450/450	1.1
29.	46N	64W	OFW	4,522	ND	30	ND	ND	ND
30.	46N	65W	OFW	8,109	1960	425	295	369/450	1.4
31.	46N	65W	OFW	7,737	1972	225	76	400/450	3.0
32.	46N	66W	OFW	8,780	1972	360	211	390/450	1.7
33.	47N	60W	P	380	ND	8	ND	ND	ND
34.	48N	65W	M	3,161	1972	210	110	261/500	1.9
35.	48N	65W	M	3,191	1972	155	101	464/500	1.5
36.	49N	83W	ND	Spring	1973	200	NA[d]	NA	NA
37.	52N	61W	ND	Spring	1969	300	NA	NA	NA
38.	52N	63W	M	1,123	1972	200	74	23/550	2.7
39.	53N	65W	P	1,341	1962	15-55	1-19	42/600	2.9-1.5

[a] Nos. 1-5: Glenrock, 6-12: Northeast NiobraraCounty, 13: Big Horn Mountains, 14-15: Kaycee, 16-24: Newcastle, 5-32: Osage, 33: Black Hills, 34-35: Upton, 36:Johnson County, 37-39: Crook County.
[b] OFW = oil field waterflood, S = stock watering, U = unused, M = municipal, **C =** commercial, A = abandoned, P = public,T = Test, In = industrial, I = irrigation.
[c] Thickness penetrated by wel l/estimated total thickness of formation.
[d] ND = no data, NA = not applicable.
Source: U.S. Geological Survey, 1976.

southeastern Powder River Basin, the Madison is about 3,000 to 4,000 feet below the land surface.[13] In this area the aquifer is roughly 100- to 500-feet thick (table 27).

The Madison Limestone and related aquifers vary widely in physical and geological charac-

[13] P W Huntoon and T Womack, "Technical Feasibility of the Proposed Energy Transportation Systems Incorporated Well Field, Niobrara County, Wyo ," *Contributions to Geology*, University of Wyoming, Vol 14, No 1, pp 11-25, 1975

teristics, and, as a consequence, so does their ability to store and transmit water. This complexity precludes simple basinwide generalizations from individual well tests, and also make it difficult to establish conclusively that a given observed effect is due to any specific cause.

The potentiometric surface of an aquifer at a given location is the level to which nonflowing water would rise in a well at that location. It is significant because the difference between the levels of the land and the potentiometric surface is the height to which water must be pumped to reach the land surface. If the potentiometric surface is above the land surface, a well will be free flowing and the rate of flow proportional to the difference in the levels. Pumping is necessary when the potentiometric surface is below the land surface and the amount of pumping power required is dependent upon the magnitude of the difference in levels. Figure 24 shows the most recent estimate of the configuration of the potentiometric surface of the Madison in northeast Wyoming and southwest Montana. These data are important in predicting aquifer activity because the ground water will tend to flow from areas of higher to areas of lower potentiometric surface.

Recharge is the process of water addition to the aquifer. The configuration of the potentiometric surface of the Madison aquifer indicates that the major areas of recharge would be the Bighorn and Laramie Mountains on the west and southwest and the Black Hills on the east. Where exposed, the Madison often contains numerous fractures, joints, and cavities which may capture percolating water and thereby localize the recharge effects. The actual recharge to the Madison in Wyoming has been estimated at about 75,000 AF/yr.[14]

In order to estimate future impacts of increased withdrawal of water from the Madison aquifer, those areas which are presently withdrawing water from the aquifer have been analyzed. In several eastern Wyoming locations (Midwest, Newcastle, and Osage) and a western South Dakota location (Edgemont), decreases in the potentiometric surface due to pumping have been observed.[15 16]

Several models are available for interpreting test-well data and predicting the effects, over time and over a given area, of pumping water from the Madison. The predictions of these models can and have been used to support differing points of view on the effects of withdrawals for slurry pipelines. However, all the models are substantially limited by the lack of data on the Madison Formation and by debatable simplifying assumptions. Figures 25 and 26 show the predicted results of the various models for potentiometric levels at the four locations for which data is available. (The specific predictions in the figures are for the withdrawal of 15,000 AF/yr from the Madison by a well field in Niobrara County.) The important conclusion is that the models probably represent the range of possibilities and the *actual* impact of increased pumping is somewhere within this range.

It is clear that increased pumping in a concentrated area on or near the periphery of the Powder River Basin is likely to have a measurable effect upon the potentiometric surface at distances up to 10 or 20 miles. The decrease will cause some wells to flow at lower pressures while greater pumping will be needed to maintain flows in other wells.

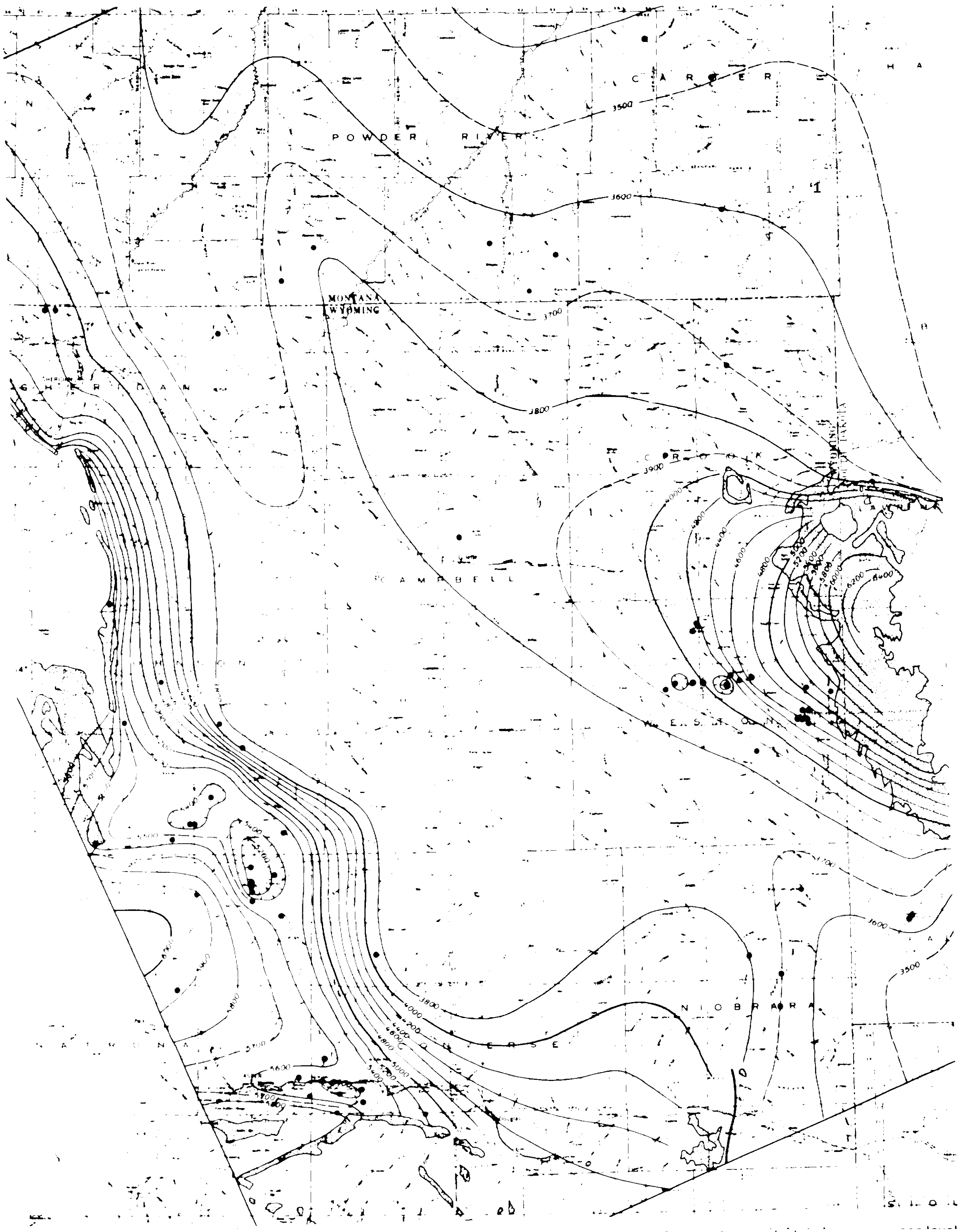
Water quality in the Madison varies from place to place. Some wells yield water which exceeds U.S. Public Health Service drinking water standards, and for example, Edgemont, S. Dak. uses the aquifer as a municipal water supply. In eastern Wyoming and southwestern Nebraska water from some other wells,

14 *Investigation of Recharge to Ground Water Reservoirs of Northeastern Wyoming [The Powder River Basin),* State of Wyoming, State E ngineer's Off Ice, June 1976

15 *P/an of Study on the Hydrology of the Madison Limestone and Associated Rocks in Parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming,* U S Geological Survey, Open File Report 75-631, Denver, Colo , December 1975

16 F A Swenson, W R Miller, et al , Maps *Showing Configuration and Thickness and Potentiometric Surface and Water Quality in the Madison Group, Powder River Basin, Wyoming and Montana,* U S Geological Survey, Miscellaneous Invest igations Series, Map 1-847-C (1 1,000,000), Reston, Va , 1976

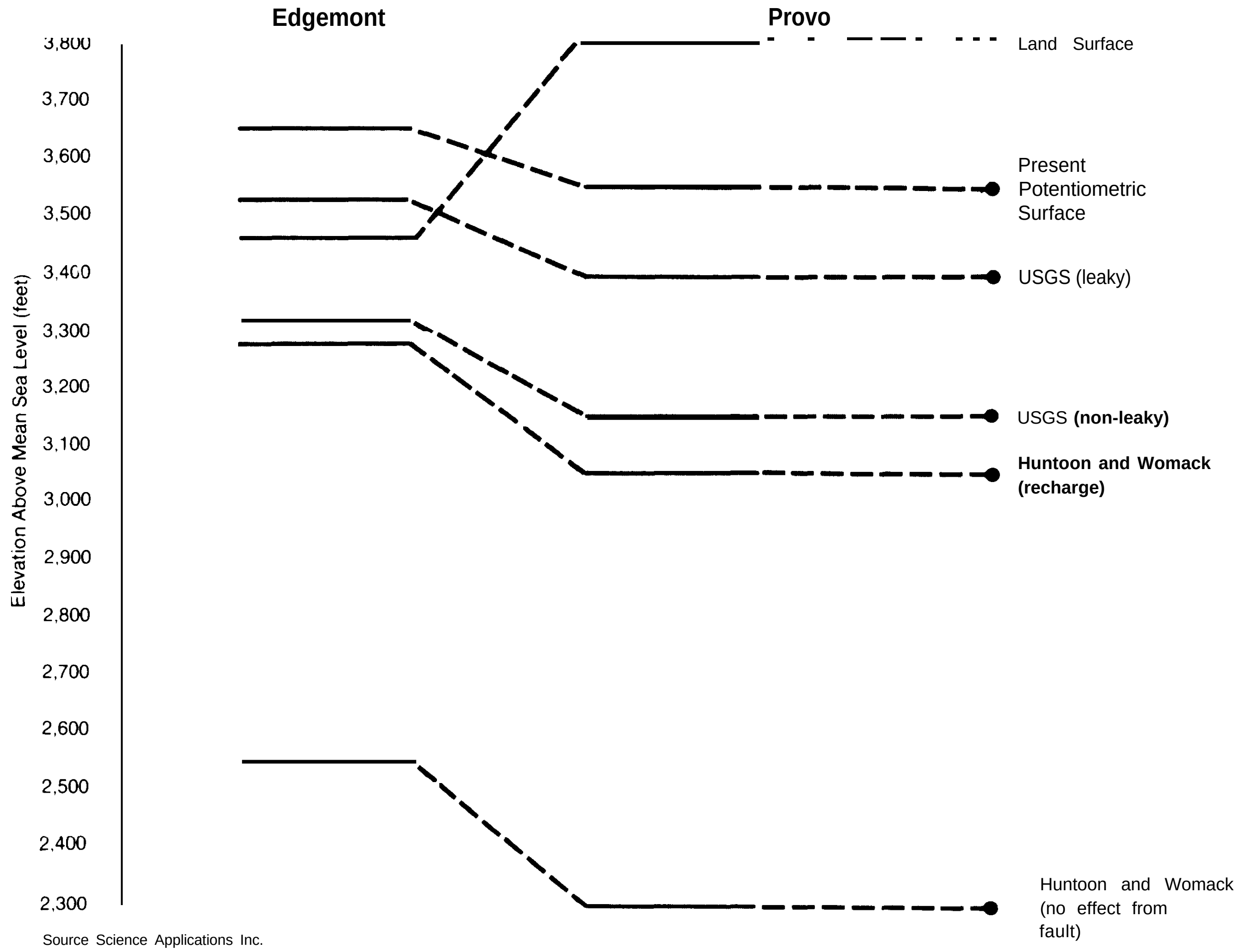
Figure 24– Potentiometric Surface of the Madison in Eastern Wyoming, Southeastern Montana, and Western South Dakota



Source Konikow L F U S Geological Survey Water Resource Investigations 63-75 (January 1976)

Contour shown in teet above mean sea level.

Figure 25—Potential Drawdown of Potentiometric Surface Near Edgemont and Provo, S. Dak., Due to 15.000 Acre-Feet per Year Withdrawal From the Madison Formation "in Niobrara County, Wyo., According to Different Models



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although not always suitable for drinking, can be used for stock watering and irrigation.

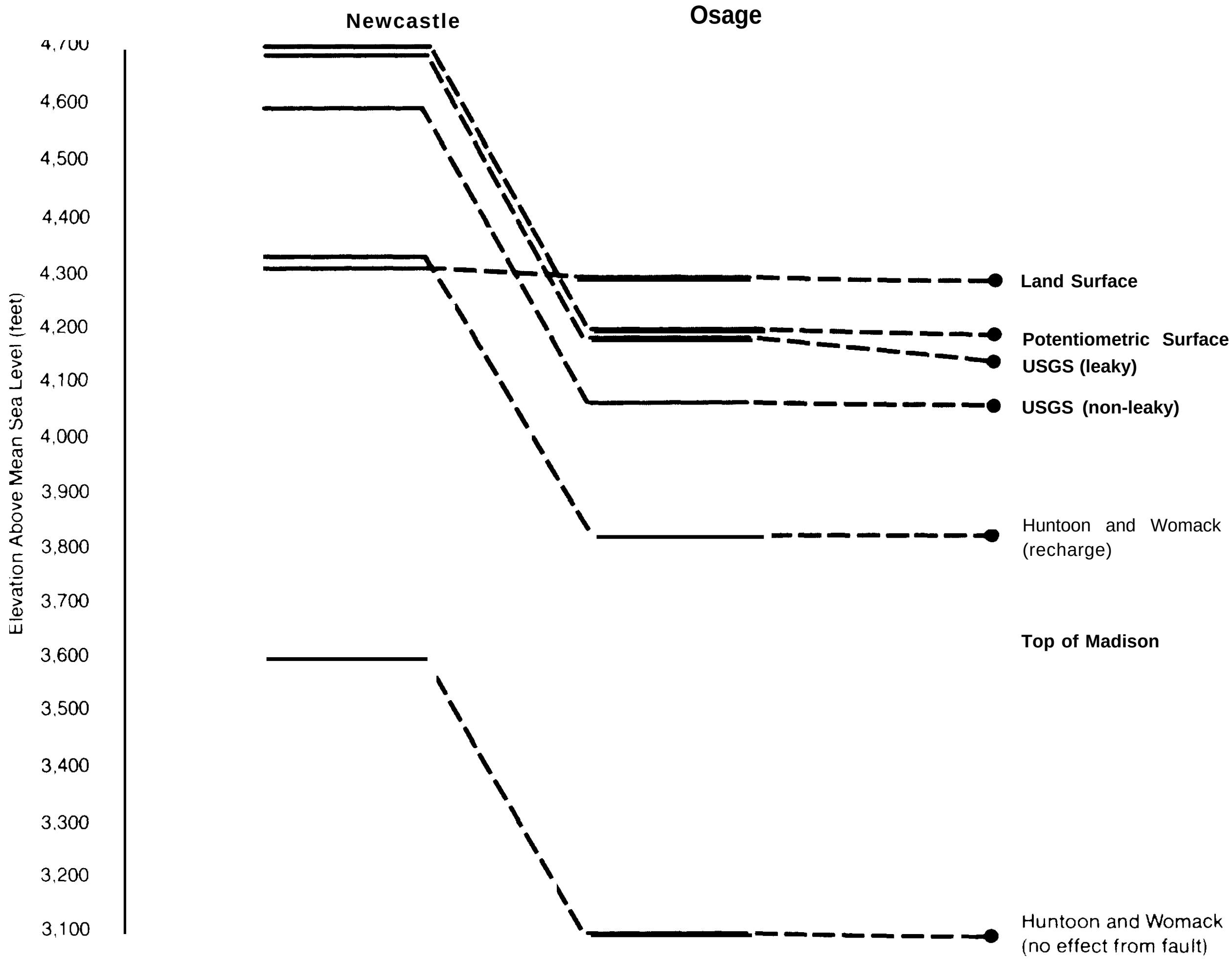
Present Wyoming uses of Madison aquifer water amount to about 25,400 AF/yr, approximately 80 percent of which is for industrial uses such as secondary oil recovery, oil refining, and electric powerplant cooling (see tables 28 and 29). About 3,600 to 3,800 AF/yr are used in Montana for secondary oil recovery and coal mining operations. [17] Annual discharges are about 1,800 AF/yr each for municipal supply at Rapid City and Edgemont, S. Dak.[18] The total present withdrawal-from the Madison is about 32,000 AF/yr.

Positing present levels for existing uses of the water in the Bighorn River Basin and the Madison Formation, there is sufficient unallocated water to supply the maximum levels of the hypothesized coal slurry pipeline.

[17] Ibid

[18] L F Konikow, *Preliminary Digital Model of Ground Water Flows in the Madison* **Group,** *Powder River Basin and Adjacent Areas, Wyoming, Montana, South Dakota, North Dakota, and Nebraska,* U S Geological **Survey Water Resource** Investigations **62-75, January 1976**

Figure 26—Potential Drawdown of Potentiometric Surface Near Newcastle and Osage, Wyo., Due to 15,000 Acre. Feet per Year Withdrawal From the Madison Formation in Niobrara County, Wyo, According to Different Models



Source Science Applications Inc

The uncertainty arises when *future* coal slurry pipeline water use is contrasted with future alternative water uses. Future alternative energy uses include present municipal and agricultural uses plus projected increased municipal, agricultural, industrial, and energy-related uses.

If all projected future alternative uses materialize, a water deficit would require importation of surface water before 2000, probably through aqueducts or increased ground water supply as through pumping the Madison aquifer. If water is imported by aqueducts from the Bighorn River Basin to the Powder River Basin: the surplus from the Bighorn would be sufficient to permit all projected growth to 2000. By 2000, however, Bighorn River surplus would be inadequate. An increase in ground water withdrawals could offset, to an unknown extent, the projected deficits.

It is impossible to identify the specific beneficial uses which would compete with coal slurry pipelines in the face of future deficits.

Table 28. Estimated Water Obtained From Madison Wells

	1973 withdrawal acre-feet	Maximum (year) acre-feet	Minimum (year) acre-feet
Wyoming			
Converse County.	540	1,651(1970)	410(1962
Crook County. . . .	187	187(1973)	5(1963)
Johnson County. .	2,116	4,345(1968)	2,100(1961)
Natrona County . .	15,542	20,103(1971)	100(1954)
Niobrara County. .	o	7(1964)	4(1966)
Sheridan County .	152	300(1933)	125(1967)
Weston County . .	6,904	6,904(1973)	1,290(1942)
Total Wyoming (1973).	25,441		
Montana[a]	*3,620*		
South Dakota[a] . . .	*3,620*		
Total (1973). . . .	32,681		

[a]Konikow, L. F., *Preliminary Digital Model of Ground Water Flows in the Madison Group, Powder River Basin and Adjacent Areas, Wyoming, Montana, South Dakota, North Dakota, and Nebraska,* U.S. Geological Survey Water Resource Investigations 63-75, January 1976,

Source: State of Wyoming, State Engineer's Office, *Investigation of Recharge to Ground Water Reservoirs of Northeastern Wyoming (The Powder River Basin)* (June 1976), unless otherwise noted.

Table 29. Uses of Madison Ground Water in Wyoming, 1973

Use	Acre-feet withdrawn
Municipal	**3,258**
Domestic, commercial, stock, fish, and irrigation	**1,558**
Industrial	**20,595**
Total	**25,441**

Source: State of Wyoming, State Engineer's Office, 1976.

Water for the Montana Pipeline

The coal source for the pipeline from Montana would be Colstrip, Mont. Flows **in the** surface streams in the immediate area are too unreliable to supply water for coal slurry pipelines, which will require 6,300 to 7,600 AF/yr. The U.S. Bureau of Reclamation has suggested the use of an aqueduct to divert water from the Bighorn River. " Such a diversion could provide about 209,000 AF/yr (see figure 27). However, Montana law may preclude use of such water for coal slurry pipelines, however, inasmuch as such use to transport coal out of State has been deemed by statute not to be a beneficial use.

By the terms of the Yellowstone River Compact, Montana's share of the Bighorn River's flow averages about 400,000 AF/yr. Although present uses of this water account for only about half this amount, projected future demands exceed supply by the year 2000. Table 30 shows that present unexercised industrial options (rights to purchase water, usually from existing or proposed storage facilities, for a given time) and applications exceed Montana's share of the Bighorn River. Pipelines will have to compete with alternative water uses for water.

Table 30. Water Supply and Demand, Bighorn River Basin, Mont.

Use category	Water quantity AF/yr
Present agriculture	200,700
Industrial options[a].	228,000
Additional applications.	422,000
Total projected demand[b].	850,700
Montana's share of Bighorn	400,000
Projected deficit.	450,700

[a]Not exercised as of January 1975.
[b]Does not include municipal use or reservoir evaporation.

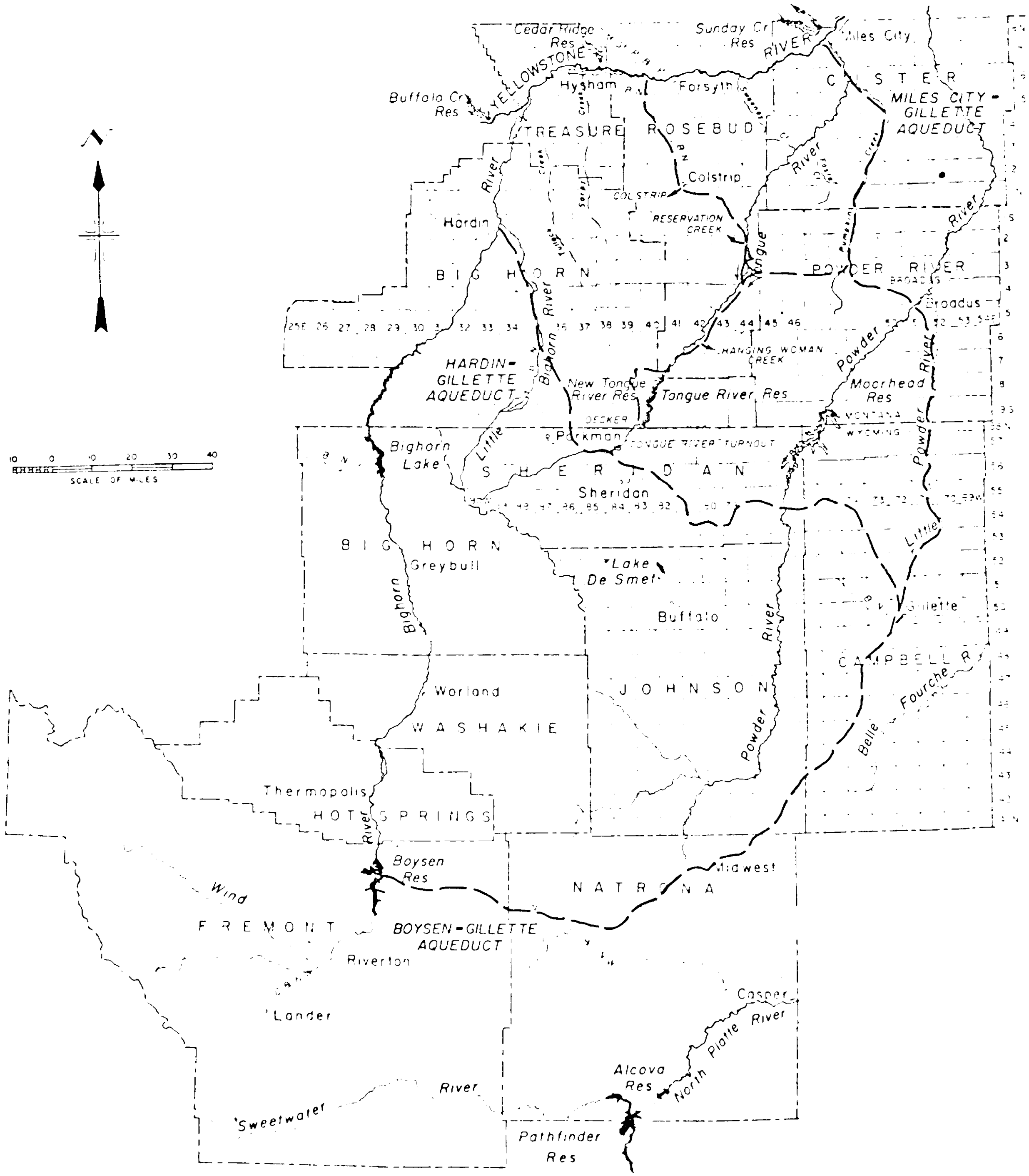
Source: U.S. Department of the Interior, Water for Energy Management Team (January 1975).

Water for the Tennessee Pipeline

The hypothetical coal slurry pipeline has its source near Tracy City, Term. The pipeline would require 10,300 to 12,100 AF/yr. The location of this pipeline source is on a divide straddling three drainage systems. To supply a coal slurry pipeline, water must either be brought

[19] *Appraisal Report on Montana-Wyoming Aqueducts,* U S Bureau of Reclamation, Denver, Colo , April 1972

Figure 27– Proposed Aqueducts, Bighorn River to Colstrip



Source U S Bureau of Reclamation, 1972.

uphill to the coal or the coal must be conveyed to a reliable water source. Ample water is available in the Tennessee River and could be withdrawn downstream from Nickajack Lake, a nearby reservoir, and pumped about 1,300 feet up to Tracy City. Ground water supply is not a feasible alternative in southeast Tennessee.

Given the large flows in the Tennessee River (average 2.56 x 10^7 AF/yr) withdrawal of up to 12,000 AF/yr by several coal slurry pipelines would not be expected to have any significant impact upon stream water quality. The primary current consumptive uses of water in the Tracy City area are municipal and do not present apparent conflict with future alternative water uses, including pipelines.

Water for the Utah Pipeline

The hypothetical coal slurry pipeline from Utah would transport coal from any of the seams in the Book Cliffs or Wasatch Plateau in east-central Utah. Water requirements for the hypothetical route would be 6,390 to 7,150 AF/yr. In addition to the water necessary for the slurry, water may be required for revegetation of the pipeline right-of-way. Water for revegetation, however, must be supplied at locations along the route, not just at the pipeline source,

Coal in this area is mined in rugged terrain characterized by high escarpments and narrow ravines. If the slurry preparation plant were at a mine site, water would have to be pumped through elevation gains of up to 1,000 feet. The alternative would be to deliver coal by train, truck, or conveyor to the base of the cliffs. The Green River at Green River City has an average discharge of 4.614 million AF/yr, and the minimum flow between 1894 and 1970 was 184.6 thousand AF/yr.[20] The Price River at Woodside, Utah (22 miles upstream from the confluence with the Green) has an average discharge of **74,620** AF/yr.[21] Physical supply of water for use in a slurry pipeline is ample. The Green River, because of its greater flow, is the most likely water source for this route. The Navajo sandstone aquifer underlies this area, but local data on yields are very limited, and it is not considered here as an alternative source.

The chief limitation upon water use for coal slurry pipelines in Utah appears to be institutional. The Green River joins the Colorado River about 50 air miles south of the town of Green River, and the Price is a tributary of the Green River. Any use of surface water (and certain ground water sources) in eastern Utah must be considered in the context of Utah's participation in the Colorado River Compact, whereunder the Lower Colorado River Basin must receive 75 million acrefeet of Colorado River water over any 10-year period; the Upper Basin's annual share is thus the total flow minus 7.5 million acre-feet. By further agreement among the Upper Basin States, Utah is entitled to 23 percent of whatever the Upper Basin has left after deliveries to the Lower Basin .[22] The State's annual allotment is about 1.2 to 1.4 million AF/yr.

Additionally, in Utah, all water belongs to the public and may be appropriated for beneficial use.[23] For an application to be approved there must be unappropriated water, the diversion plan must be physically and financially feasible, and the appropriation must not be speculative. Whether water use for a coal slurry pipeline meets these requirements must be determined by the State engineer, under guidelines from the Utah Board of Water Resources.

It is questionable whether the transfer of

[20] *Surface Water Supply of the United* States, *1* **966-1970, Part 9,** *Colorado River Basin,* Vol 2, *Colorado River Basin from Green River to Compact Point,* **U S** Geological **Survey, Water-Supply Paper 2125, 1971**

[21] Ibid

[22] G D Weatherford, **"Legal** Institutional **Assessment of the Water Allocation** Priorities in **the Colorado** River **Basin, "** *Utah Coal for Southern California* Energy *Consumption,* P C Grew, M Simmons, and B Sokolow **(Eds),** University **of California at Los** Angeles, Department of Environmental Science and Engineering, Report 76-19, pp 3-1 to 3-23, 1976

[23] R Pattich, J Wegner, et al , "Utah Water Law, " *Study* of *Alternative Locations of Coal-Fired Electric Generating Plants to Supply Energy From Western* **Coal** *to the Department of Water Resources,* University **of California at Los Angeles, Institute of Geophysics and Planetary Physics and Off Ice of Environmental Science and** Engineering, **pp 6-109 to 6-120, March 1977**

Utah water to another State is legal.[24] 25 Such a transfer may be possible if the receiving State reciprocates. Transport of water from Utah to California would constitute transfer from the Upper Colorado River Basin to the Lower Basin and must be compatible with the Colorado River Compact. In the final analysis, the hypothetical coal slurry pipeline would compete with other future alternative water uses, many of them energy related, for a limited water supply.

Alternative Water Supply Sources

Given the relative scarcity of water in some potential coal slurry pipeline origins, it has been suggested that pipelines use water less suitable for other beneficial uses. [26 27] Saline water is defined as water having a TDS (total dissolved solids) concentration exceeding 1,000 miligrams per liter (mg/1).A number of saline western ground water sources, including parts of the Madison Limestone, have been identified 28 For example, water with a TDS concentration exceeding about 1,300 (mg/I is not useful for crop irrigation, Although water with high concentrations of TDS or other constituents may require treatment by the user, it can liberate fresh water at the pipeline source for other uses, In addition, diversion of highly saline waters from tributary streams could help meet downstream salinity reduction goals. It has also been suggested that primary sewage treatment effluent be used as the coal slurry carrier medium. 29 30 Irrigation return flows are another possible water source. Finally, recovered slurry water could be recycled in the coal slurry pipeline.

End uses of the recovered slurry water may affect the feasiblity of using saline water or water with high TDS. Use as evaporative cooling tower makeup or direct discharge to streams would require treatment of the recovered slurry water, although conventional lime and soda ash softening followed by ion exchange resin treatment may suffice. [31]

Primary sewage treatment effluent also has high TDS, as well as considerable organic material, bacteria, and other contaminants. Secondary treatment effluent, which is considerably more amenable to reuse, was used in 1973 in nine powerplant cooling systems, 32 and has been proposed for at least one more, and has been suggested for use in pipelines. An important question is whether local communities in coal-producing areas can generate enough sewage effluent to supply a coal slurry pipeline. For example, all the community domestic wastewater treatment facilities in the two counties near the origin of the hypothetical Utah slurry pipeline, produce a combined total of 3.4 million gallons per day of effluent, or about 3,850 AF/yr.[34] If this could all be collected, it would still be insufficient except as a supplementary supply. Advantages of using sewage effluent are that a reliable minimum daily flow is obtainable in areas of water shortage, and such use decreases the need for construct ion of sewage treatment facilities.

[24] W Gertsch, U S Energy Research and Development Administration Idaho Operations Office, Idaho Falls, Idaho, personal communication, July 19, 1977

[25] David Everett, U S Bureau of Land Management, Cedar City District Office, Cedar City, Utah, personal communication, July 11, 1977

[26] J K Rice, J M Evans, and M Warner, *Environmental Considerations of the Use of Saline Water in Coal Slurry Pipelines*

[27] James Lambert, U S Bureau of Land Management, Cheyenne, Wyo, personal communication, Aug 21, 1977

[28] *National Energy Transportation*, Vol 1, *Current Systems and Movements*, Congressional Research Service, May 1977

[29] A C Buck, "Negligible Environmental Impact of Coal Slurry Pipelines" *Proceedings of the 2nd International Technical Conference on Slurry Transportation* Las Vegas N ev, pp 81-87, Mar 24, 1977

[30] J W Moore, Statement before U S House of Representatives Committee on Interior and Insular Affairs, Subcommittee on Indian Affairs and Public Lands – Mines and Mining Cheyenne, Wyo, June 9, 1977

[31] G K Malik, Associate Plant Engineer, Mohave Generating Station, Nev, personal communication, July 12, 1977

[32] E Goldman and P J Kelleher, 'Water Reuse in Fossil Fueled Power Stations," *Complete Water Reuse Industry's Opportunity*, L K Cecil (Ed), American Institute of Chemical Engineers, pp 240-249, 1973

[33] C L Weddle and A C Rogers, *Water Reclamation Process Evaluation for the Arizona Nuclear Power Project* presented at the American Institute of Chemical Engineers Water Reuse Conference, Chicago, Ill, May 4-8, 1975

[34] L J Meyers, R D Millar, and R E Turley "Water Challenges in Carbon and Emery Counties, *Impact of Energy Development on Utah Water Resources, Proceedings of the 3rd Annual Conference of the Utah Section of the American Water Resources Association*, pp 97-131, Feb 20, 1975

A final alternative water source is recycling and reuse of the recovered coal slurry pipeline wastewater. The major disadvantage of this alternative is the added cost of a return pipeline. The advantage is that water requirements would be substantially decreased. The extent of water savings is dependent upon the moisture content of the coal, as well as the efficiency of the dewatering process, and typically about two-thirds of the water could be recycled.

If saline water were to be used in a coal slurry pipeline, the main problem for the system itself would be increased corrosivity in the presence of high-dissolved solids concentrations. Increased use of corrosion inhibitors may be required. Suspension of finely divided coal in water with high sodium concentrations may cause, through an ion exchange, an increase in sodium bound to the coal surface, resulting in fouling problems when the coal is burned .35 A mitigating measure could be to wash the coal with low-TDS or acidified water.

Coal-Water Interactions and Corrosion

Possible chemical interactions between coal and the carrier medium are important because of possible adverse environmental impacts from: 1) a slurry spill or pipeline rupture; 2) slurry dewatering process and water reuse or waste water disposal; and 3) alteration of combustion characteristics of the end-product coal. Nonetheless, very little is known about coal-water interactions.

Coal, a combustible solid formed from decomposed vegetation, has a wide variety of physical and chemical properties. The chief elements in coal are carbon, hydrogen, and oxygen, with smaller amounts of nitrogen, sulfur, and a large number of trace elements. Oxygen content ranges from about 1.5 percent by weight in anthracite to about 30 percent in lignite, The higher the oxygen content the more chemically reactive the coal.

[35] J K Rice, J M Evans, and M Warner, *Environmental Considerations of the Use of Saline Water in Coal Slurry Pipelines*

Coal in slurry form has a large surface area in contact with the water. For example, if each coal particle is assumed to be spherical and completely surrounded by water, then given the particle size distribution of the existing Black Mesa pipeline[36] the contact area, or possible reactive surface, for one contract ton of coal is about 220,000 square meters, or about 55 acres. Thus, because of the variety of reactive compounds in coal, the large reactive surface, and the long residence time (about 13 days for a 1,1 70-mile pipeline), coal-water interactions could be substantial.

Although considerable evidence is available concerning what materials will be leached from coal by water in the presence of air, almost none exists for the anaerobic conditions that will be encountered in a pipeline. The reactions involved in the well-known acid-mine drainage phenomenon, for example, require oxygen. Oxygen will be present in a slurry pipeline system only where the slurry is prepared and first introduced into the pipe.

In summary, as long as the slurry water is oxygenated for at least the initial part of the journey, it is likely that some constituents will be transferred from the solid to the liquid phase. The extent of leaching will depend upon the initial pH, the presence of potentially leachable species in the feed water, and the tendency of dissolved ions to precipitate at slurry temperature and pH. Coal composition is also critical. Before firm conclusions on chemical reactions in a real slurry may be drawn, information on leaching under anaerobic conditions is necessary.

Corrosion and corrosion inhibitors may affect slurry wastewater quality. In general, corrosivity (the corrosion rate) increases with increasing temperature, dissolved ionic strength, and decreasing pH. These factors can be directly affected by coal surface interactions.

Chemical additives are known to be effective in minimizing corrosion. If corrosion inhibitors are not used, an appreciable amount

16 M L Dina, *Operating Experience at the 1580-MW Coal Slurry Fired* Generating *Station*, presented at the International Conference on Slurry Transportation at Battelle Memorial Institute, Columbus, Ohio, Feb 3, 1976

of iron will enter the slurry, but apparently only a small amount of iron will remain in solution. One corrosion inhibitor, hexavalent chromium, could pose environmental problems in the event of a spill. Wildlife drinking the spilled slurry wastewater with the corrosion inhibitor could be poisoned. 37

Slurry Water Reuse and Impacts

At the receiving end of a coal slurry pipeline, the slurry may be dewatered by several means (either alone or in combination): centrifugation, chemical flocculation, [38] vacuum filtration, [39] or heating. Slurry dewatering yields are variable, but calculations based on figures reported by one plant[40] indicate that 64 percent of the slurry carrier medium is available for reuse.

[37] G.K. Malik, Associate Plant Engineer, Mohave Generating Station, Nev., personal communication, July 12, 1977.

[38] M.L. Dina, *Operating Experience at the 1580-MW Coal Slurry Fired Generating Station,* presented at the International Conference on Slurry Transportation at Battelle Memorial Institute, Columbus, Ohio, Feb. 3, 1976.

[39] *Proposal for a Coal Slurry Transportation System by Houston Natural Gas Corporation and Rio Grande Industries, Inc.* Houston Natural Gas Corporation, undated.

[40] M.L. Dina, *Operating Experience at the 1580-MW Coal Slurry Fired Generating Station,* presented at the International conference on Slurry Transportation at Battelle Memorial Institute, Columbus, Ohio, Feb. 3, 1976.

The ultimate use of the recovered water depends upon its chemical quality at the point where it leaves the slurry system and the technical and economic feasibility of treating it to permit alternative reuses. The three major potential reuses are: makeup water for a powerplant cooling system, discharge to surface waters, and agricultural irrigation.

Table 31 lists the effluent requirements which recycled coal slurry water must meet in order to be discharged into a water of the United States from a steam powerplant, the most likely end point of slurry pipeline. The effect of contaminants in recovered slurry water upon compliance with water quality standards is difficult to assess, because in most cases the recovered slurry water will be given more treatment or mixed with other water streams within the plant. Prior to discharge, the powerplant or other coal slurry pipeline terminus would be required to obtain a discharge permit under the National Pollution Discharge Elimination System of the Federal Water Pollution Control Act of 1972, administered by the Environmental Protection Agency (EPA). Also, some of the 65 priority pollutants identified under the settlement agreement in National Resources Defense Council vs Train include trace materials present in coal.

Table 31. EPA Discharge Standards for New Sources, Steam Electric Power Generating Point Source Category

Effluence characteristic	Source	Maximum for any one day	Maximum average for 30 consecutive days
pH	All except once-through cooling	6.0-9.0	
Total suspended solids	Low-volume wastes[a]	100 mg/l	30 mg/l
	Bottom ash transport	100 mg/l	30 mg/l
	Boiler blowdown	100 mg/l	30 mg/l
	Fly ash transport	Zero discharge	
Total copper	Boiler blowdown	1.0 mg/l	1.0mg/l
Total iron	Boiler blowdown	1.0 mg/l	1.0 mg/l
Corrosion inhibitors	Cooling tower blowdown	No detectable amount	

[a] Wastewaters from wet scrubbers, ion exchange water treatment, blowdown from recirculating house service water system, etc.

[b] Mass discharge limit is 0.05 x flow x values in table.

c Include, but are not limited to, zinc, chromium, and phosphorus.

Source: 39 C.F.R. 36186,40 C.F.R. 7095,23987, and 42 C.F.R. 15690.

The second alternative end use—direct discharge to surface streams–might be considered if the water from the slurry were not used after dewatering at the destination powerplant, or if the plant used once-through cooling. A discharge permit would be required in this case as well. No standards currently exist for slurry discharge so "engineering judgment" as to best available technology would apply.

as to best available technology would apply.

The only significant problem with the third alternative slurry end use — agricultural irrigation — is the high levels of TDS (400 to 1,100 mg/1) in slurry water. Dilution with better quality local water could reduce the TDS levels sufficiently to permit agricultural uses.

COMMUNITY DISRUPTION BY RAILROADS

The major environmental impact of increased unit train operation will be the impact upon the daily lives of the people of the communities through which the unit trains will pass. Many towns, especially in the West, have been built around and because of the railroads. Railroad rights-of-way often divide major portions of towns. The impact of increased unit train operations will be to increase the volume of traffic on certain routes, and perhaps this increase will reach a point where it disrupts the transportation, land use, and social patterns of the residents. The impacts are not environmental in the strict, traditional sense. They are instead social impacts — affecting the lifestyles of people.

Virtually all the train-related environmental impacts discussed elsewhere in this chapter have a social and psychological component. Social components of the impacts cannot be readily quantified largely because of the variability of human response. Nonetheless, the possibility and variability of human reactions must be noted. For example, 26,000 additional people living between Gillette, Wyo., and Houston, Tex., would be exposed to noise levels exceeding EPA recommended standards as a result of 17 million tons per year of increased coal traffic along the hypothetical route. If train noise makes an impacted area less desirable, then the people affected will either move or adjust their lives to the noise. Increased train traffic could alter commuting patterns. People may have to leave home earlier every day to compensate for possible delays caused by trains on their trip to work. The main point here is that thousands of people will each be affected in a relatively small way.

One immediate measurable aspect of the disruption is rail-highway grade crossing accidents. **In the period 1965-74, an annual U.S. average of 21,000 rail-related accidents occurred, of which 5,000, or 24 percent, occurred at rail-highway grade crossings. In attempting to determine whether such accidents** will increase with an increased volume of unit train operations, simple assumptions are inapplicable. Accident rates are a function of type of crossing protection, numbers of tracks, numbers of trains and vehicles per day, urban or rural setting, and time of day. It is clear from analysis of 3,870 grade crossings in **21 States that increased unit train operation** would result in increased accidents. The increase is not in direct proportion to the increase in train volume. A 74.5 million tons per year increase in coal traffic could result in 8 deaths and 30 injuries above present levels if the case assumptions are correct (see table 32). For example, in one hypothetical case, a 90-percent increase in train traffic will yield a 21-**percent increase** in deaths and injuries. These accident rates would be reduced by the installation of any traffic protection improvements.

The frustration or inconvenience to the local community and accidents indirectly related to increased train volume are not readily quan-

Table 32. Predicted Annual Injuries and Deaths Based on Present and Hypothetical Train Traffic Levels

Route	Present rail traffic		Rail traffic with hypothetical added tonnage		Incremental impact of added tonnage		No. of crossings	Coal tonnage (10^6 tons/Yr)
	Deaths	Injuries	Deaths	Injuries	Deaths	Injuries		
Gillette-Dal lab.	6.0	23.1	8.1	31.1	2.1	8.0	659	18
Gillette-Houston	10.9	42.8	13.2	51.9	2.3	9.1	1,393	17
Colstrip-Becker/Portage	8.6	33.1	9.4	36.6	0.8	3.5	695	13.5
Tracy City-Waycross	6.0	23.6	6.5	25.2	0.5	1.6	480	16
Waycross-Tampa	1.3	5.1	1.6	6.4	0.3	1.3	190	8
Waycross-Ft. Lauderdale	4.1	15.9	5.4	20.9	1.3	5.0	281	8
Price-Barstow	1.5	5.7	1.8	7.1	0.5	2.3	172	10
Total	38.0	149.0	46.0	179.0	8.0	31.0	3,870	74.5

Source: Science Applications, Inc.

Table 33. Annual Added Vehicle Operation Costs **(1974 Dollars) and Travel Time Due To Increased Coal Train Traffic**

Movement	Vehicle operation costs ($)		Traveler time costs ($)		Total ($)			Time stopped (hrs.)		
	T_1	T_2	T_1	T_2	T_1	T_2	T_2-T_1	T_1	T_2	T_2-T_1
Gillette to Dallas	3,160	3,532	2,184	4,489	5,344	8,021	2,677	347	1,366	1,019
Gillette to Houston	3,639	4,023	3,024	5,288	6,663	9,311	2,648	647	1,693	1,046
Colstrip to Becker.	1,879	2,028	2,112	3,013	3,991	5,041	1,050	602	983	381
Colstrip to Portage.	Cannot distinguish between T_1 and T_2.									
Tracy City to Waycross. . . .	2,707	2,832	3,108	3,589	5,815	6,458	643	898	1,225	327
Waycross to Tampa	526	542	423	467	949	1,009	60	86	104	18
Waycross to Ft. Lauderdale	4,169	4,297	5,078	5,440	9,247	9,737	490	1,456	1,820	364
Price to Barstow	650,	691	583	800	1,233	1,491	258	137	225	88
Totals							7,826			3,243

T_1 — Present rail traffic In trains per day. T_2 — Rail traffic with hypothetical added tonnage in trains per day.
Source: Science Applications, Inc.

tifiable. Stopping and waiting for trains to pass through railroad crossings results in additional vehicle operation and travel-time costs. Assuming present train and highway traffic plus the added coal trains considered in the four case studies, the estimated added costs were calculated. As shown in table 33, the coal unit trains would impose estimated added annual delays of 3,243 vehicle hours if no new grade crossings are built. The precise amount of time and cost borne by any one person or community cannot be accurately calculated, but spread across miles of track individual delays and costs should be relatively minor.

Mitigation of increased railroad-highway accidents and traffic delays requires costly grade separations. Cost aside, grade separations are an important alternative for vehicular traffic at railroad crossings, although other types of disruption may not be easily mitigated.

Increased train traffic in communities that are divided by railroad tracks without grade separations could yield unquantifiable problems. For example, emergency fire, medical, or police vehicles may occasionally be temporarily delayed in reaching emergency situations. Grade separations should therefore be considered where this type of problem is significant.

Increased rail traffic could cause problems in rural areas where the land is primarily used in ranching and farming. Either "sheep-tight" fences, designed to reduce hazards to free-ranging animals, or frequent train traffic will prevent ranchers from crossing railroad tracks with their herds. Increased unit train traffic, additional fencing, or new rail construction could make this problem worse. On the other hand, cattle passes are built in new rail lines, and old lines often parallel highways, which block the passage of cattle independently of rail activity.

Another impact of increased train traffic with social and psychological implications for the affected community is noise. The main noise sources in unit train operations are the locomotives' diesel-electric motors, the interaction between wheels and rails, and the vibrations of hopper cars.[41] Maximum train sound levels range between 80 and 100 decibels (dBA) at a distance of 50 feet,[42] but the perception of sound is very subjective and subject to reduction by land forms, thick vegetation, and densely packed housing or buildings. The day-night average sound level (L_{dn}), which is a noise exposure measure weighted more heavily for nighttime than for daytime, increases with increasing numbers of rail line haul operations. Table 34 identifies the human effects of various EPA recommended noise levels outdoors in residential areas and on farms. The Environmental Protection Agency has judged the level of 55 dBA to be the maximum allowable L_{dn} which protects public health and welfare, with an adequate margin of safety.

Guidelines for community noise exposure, based on the L_{dn}, were available, so the population potentially exposed to noise levels exceeding the standard was estimated as shown in table 35. **In short,** the noise impact for each hypothetical railroad route depended upon two factors: 1) the predicted increase in the number of railroad line-haul operations due to heavier coal traffic, and 2) the population densities along the proposed routes. Although the increased number of people likely to be subjected to levels above 55 dBA can only be roughly estimated, it is clear that the number will increase.

The impact upon the lives of the affected people of the increased exposure is impossible to assess because noise impacts depend heav-

41 J M Fath, D S Blomquist, et al , Measurement *of Railroad Noise* – **Line** *Operation and Retarders,* National Bureau of Standards **(NTIS COM-75-10088), 1974**

42 Ibid

Table 34. Summary of Noise Levels Identified by EPA as Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety

Effect protected against	Recommended noise level		Area
Hearing loss	$L_{eq(24)}$[a]	70 dBA	All areas
Outdoor activity interference and annoyance	L_{dn}	55 dBA	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq(24)}$	55 dBA	Outdoor areas where people spend limited amounts of time, such as schoolyards, playgrounds, etc.
Indoor activity interference and **annoyance**	L_{dn}	45 dBA	Indoor residential areas
	$L_{eq(24)}$	**45 dBA**	**Other indoor areas with human activities such as schools, etc.**

[a]L_{eq} is the constant A-weighted sound level which conveys an equivalent amount of sound energy as does an A-weighted time-varying sound over a given time period. $L_{eq(24)}$ is the L_{eq} of a 24-hour period.

Source: Adapted from U.S. Environmental Protection Agency, NTIS:PB 239429(1974).

Table 35. Population Exposed to Noise Levels Exceeding EPA Community Noise Guidelines Along Case Study Routes

	Total trains per day						
Route	10	25	50	90	T_1a	T_2a	Percent increase
Gillette-Dallas [b]	67,800	111,000	164,900	220,600	58,000	88,000	52
Gillette-Houston [c]	70,300	115,000	170,800	228,600	78,000	104,000	33
Colstrip-Becker [d]	30,900	50,500	75,000	100,300	45,000	53,000	18
Becker-Portage [e]	21,300	34,900	51,800	69,400	32,500	34,000	5
Tracy City-Waycross [f]	29,700	48,600	72,200	96,600	50,000	63,000	26
Waycross-Tampa [g]	11,100	18,200	27,100	36,200	10,500	14,500	38
Waycross-Ft. Lauderdale [h]	28,300	46,300	68,700	92,000	44,000	51,000	16
Price- Barstool	16,800	27,400	40,700	54,500	19,000	22,500	18

[a] T_1 is the current number of trains per day as it appears in grade-crossing inventory data. $T_2 = T_1$ plus the projected increase in coal trains per day. [b] Average T_1 and T_2 are 7.2 and 16.6, respectively. [c] Average T_1 and T_2 are 11.4 and 20.8, respectively. [d] Average T_1 and T_2 are 19.6 and 26.6, respectively. [e] Average T_1 and T_2 are 21.6 and 23.4, respectively. [f] Average T_1 and T_2 are 20.7 and 35.3, respectively. [g] Average T_1 and T_2 are 9.1 and 16.4, respectively. [h] Average T_1 and T_2 are 22.4 and 29.7, respectively. [i] Average T_1 and T_2 are 12.6 and 15.9, respectively.

Source: Science Applications, Inc.

ily upon subjective factors which vary from individual to individual. Among the factors which will influence individual perception of impact are:

- Length and speed of the train;
- Time of day noise occurs (this is taken into account in estimating the L_{dn} value);
- Whether windows are opened or closed;
- Background noise level when trains are not present;
- Presence of particularly disturbing or pleasing sound frequencies, i.e., some people may enjoy the sound of a train horn in the night, while others may dislike it;
- History of prior exposure to train noise; and
- History of noise exposure in general.

For example, n terms of total number of people impacted by train noise, the effect would be greatest in urban areas. Background noise and noise tolerance may well be highest in these areas however, thereby minimizing the subjective response to the increased train noise,

Careful planning now can help to avoid some of the serious negative impacts of increased traffic. Rapidly developing communities should plan urban growth to avoid community division by railroad tracks. Rail traffic should be routed around densely populated areas, and where new tracks are being laid, they should whenever possible bypass extant communities. Areas along railroad rights-of-way can be zoned nonresidential so as to minimize the noise impact of increased rail traffic, Where warranted, grade separations can be built or tracks otherwise relocated.

CONSTRUCTION IMPACTS

With the exception of the previously enumerated water requirements for coal slurry pipelines and the peculiar community impacts of railroad unit train operations, the environmental impacts of construction and operation of coal slurry pipelines and railroads are comparable in many respects. Most of the railroad lines which will be utilized by coal unit trains are already in existence, and impacts from new track construction will therefore not be as extensive as impacts from coal slurry pipeline construction. This section discusses the environmental impacts of pipeline and new railroad construction activities. Some impacts, noise from construction equipment, for example, will occur only during actual construction, whereas other impacts, like destruction of vegetation, will require a few years to rectify. In most locations, construction impacts for coal slurry pipelines and new railroad construction are relatively minor. In arid and biologically sensitive areas, however, construction impacts are magnified. Fortunately, by careful advance planning, most particularly sensitive locations–marshes, ponds, refuge areas, etc., can be avoided by route alterations. When these locations cannot be bypassed, adverse biological impacts can be mitigated by performing construction activities during the biologically least sensitive time of the year. The adverse impacts of construction on rare, threatened, or endangered species must be minimized, if not avoided entirely. [43]

The same type of short- and long-term impacts that are discussed for pipelines will be experienced in railroad construction. However, the mitigating measures available after completion of a pipeline, i.e., revegetation, recontouring and eventual return to original land uses, are not entirely applicable to railroad rights-of-way because of the continued above--ground surface existence of the rail lines,

The most obvious environmental impact of pipeline construct ion is the clearing of vegetation —trees, shrubs, and grasses—from the pipeline route and right-of-way (see figure 28).[44] 45 Construction of the pipeline also requires trenching by blasting and excavation with backhoes, stockpiling of the soil, installation of the pipe, and back-filling. Since 100 foot rights-of-way are required, as much as 12 acres per mile of pipeline could be impacted.

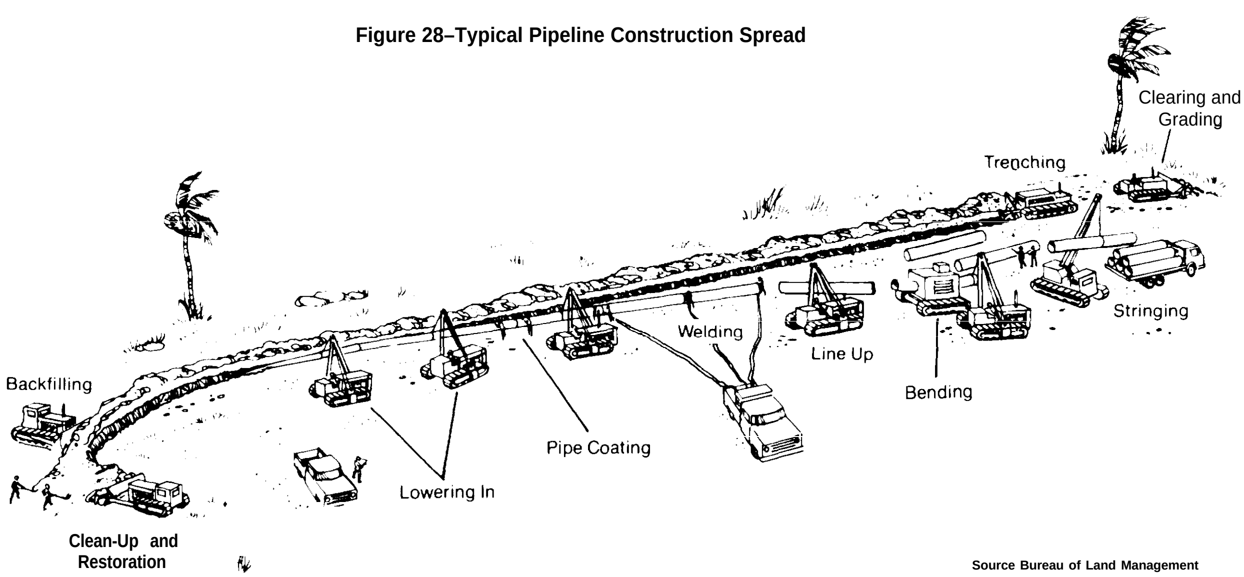
The loss of vegetation will, in turn, temporarily disrupt, on a local scale, primary biological productivity, which provides energy for higher organisms. **Additionally, some animal communities will be affected** by increased human activity (e. g., hunting and vehicular accidents). **In some cases the animals will be destroyed;** in other cases, they will be forced to relocate until the construction activity subsides or the habitat returns to its original or a comparable condition. Forced relocation of wildlife during reproductive or breeding seasons may magnify the adverse impact on wildlife.

[43] *Threatened Wildlife of the United* States, U S Department of the Interior, Fish and Wildlife Service, U S Government Printing **Off Ice, Washington, D C , March 1973**

44 F C Vasek, **H B Johnson, and D H** Eslinger, **"Effects of** Pipeline Construction **on Creosote Bush Scrub Vegetation of the** Mojave **Desert, "** *Madrono,* **Vol 23, No 1,** pp 1-13, 1975

[45] *Final Environmental Impact Statement, Alaska Natural Gas Transportation System, Overview Volume,* **U S Bureau of Land Management**

Figure 28–Typical Pipeline Construction Spread



Source Bureau of Land Management

Construction of pipeline and railroad facilities for coal handling will require permanent use of land for spurs and sidings, bridges, loading and unloading facilities, and maintenance stations. During the construction phase, vegetation will be destroyed and local fauna will be forced to relocate. The effects of floral and faunal disruption from rail construction will be similar to the effects from coal slurry pipeline construction, however, they will generally not be reversible as they are for pipelines. Disruption of biological communities is discussed in this chapter as an impact of railroad operation.

Increased presence of people and machinery during construction increases the fire hazard for both railroad and pipeline construction. Fire would result in further loss of vegetative cover, wildlife habitats, and disruption of biologic communities.

The duration of coal slurry pipeline construction impacts may be governed by the extent of compaction, mixture of soil layers, and alteration of drainage patterns, all of which affect the potential for revegetation. Erosion by both wind and water of lands left without vegetative cover could be substantial, particularly on steep slopes in arid climates.[46] Soil particles may be blown or carried away by surface runoff, resulting in loss of topsoil, unsightly and potentially hazardous alterations of the ground surface, and pollution of rivers and streams.[47] Rapid establishment of a new vegetative cover will help minimize these problems.

Pipeline construct ion will temporarily disrupt soils and destroy vegetation along the right-of-way, creating an undesirable visual effect and exposing bare soil to chemical change and erosion. Experience has shown that most areas affected by pipeline construction can be successfully revegetated. Revegetation is a natural process which occurs after a major disturbance of the vegetative cover, whether by fire, erosion, or human activity. Natural revegetation is a relatively slow process and may require a number of years[48 49] depending on various geographic, geological, and climatic factors. Rapid revegetation to reduce erosion and restore biological productivity by deliberate planting of desirable plant species is necessary in some areas. In Wyoming, crested wheat grass (Agropyron desertorum) has been used to establish a quick grass cover. It does not spread, but it is not invaded by native species and leaves an area usually discordant with the surrounding region. Potential revegetation problems in the West include: prevention of mixing the top soil with the "hardpan" or "caliche" (a layer of impenetrable carbonate soils); inadequacy of water supply for plant growth;[50 51] and difficulty of quickly establishing ground covers which will be easily invaded by the surrounding native species. Revegetation can also minimize the impact of construction activities related to railroad construction. The track and immediate right-of-way may not be revegetated but the wider area affected by heavy construction activity can be.

The aesthetic and productive value of land may be temporarily decreased by pipeline construction. Most of the pipeline right-of-way in the hypothetical routes examined in this report cuts through agricultural land, and disruption of agriculture therefore could be a significant environmental impact. The production of at least one full growing season would be lost for croplands, possibly more for natural grazing lands. For example, as much as 7,600 acres of pastureland and 3,500 acres of harvested cropland would be lost for the single hypothetical

[46] D G A Whitten and J R V Brooks, *The Penguin Dictionary of Geology*, Penguin Books, Baltimore, Md , 1972

[47] *Final Environmental Impact Statement, Alaska Natural Gas Transportation System, Overview Volume*, U S Bureau of Land Management

[48] F C Vasek, H B Johnson, and D H Eslinger, "Effects of Pipeline Construct Ion on Creosote Bush Scrub Vegetation of the Mojave Desert," *Madrono*, Vol 23, No 1, pp 1-11 1975

[49] W T Plass, "Revegetating Surface-Mined Land," *Mining Congress Journal*, Vol 60, No 4, pp 53-59, 1974

[50] A R Verma and J L Thames, 'Rehabilitation of Land Disturbed by Surface Mining Coal in Arizona," *Journal of Soil and Water Conservation*, pp 129-131, May-June 1975

[51] F C Vasek, H B Johnson, and D H Eslinger, "Effects of Pipeline Construction on Creosote Bush Scrub Vegetation of the Mojave Desert," *Madrono*, Vol 23, No 1, pp 1-13, 1975

Wyoming to Texas pipeline (table 36). Note that the lost acreages represent very small percentages of the county totals. Loss of agricultural productivity will probably be a negligible impact of railroad construction activity because so little new construction will be necessary, and the small amounts of new construction will most likely be as spurs and therefore not transect agricultural lands.

Pipeline construction may disrupt recreational activities and aesthetic values in certain areas. This construction impact can be minimized by careful route planning to avoid recreational areas, and to time construction with seasons of low use. Disruption of streambeds and flows can also be minimized by scheduling construction during low-flow periods, so as to avoid temporary impacts such as sediment loading, reduced visibility, photosynthesis, and resultant altered productivity.

Pipeline grades must be below 16 percent. Notching or sidehill cuttings to achieve these gradients may create sharp topographic features and surface runoff.[52][53] Careful recontouring of the lands to the original contours will minimize long-term adverse impacts on slopes and streams. Railroads require a 1-percent grade, so greater amounts of grading, cutting, and filling may be required for the limited amounts of new track construction. Wherever possible, steep slopes should be stabilized to acceptable angles and physically covered to prevent erosion until vegetation is established.

Dust-particle emissions from land clearing, blasting, excavation, grading, cut and fill operation, and operation of vehicles on unpaved roads is another impact of pipeline construction. Estimates of the precise amount of dust emissions are site-specific in that they depend upon soil moisture, soil particle size and distribution, and local meteorological conditions such as wind and humidity. Dust emissions can be reduced by about 50 percent by wetting down the construction area twice daily.[54]

Dust-particle emissions during railroad construction are of the same character as air emissions from coal slurry pipeline construction. A quantitative comparison is not attempted, however, because of the site specificity of such factors.

Noise emissions are another impact of pipeline and railroad construction. Most pipeline construction will avoid heavily populated areas, noise is a relatively minor impact, and the magnitude of pipeline construction noise is no different from other construction noise.

The impacts of construction of coal slurry pipelines and new railroad trackage are qualitatively similar. It is expected that new track construction will require greater circuitry, grading, and cut and fill activities because of the lesser-required grade for railroads (1 percent) as compared to pipelines (16 percent). However, the total amount of new track construction will be very small compared to pipeline construction, because the railroad network necessary for coal unit train operation is largely extant. Finally, because pipelines will be buried beneath the Earth's surface there is greater opportunity to mitigate adverse construction impacts by recontouring and revegetation of the pipeline right-of-way. Pipeline routes can also now be planned to avoid especially sensitive areas of biological, agricultural, or other important human activity. This rerouting to mitigate environmental impacts must be balanced with the costs of various routes.

The geographical area of construction affects the significance of these impacts. Although extensive pipeline construction is anticipated, the narrowness of the rights-of-way

[52] B W Sindelar, R L Hodder, and M E Majerus, *Surface-Mined land Reclamation Research in Montana,* Montana State University, Montana Agricultural Experiment Station, Research Report 40, April 1973

[53] W C Bramble and R H Ashley, "Natural Revegetation of Spoils Banks in Central Pennsylvania," Ecology, Vol 36, No 3, pp 417-423, 1955

[54] G A Jutze, K Axetell, jr , and W Parker, *Investigation of Fugitive Dust Sources Emissions and Control,* U S Environmental Protection Agency, Research Triangle Park, N C , EPA-45013 -74-036a, June 1974

Table 36. Agricultural Land Use Along Hypothetical Wyoming-Texas Pipeline Route

	Total acreage			Acreage			Total county	
State/County	County	Farmland	7% of county land in farms	Pastureland	Harvested crop land	Woodland	Miles traversed	Acres disturbed
WYOMING								
Campbell	**3,043,520**	**2,905,296**	**95.5**	**2,650,848**	**66,637**	5,821	46	552
Weston	**1,540,416**	**1,514,920**	**98.3**	**1,269,502**	**16,424**	96,974	17	204
Converse	**2,740,224**	**2,439,713**	**89.0**	**2,332,325**	**41,427**	17,178	3	36
Niobrara	**1,672,960**	**1,593,748**	**95.3**	**1,499,910**	**50,309**	11,946	69	828
Goshen	**1,425,984**	**1,299,978**	**91.2**	**1,014,638**	**166,666**	14,962	21	252
	10,423,104	9,753,655	**93.6**	**6,116,375**	341,463	146,881	156	1,872
NEBRASKA								
Sioux	1,320,192	1,014,620	**76.9**	**918,495**	**56,064**	**29,448**	30	360
Scotts Bluff	464,448	434,023	**93.4**	**225,015**	**165,723**	**3,594**	24	288
Banner	472,320	412,126	**87.3**	**220,069**	**99,571**	**767**	19	228
Merrill	897,408	778,422	**86.7**	**566,863**	**142,092**	**5,640**	3	36
Cheyenne	758,912	767,591	**101 .2a**	**218,688**	**276,944**	**836**	44	528
	3,913,280	**3,406,782**	87.1	**1,231,553**	**740,394**	**40,285**	120	1,440
COLORADO								
Logan	1,166,272	**1,149,769**	98.6	**579,793**	**284,267**	**6,866**	40	480
Phillips	435,200	**467,309**	107.4[a]	**99,194**	**217,896**	**739**	4	48
Yuma	1,522,816	**1,433,473**	94.1	**819,067**	**365,958**	**6,217**	65	780
	3,124,288	**3,050,551**	**97.6**	1,497,454	**868,121**	13,822	109	1.308
KANSAS								
Sherman	675,200	617,347	**91.4**	178,537	263,277	**1,833**	**36**	432
Wallace	583,040	507,271	**87.0**	229,010	150,332	**417**	**35**	420
Logan	686,720	589,876	**85.9**	266,836	161,968	**4,605**	**9**	108
Wichita	463,360	420,293	**90.7**	87,719	205,131	**233**	**36**	432
Kearny	547,264	495,951	**90.6**	174,168	181,435	**344**	**4**	48
Finney	832,896	669,155	**80.3**	197,759	315,943	**962**	**39**	468
Haskell	371,200	365,903	**98.6**	48,892	237,692	**206**	**17**	204
Gray	557,952	519,931	**93.2**	97,831	279,155	**1,220**	**6**	72
Meade	626,368	674,923	**107.8[a]**	332,409	213,988	**3,619**	**38**	456
	5,344,000	4,860,650	**91.0**	1,613,161	2,008,921	**13,439**	220	2,640
OKLAHOMA								
Beaver	**1,145,344**	1,096,044	**95.7**	652,135	334,576	**8,905**	38	456
Ellis	**794,880**	705,121	**88.7**	503,162	146,756	**13,387**	54	648
Roger Mills	**729,600**	686,026	**94.0**	495,104	106,372	**6,388**	27	324
Beckham	**580,480**	498,778	**85.9**	304,389	153,787	**6,221**	4	48
Washita	**645,696**	623,462	**96.6**	243,708	335,668	**7,133**	28	336
Kiowa	**657,216**	635,696	**96,7**	277,243	311,083	**3,605**	43	516
Tillman	**576,832**	525,189	**91.0**	170,952	312,392	**3,579**	29	348
Comanche	**693,760**	399,659	**57.6**	264,683	94,666	**9,545**	3	36
Cotton	**416,320**	365,037	**76.7**	179,688	163,172	**3,348**	4	48
	6,240,128	**5,535,023**	88.7	3,091,064	1,958,472	62,111	230	2,760
TEXAS								
Wichita	390,912	**305,699**	78.2	184,627	96,151	**6,679**	19	228
Clay	705,344	**633,564**	89.8	524,734	72,875	**9,326**	34	408
Jack	604,928	**485,116**	80.2	417,9343	12,208	**33,659**	36	432
Parker	577,664	**429,407**	74.3	337,041	33,825	**28,139**	37	444
Hood	272,640	**221,006**	81.1	180,252	20,142	**8,254**	5	60
Johnson	473,472	**314,219**	66.4	174,185	86,124	**6,171**	25	300
Hill	646,400	**449,540**	69.5	195,644	200,984	**8,106**	32	384
McLennan	640,000	**521,270**	81.4	285,137	161,548	**17,048**	28	336
Falls	488,960	**521,270**	81.1	238,310	116,653	**18,831**		312
Limestone	595,520	**431,771**	72.4	328,869	47,176	**31,216**	(b)	(b)
Robertson	561,216	**380,628**	67.8	281,047	47,176	**52,967**	28	336
Brozos	374,720	**261,086**	69.7	190,820	32,098	**36,640**	19	228
Grimes	512.704	**339.505**	66.2	269,090	23,460	**29.305**	39	468
Mont-gomery	697,408	171,985	24.8	130,727	5,717	44,716	7	84
	7,541,888	5,341,483	70.8	3,738,421	**956,583**	331,057	335	4,020

[a]The acreages of farms which are in more than one county are credited to one county sometimes making the farmland averages fOr that county greater than the total acreage for that county.

[b]The Pipeline route runs along the approximate boundary between these two counties.

Source: Science Applications, Inc.

limits the regional environmental significance. The impacts discussed here are geographically very narrow, but in certain very sensitive ecosystems, such as deserts, wetlands, and habitats of rare or endangered species, these impacts assume greater significance than they would elsewhere.

OPERATIONAL IMPACTS

This section discusses the impacts of operation, as opposed to construction, of coal slurry pipelines and coal unit trains. The major impacts for each mode of transportation, water requirement for pipelines, and community disruption including railroad highway accidents and delays and noise by unit trains, have been discussed earlier.

Air

Pipeline operations will have an indirect and relatively minor impact upon air quality if the electricity required to run pumps, slurry preparation equipment, and dewatering facilities is generated by combustion of fossil fuels. If it is assumed that the electricity would be provided by coal-fired powerplants operating at 35 percent efficiency and meeting EPA new source performance standards for nitrogen oxides (NO_x), sulfur dioxide (SO_x), and particulate emissions, then emissions of these pollutants for all of the four pipeline cases would be 12,000, 21,000, and 1,700 tons per year of NO., $S0_x$, and particulate, respectively.

The environmental impact of the total number of emissions is difficult to assess. In most cases, power will be required at various points along the pipeline route, thus, the impact of the air emissions would therefore be widely distributed. I n reality, these emissions would increase local levels by less than a few percent and probably not have a significant impact on local ambient air quality.

Diesel-electric locomotives emit carbon monoxide (CO), hydrocarbons (HCs), nitrogen oxides (chiefly nitric oxide (NO)), particulate, and other pollutants during line-haul operations. The amount of each pollutant emitted depends upon several factors, including fuel composition and heating value, load, grade and use or lack of abatement equipment. In table 37, emission factors, in terms of pounds of pollutants emitted per 1,000 gallons of diesel fuel consumed, are listed. To put these emissions into perspective, consider the emissions for a unit train coal movement from Wyoming, of about four times the volume of the hypothetical pipeline to Dallas, Tex. Such a movement of 65 million tons of coal would require 228 million gallons of diesel fuel per year.

Table 38 shows the emissions expected therefrom and compares the train emissions to the emissions from highway vehicle traffic.

Another useful way of examining air-pollution impacts would be to determine the impact on ambient air quality. Table 39 shows the locomotive emissions and resultant ambient concentrations for the very unlikely worst case situation in Wyoming. Wyoming State ambient air quality standards are shown for comparison. Ambient concentration of CO, SO_x and particulate would be at least two orders of magnitude below Wyoming standards. Hydrocarbon emissions approach the standard. Nitrogen oxide emissions appear to exceed the standards, although, the standards are for nitrogen dioxide while emissions are predominantly nitric oxide. Thus, even the worst case analysis of locomotive emissions would not, in and of itself, violate ambient air quality standards.

The environmental impact of these pollutants is difficult to assess. They clearly represent a source of increased air emissions,

Table 37. Diesel Locomotive Emission Factors

Emissions, lb/1 ,000 gal. fuel consumed

	Engine type				
Pollutant	2-Stroke supercharged road	2-Stroke turbocharged road	4-Stroke road	Composite average used	
Carbon monoxide.	66	160	180	174C	160[d]
Hydrocarbons.	148	28	99	78c	28[d]
Nitrogen oxides (NO_x as NO_2)...	350	330	470	430[c]	330[d]
Particulates [a].		25[b]		25	
Sulfur oxides		57[b]		57	
Aldehydes (as HCHO)		5.5[b]		5.5	
Organic acids		7[b]		7	

[a]Based upon highway diesel emissions; no actual Locomotive particulate emission test data available.
[b]Based upon national distribution of engine types.
[c]For all case studies except Utah-California.
[d]For Utah-California case study.
Source: U.S. Environmental Protection Agency, *Compilation o/Air Pollutant Emission Factors,* 2nd Ed. (Feb. 1976).

Table 38. Estimation of Vehicle Equivalent of Diesel Locomotive Air-Pollutant Emissions for 65 Million Tons of Coal per Year Between Wyoming and Texas

		1977 Highway vehicle equivalents	
Pollutant	Locomotive emissions lb/h r-mile	Automobiles vehicles/hour	All vehicle types vehicles/hour
Carbon monoxide.	3.7	39-92	29
Hydrocarbons.	1.7	190-530	100
Nitrogen oxides	9.1	700-1,100	910
Sulfur oxides.	1.2	N D[c]	2,500[d]
Particulate.	0.53	N D[c]	**450**[d]

aAssumes consumption of 228 million gallons/year of diesel fuel, 1,227-mile one-way haulage distance.
[b]Highway vehicle equivalents were defined as the number of highway vehicles which would emit the same amount of the specified pollutant as would the train movement of specified dimensions.
[c]NO data for comparison.
[d]National average emissions are 4.9 x 10-4 lb/mile SO_x and 1.2 x 10-3 lb/mile of particulates.
Source: Science Applications, Inc.

yet they are neither from an easily controlled stationary source nor a continuous mobile source, like, for example, continuous passage of automobiles. Rather, train passage is a relatively isolated event, with opportunity for pollutant dispersal during intervals between train passages. The impact of air emissions from unit train operations cannot be compared to air emissions associated with coal slurry pipeline operation in any meaningful manner. Pipeline- related emissions are from powerplants which produce the energy *for* pipeline uses, whereas railroad unit train emissions are dispersed over the length of the rail route.

Table 39. Worst Case Ambient Air-Pollutant Concentrations for Unit Trains Transporting 65 Million Tons of Coal per Year From Wyoming to Texas[a]

Pollutant	Locomotive emissions lb/h r-mile	Worst case concentrate ion μg/m³	Wyoming standard μg/m³	Time period
Carbon monoxide	2.92	210	10,000	8-hr maximum, not to be exceeded more than once/year
Hydro-carbons	1.31	95	160	3-hr maximum, not to be exceeded more than once/year
Nitrogen oxides	7.20	520	1 00[b]	Annual arithmetic mean
Sulfur oxides	**0.95**	**2.9**	**260**	**24-hr maximum, not to be exceeded more than once/year**
Particulate	**0.42**	**1.3**	**150**	**24-hr maximum, not to be exceeded more than once/year**

[a]Assumes shipment of 65 $\times 10^6$ tons/year over 1,227 miles, with diesel fuel consumption of 227,871,000 gallons/year.
[b]Standard is for NO_2, whereas emissions are mostly NO.
Source: Science Applications, Inc.

Dust Emissions

It has been suggested that unit coal train operations, including loading and unloading of hopper cars, occasionally result in the emission of coal fines and other fugitive dust particles to the atmosphere. Fugitive dust emissions may occur (1) during loading of hopper cars, (2) during unloading, (3) as blowoff from hopper cars in transit, or (4) through entrainment of dust accumulated alongside the tracks.

Modern train loading facilities consist of 10,000-ton-capacity temporary storage silos equipped with chutes for depositing the coal directly into the hopper cars, with water jets to spray the falling coal to suppress coal dust. For all practical purposes, dust emissions are confined to an area extending a few feet from the silo exit and entrance, and do not pose a community air-pollution problem. (Workers control the loading from within sealed enclosures and are thus not exposed to the coal dust.) Coal losses appear to be negligible compared to the volume loaded.

The main types of unloading are bottom dumping and rotary dumping.[55] Rotary dumping facilities are entirely enclosed and would present about the same minimal degree of pollution hazard as would the loading silos. Emissions from any type of loading facility would remain within the boundaries of the receiving facility, except for occasional entrainment by gusts of wind.

Although blowoff from coal trains has been raised as an environmental issue, supporting scientific data are lacking. Predictions of increased emissions due to expanded coal transportation appear to be extrapolations of historical experience in the East, where relatively dry coal was more likely to leak from poorly sealed hopper cars.[56] Western coal, having a relatively high moisture content, tends not to be dusty. An increasing number of hop-

55 R, G. S., "Decide Between Rotary and Bottom-Dump Coal Unloading," *Power,* Vol. 119, No. 8, p 47,1975,

56 FE Armbruster and B. J Candela, *Research A nalysis of Factors Affecting Transportation of Coal by Rail and Slurry Pipelines,* Final Report, Vol. 1, prepared by Hudson Institute, Inc , N Y , for Burlington Northern Inc , April 1976

per cars, notably those unloaded by rotary dumping, have permanently sealed bottoms. It is believed that most fine particles are either lost during the first few miles of haulage or settle to the bottom of the hoppers very early. 57

The Western Weighing and Inspection Bureau, which performs weighing services for western railroads, reports that it has received no claims of coal lost in transit. 58 Any difference between the weights of the coal cars at origin and destination, which would reflect the amount of coal lost, are not detectable.[59] Local officials in Wyoming, Colorado, and Illinois, all of which have appreciable coal train traffic, report that they have received no complaints of fugitive coal dust emissions.[60 61 62 63]

Finally, it has been observed that a moving train may stir up dust accumulated alongside the right-of-way. The extent and effects of this entrainment depend upon local conditions, such as recency of precipitation and wind speed and direction. In a strong wind, the impacts of the train could probably not be distinguished from those of general airborne particulate pollution.

In summary, western experience and limited scientific evidence indicate that fugitive dust emissions from unit train operations are likely to have negligible impact on air quality.

Disruption of Biological Communities

Railroad lines generally constitute a visible linear strip of artificial texture, color, and landform across the landscape. The cleared break in the vegetational community divides the natural territory and provides room for the establishment of a new transitional community along the edge of the permanently cleared roadbed shoulder. This transitional community is characteristically an area of open low-herbaceous vegetation maintained in an immature stage of succession by maintenance of the railroad right-of-way and occasional fires. Transition zones often exhibit high plant diversity and greater biological productivity.[64] Habitats associated with railroad lines often support different flora and fauna than the surrounding region.[65 66 67] Increased rail operations will perpetuate this man-created ecotone.

While division of natural territories may enhance development of transitional communities, its effects are not all beneficial. Creation of a visible discordant strip may affect wildlife behavior patterns, as some species are hesitant to enter a region which has been disturbed. In addition, wildlife movements may further be affected by the additional noise and activity of passing trains, and the establishment of fences to protect livestock from accidental collision.

The question of the effect of railroad fencing and operation upon wildlife migration is controversial. Arguments supporting and opposing the contention that railroads constitute barriers are each handicapped by a lack of

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[57] Thomas Healey, Environmental Division, Peabody Coal Company, St Louis, Mo , personal communication, Sept 16, 1977

[58] D Thomason Western Weighing and Inspection Bureau, Denver, Colo , personal communication, Sept 19, 1977

[59] Gary Root, General Manager of Transportation and Distribution, Amax Coal Company, personal communication, Sept 19,1977

[60] Bernard Dailey, Wyoming Department of Environmental Quality, Air Quality Division, personal communication, Sept 9, 1977

[61] William Reese, Colorado Department of Public Health, Air Pollution Control Division, personal communication, Sept 15, 1977

[62] Anthony Telford, Illinois Environmental Protection Agency, Division of Air Pollution Control, Analysis Section, personal communication, Sept 15, 1977

[63] Edward Crooke, Director of Environmental Studies, Argonne National Laboratory, Argonne, Ill , personal communication, Sept 15,1977

[64] R L Smith, *Ecology and Field Biology*, 2nd Edition, Harper and Row Publishers, San Francisco, Calif , 1974

[65] J G. Kelcey, "Industrial Development and Wildlife Conservation," *Environmental Conservation*, Vol 2, No 2, pp 99-108, 1975

[66] B Lejmbach, "The Flora of Railway Tracks of Eastern Pomerania Coast," *Fragm Florist Gebot*, Vol 21, No. 1, pp 53-66, 1975, cited in *Biological Abstracts, No 47275*, November 1976.

[67] V V Sentemov, "Adventitious Species of Corispermum L in the Flora of the Udmurtian ASSR," Bot *ZH*, Vol 54, No 6, p. 934, 1969, cited in *Biological* Abstracts, No 59045, June 1971.

hard data." Theoretically, a fence designed to be sheep- and antelope-tight will present a physical barrier and alter established animal predation patterns, isolate communities, and thereby prevent cross-breeding, and disrupt seasonal migration. The effect of such a barrier is of particular concern if migration to traditional breeding or nesting areas is inhibited and reproduction is reduced. " It is believed by some that antelope movement (especially the longer range migration of antelope during severe storms) may be restricted. On the other hand, in many instances the railroad right-of-way parallels a major highway which might, in itself, act as a barrier anyway.

If it is assumed that livestock protection fences will present a barrier to wildlife migration, provision for crossing should be required. However, wildlife behavior response is difficult to predict. Even if crossings of adequate size and distribution are provided, wildlife may not use them, especially if the animals are frightened by trains, storms, or predators.

Wildfires also disrupt biological communities. Railroads are reportedly a significant cause of vegetation wildfires. For example, tables 40 and *41* show wildfire occurrences in Nebraska and Wyoming. Although the precise number may under-report the number of fires[70] and may in some cases (about 15 percent[71]) misidentify the source, it is clear that railroads do cause a number of fires. The railroad fires burn substantial acreage, as shown in table 42.

Fires can be started by sparks from locomotive exhaust and steel brakeshoes or by operating and maintenance crews. To reduce the fire hazard, nonsparking brakeshoes are generally used for coal unit trains, fireguards are created along the right-of-way by mechanical or chemical clearing, and other spark-arresting equipment and fuel additives are employed. Turbochargers, with which most unit-train locomotives are expected to be equipped in the future, also act as spark arresters.[72]

Careless use of flares by maintenance-of-way crews has been identified as a cause of. fires, but its significance is uncertain. According to a. Wyoming State fire official, railroads seem receptive to suggested fire prevention programs directed toward railroad personnel.[73] Other measures to reduce fire hazards include ontrack fire patrols by the railroad companies[74] and nonsparking composition brakeshoes on new hopper cars.[75]

With improved fire prevention techniques, increased use of the trackage (which may result in greater reporting, awareness, and prevention of fires), and the increased exposure of wildlands to sparks, the incremental change in wildfires due to unit train operation is difficult to determine.

The major operational impact of coal slurry pipelines with disruptive effects on biological communities is accidental spills of slurry. There are three principal ways by which a slurry spill could occur along the transmisison route: 1) pipeline rupture due to excessive pressure; 2) breakage resulting when the pipeline is accidentally struck by digging equipment; and 3) washout of the pipeline during a flood. Under the relatively high pressures of coal slurry in portions of the pipe, small leaks will normally develop quickly into major

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68 **James** Lambert, U S Bureau of Land Management, Cheyenne, Wyo , personal communication, Aug. 23,1977

69 *Final* [environmental *Impact Statement, A laska Natural Gas Transportation System, Overview* **Volume, U S.** Bureau of Land Management.

70 U S Department of the Interior, *Final Environment/ Statement, Proposed Development of Coal Resources in the Eastern Powder River Coal Basin of* **Wyoming, Vol. I I 1, U.S. Department of Agriculture, Interstate Commerce Commission, 1974.**

71 **Michael Gagin, Wyoming State Forestry Division, Cheyenne, Wyo , personal communication, Aug. 26,1977**

72 **U S Department of the Interior,** *Final* **Environment/** *Statement, Proposed Development of Coal Resource in the* **Eastern** *Powder River Coal* **Basin** *of* **Wyoming, Vol 111, U S Department of Agriculture, Interstate Commerce Commission, 1974.**

73 Michael Gagin, Wyoming State Forestry Division, Cheyenne, Wyo , personal communication, Aug. 26,1977

74 Allan R. Boyce, Burlington Northern, St. Paul, Minn , personal communication, Sept. 6, 1977,

75 Al lan R Boyce, Burlington Northern, St Paul, Minn., personal communication, Aug 15, 1977.

Table 40. Wildfire Occurrence in Nebraska, 1971-76

Cause	Year						6-yr
	1971	1972	1973	1974	1975	1976	avg.
Railroad.	274	373	387	723	535	763	509
Debris burning	413	593	208	426	420	798	476
Equipment use	211	113	123	244	185	278	192
Lightning	102	73	99	311	107	173	144
Smoking	51	79	51	150	108	170	102
Electric fences..	33	41	16	37	28	23	30
Children	24	29	6	34	27	50	28
Incendiary	13	5	4	43	33	34	22
Campfires	4	2	1	11	3	9	6
Miscellaneous	127	209	121	322	313	389	247
TOTAL	1,252	1,517	1,016	2,301	1,759	2,687	1,755

Source: Westover D.E., *Nebraska Wildfires,* State of Nebraska, Department of Forestry (1977)

Table 41. Wildfire Occurrence in Campbell and Converse Counties, Wyo., 1971-73

Cause	Number of fires				Acres burned			
	1971	1972	1973	1971-1973	1971	1972	1973	1971-1973
Railroads.	43	28	32	34	1,163	2,762	242	1,389
Lightning.	21	40	30	30	21,981	8,170	3,025	11,052
Other	13	34	21	23	2,066	1,020	184	1,090
TOTAL. .	77	102	83	87	25,190	11,952	3,451	13,531

Source: U.S. Department of the Interior, *Final E/S, Proposed Deveopment of Coal Resources in the Eastern Powder River Coal Basin of Wyoming (1974).*

Table 42. Acreage Burned by Wildfires in Nebraska, 1971-76

Cause	Year						6-year average
	1971	1972	1973	1974	1975	1976	
Debris burning.	13,647	12,975	1,467	3,655	30,272	4,315	11,055
Railroad	4,652	13,183	2,080	7,197	6,752	2,424	6,048
Lightning	7,224	2,249	8,467	7,309	4,402	5,095	5,791
Equipment use	1,740	4,489	4,465	5,307	8,822	4,850	4,945
Miscellaneous.	5,151	3,788	980	6,105	1,800	3,567	3,565
Smoking.	555	2,021[a]	608	3,147	399	1,222	1,325
Children	71	69	3,662	177	27	56	677
Incendiary	18	27	0	2,410	262	50	461
Electric fence	--		5	298	799	99	300
Campfire.	30	11	10	86	30	16	31
TOTAL	33,088	158,812	21,744	35,691	53,565	21,694	34,198

[a]This figure does not include the Mullen Fire of March 1972, which burned 120,000 acres.

Source: Westover, D. E., *Nebraska Wildfires,* State of Nebraska, Department of Forestry (1977).

ruptures.[76] The quantity of slurry released to the environment will depend upon the flow rate, pressure, burial depth, overburden density, time for detection and pipeline shutdown, and proximity of holding ponds. Pipelines have been constructed with reserve holding ponds along the way. Using this approach, the slurry flow would be arrested in event of spill and the offending section of pipeline evacuated into the pond.

Only one coal slurry pipeline spill has been recorded, " and the environmental impacts, primarily land and water impacts, are therefore only speculative. Presumably, the coal particles will be filtered from the water by the top few feet of soil. The effect of the coal in the soil upon plant growth is unknown. The impact of a spill into streams depends upon the relative flows of the stream and the spill. Coal sludge could temporarily harm aerobic benthic organisms, hamper fish feeding, smother eggs and larvae, and adversely affect spawning. Temperature changes and coal sludge could result in fish kills as well. These impacts, however, are not likely to be severe.

7. **Edward j Wasp, Vice President, Energy Transportation Systems, Inc , San Francisco, Calif , personal communication, July 8,1977.**

77 John Montfort, Black Mesa Pipeline Company, Flagstaff, Ariz , personal communication, Sept 21,1977

Energy/Materials Requirements

An environmental impact of pipeline construction and operation and railroad expansion and operation is the consumption of energy and materials made from natural resources. Steel and energy requirements for the four hypothetical pipeline routes are shown in table 43, and steel for hopper cars, locomotives, and rails (for new construction and replacement) and energy to produce the steel and for transportation of coal are shown in table 44. The direct steel requirements for pipelines and railroads to transport 74.5 million tons of coal over a 35-year period are 1.3 million tons for pipelines and 3.5 million tons for railroads. Although pipelines require less steel, recycling is less costly for railroads. Similarly, the energy directly required to produce the steel and for coal transportation is greater for pipelines than for rail, averaging for the cases 610 Btu per net ton-mile for pipelines and 390 Btu per net ton-mile for railroads. Greater rail circuity diminishes this relative advantage somewhat. Averages are frequently misleading, however, and energy requirements can differ quite widely in a given case. The results presented here include pipelines which for economic reasons would probably not be constructed. In addition, railroad locomotives use diesel fuel derived from petroleum, while pipe-

Table 43. Steel and Energy Requirements for the Case Study Pipelines

(35-year life cycle)

	Wyoming to Texas	Montana to Wisconsin	Utah to California	Tennessee to Florida	Grand totals
Coal transport (10° tons/year)	**35**	**13.5**	**10**	**16**	**74.5**
Steel requirement (10^3 tons)	**733**	**216**	**133**	**245**	**1,327**
Energy for making steel (10^{12} Btu)	**17**	**5**	**3**	**6**	**31**
Energy for construction (10^{12} Btu)	**3**	**2**	1	**2**	**8**
Energy for operation (10^{12} Btu/year)	**14**	**7**	**6**	**10**	**37**
Total energy (10^{12} Btu/year)	**15**	**7**	**6**	**10**	**38**
Total energy per 10° tons of coal transported (10^{12} Btu)	**0.4**	**0.5**	**0.6**	**0.6**	**0.5**
Operation energy per net ton-mile (Btu)[a]	410	710	1,150	920	610
Percentage of energy content of the coal required to transport it 1.000 miles	2.3	3.9	6.4	3.8	3.2

[a]Rounded to nearest 10 Btu.
Source: Data from Science Applications, Inc.

Table 44. Steel and Energy Requirements of the Railroad Case Studies

(35-year life cycle)

	Wyoming to Texas	Montana to Wisconsin	Utah to California	Tennessee to Florida	Grand totals
Coal transport (10' tons/year).	35	13.5	10	16	74.5
Steel for hopper cars(10^3 tons)	461	110	102	218	891
Steel for locomotives (103 tons).	110	22	30	58	220
Steel for rails (10^3 tons).	1,446	319	201	398	2,364
Total steel requirement (10^3 tons)	2,017	451	333	674	3,475
Energy for making steel (10^{12} Btu).	12	3	2	4	21
Energy for transportation (10^{12} Btu/year) .	17	4	2	8	32
Total energy (10^{12} Btu/year)	17	4	3	8	32
Total energy per 10^6 tons of coal transported (10^{12} Btu)	0.5	0.3	0.3	0.5	0.4
Transportation energy per net ton-mile (Btu)[a].	340	360	440	580	390
Percentage of the energy content of the coal required to transport it 1,000 miles	1.9	2.0	2.4	2.4	2.0

aRounded to nearest 10 Btu. Mileages arelargerthan forpipelines duetogreater circuity.

Source: Data from Science Applications, inc.

line pumps operate on electricity often derived from other fuels.

Occupational Health and Safety

Occupational injuries and disability days for pipeline construction and operation and railroad operation are shown in tables 45 and 46, respectively. Historical data on accidents on coal slurry pipelines are limited, and pipeline accident rates were estimated from oil pipeline data. The last column of table 45 shows the number of injuries and disability days for construction for 3,146 miles of pipeline (the total length of the four hypothetical routes) and transport of 74.5 million tons of coal annually. On the average, one disability day would result from each 45 million ton-miles of coal transported, about half of which are due to construction, if one assumes that the pipeline will be in operation for 35 years. Data were not available for estimating deaths due to pipeline construction or operations.

Deaths, injuries, and disability days for railroad employees were estimated from accident rates on general freight train operations excluding labor categories not applicable to unit trains. As shown in table 46, in carrying the same 74.5 mill ion tons of coal per year as pipelines, railroads would, according to the estimate, experience 1.9 deaths, 304 lost work-day injuries, and 14,000 disability days annually. One disability day occurs per 6 million ton-miles of coal transported and one death per 43 bill ion ton-miles.

Employees will be exposed to noise from several operations in coal slurry pipeline systems, including water pumping, coal slurry preparation, slurry pumping, and dewatering.[78] Coal slurry preparation involves crushing and grinding operations which generate considerable noise. Pipeline employees are reportedly exposed to noise levels in the range of 90 to 95 dBA by these processes[79] but the plants are sufficiently few and remote to avoid significant community noise impacts. Deep-well submersible pumps are used to draw water from wells, and because of the depth at which the pumps are located, no noise is

[78] W S Gray and P F Mason, "Slurry Pipelines: What the Coal Man Should Know in the Planning Stage, " *Coal Age,* Vol 80, No 9, pp 5a-62, 1975

7. John Montfort, Black Mesa Pipeline Company, Flagstaff, Ariz , personal communication, June 30, 1977

Table 45. Predicted Occupational Injuries and Lost Workdays From Case Study Pipeline Construction and Operation

	Wyoming to Texas	Montana to Minnesota & Wisconsin	Utah to California	Tennessee to Florida	Total
Construction					
Injuries	281	221	125	193	820
Lost workdays	5,228	4,112	2,326	3,591	15,257
Operation					
Injuries per year	31	8	4	9	
Lost workdays per year	577	149	74	167	967
Million net ton-miles[a]					
Per injury	942	702	653	724	831
Per lost workday	51	38	35	39	45

[a]Including construction assuming a 35-year pipeline life.
Source: Science Applications, Inc.

Table 46. Predicted Occupational injuries, Lost Workdays, and Deaths From Case Study Unit Train Service Expansion

	Wyoming to Texas	Montant to Minnesota &Wisconsin	Utah to California	Tennessee to Florida	Total
injuries					
Number per year	140	48	38	78	304
Lost workdays per year	6,300	2,160	1,710	3,510	13,680
Deaths per year	0.98	0.27	0.12	0.51	1.9
Million net ton-miles[a]					
Per injury	355	235	180	176	268
Per lost workday	7.9	5.2	4.0	3.9	6.0
Million net ton-miles[a]					
Per death	51,000	41,000	35,000	27,000	43,000

[a]Mileage is larger than for pipelines due to greater circuity.
Source: Science Applications, Inc.

reported at ground level. The mainline pumps of pipelines can be quite noisy, like any unshielded 5,000 horsepower pump emitting 82 dBA at 50 feet.[80] However, built-in shielding and enclosure in a pumphouse reduce the sound level significantly .8' Railroad noise was discussed in the section of this chapter on community disruption, and railroad employees are exposed to the same sources at closer proximity.

The above figures should be regarded as estimates because of the type of data available and the assumptions made in extrapolating disability days from these data. Nonetheless, the figures provide a useful indication of total and relative employee health and safety for railroads and coal slurry pipelines. Even including the accidents associated with construction of pipelines, as well as operation, railroads experience significantly more disability days than pipelines.

[80] *Draft Environmental Impact Statement, Crude Oil Transportation System: Valdez, Alaska to Midland, Tex.*, U.S. Bureau of Land Management, November 1976

[81] Nick Tuttle Williams Brothers Process $2 rvices, Tulsa, Okla , personal communication, June 28,1977.