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SURVEY REPORT

FORT PECK, MONTANA - POCATELLO, IDAHO SITES

PREPARED FOR
THE UNITED STATES ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

M A R C H

SMITH, HINCHMAN & GRYLLS, INC.
ARCHITECTS AND ENGINEERS
DETROIT, MICHIGAN

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March 26, 1949

File No. 8537

Mr. Roger S. Warner, Jr.
Director of Engineering
Atomic Energy Commission
Washington 25, D. C.

Dear Mr. Warner:

With this letter we present four copies of our "Survey Report on Fort Peck, Montana and Pocatello, Idaho Sites." This report, dated March, 1949, is in furtherance of our contract with the Commission No. AT-(49-1)-311, January 5, 1949. The report in its present form supersedes the Interim Report submitted on February 7, 1949.

The report concludes and recommends that the Reactor Testing Station be located at the Pocatello Site. A study of the two locations under consideration at Pocatello indicates further that the Big Lost River Location, which includes the Naval Proving Ground, is preferable to the Alternate Location south of the Blackfoot-Arco highway.

The general conclusion favoring Pocatello was reached after a thorough consideration of the many factors involved in a selection of site for this project. In respect to all of these factors, except isolation, the area selected is believed to be superior to the Fort Peck Site. Pocatello offers advantages as to climate; geology; availability of manpower, land, and materials of construction; transportation; and social-economic factors. Fuel, electric power, water, and construction costs will be less at Pocatello, and in respect to drainage and security this site offers further advantages. With respect to isolation, the Montana area is more sparsely populated and there are fewer people within specified distances of the Fort Peck Site. The differences between the sites in isolation are not considered sufficient to become a determining factor in selecting a site.

In the report is included an economic analysis of the sites insofar as the information available permits. It is believed that the cost of construction of the facilities would be considerably higher at Fort Peck. We roughly estimate the difference in this cost at fifty million dollars. Annual operating costs, including capital charges, labor, fuel, electric power, water, and supplies are estimated to be at least three and one half million dollars less at Pocatello. Consideration of the site characteristics of the two locations in the Pocatello area indicates that the use of the Big Lost River Location will result in a lower construction cost. This difference is expected to be in the order of four million dollars. Should it be impossible to secure the Navy ground for this project then the Alternate Location is recommended.

The social and economic aspects of the Pocatello area are far superior to those at Fort Peck. A project of the size of the Reactor Testing Station would result in much less economic disturbance at Pocatello and the providing of homes, recreational and shopping facilities would be a much simpler problem.

An additional fifty copies of the report are being sent under separate cover. Should further discussion of the Survey Report be desired, we will be pleased to assist your office in any manner we can.

Very truly yours,

SMITH, HINCHMAN & GRYLLS, INC.

H. W. Grubb

H. W. Grubb

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SURVEY

on

FORT PECK, MONTANA AND POCATELLO, IDAHO SITES

for

UNITED STATES ATOMIC ENERGY COMMISSION

WASHINGTON 25, D. C.

MARCH, 1949

CONTRACT NUMBER AT-(49-1)-311

Prepared By

SMITH, HINCHMAN & GRYLLS, INC.

Detroit, Michigan

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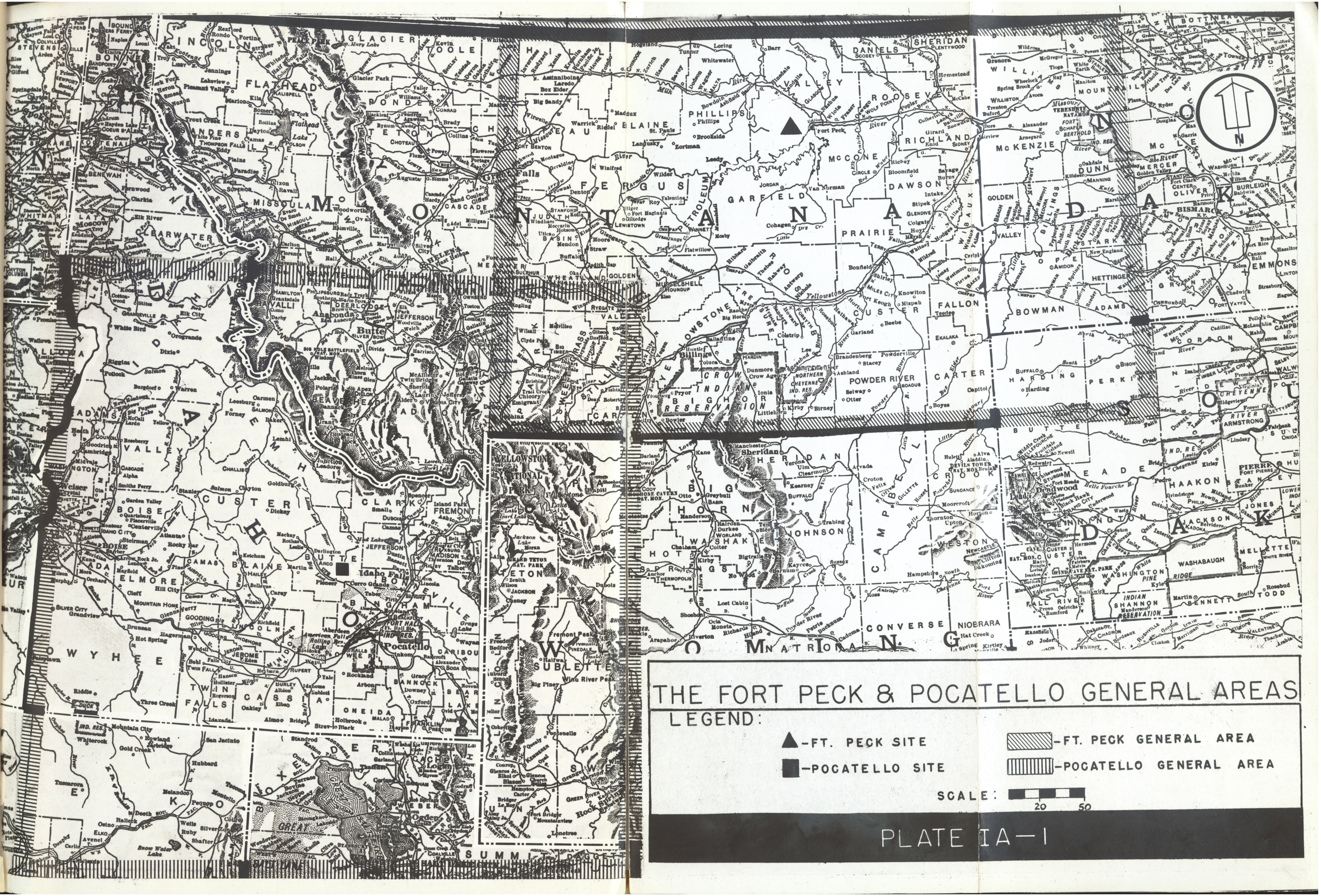
CONCLUSIONS AND RECOMMENDATIONS

I A. INTRODUCTION

This survey report covers two sites being considered by the United States Atomic Energy Commission as possible locations for a Reactor Testing Station. These sites are identified as the Fort Peck Site, located twenty-five miles west of Fort Peck, Montana, and the Pocatello Site, located fifty-three miles northwest of Pocatello, Idaho. The geographical locations of the two sites and the general areas around each are shown on Plate I A-1.

Each of the sites has been studied with respect to the requirements established for the proposed project and field trips to the areas under consideration were made in order to obtain the most recent and reliable information available. An Interim Report including all data assembled at that time was submitted on February 5, 1949, in order that the Commission might have data and information as quickly as possible. This earlier report included a preliminary evaluation of the sites and a site selection.

This report includes additional data and information assembled after the Interim Report was submitted. Several conferences have been held with Commission representatives, consultants, and others, and additional field trips have been made to amplify and clarify information obtained earlier.



THE FORT PECK & POCATELLO GENERAL AREAS

PLATE IA-1

I B. SUMMARY OF SITE CHARACTERISTICS

The specific requirements of the site to be selected for the Reactor Testing Station are discussed in a later section of this report. In the following is presented a summary of site characteristics with respect to each of the requirements. At the Pocatello Site, two possible locations have been studied and these have been identified as the Big Lost River Location and the Alternate Location. Where differences were found in these sites separate comments are presented.

The Fort Peck Site is shown in detail on Plate I D-1 and the Big Lost River Location and the Alternate Location at the Pocatello Site are shown on Plates I D-2 and I D-3, respectively.

The summary of site characteristics is as follows.

1. ISOLATION

The following is a tabulation of population distribution in the areas surrounding each of the sites.

Population Within:	Fort Peck	Pocatello Big Lost River	Alternate
Site Area	30	0 to 4	0
50 miles	25,000	68,000	50,000
50 to 100 miles	34,000	111,000	153,000
100 to 200 miles	140,000	815,000	965,000

Note that population within the site area is given in the above table. Data presented in the Isolation section is based on population within a 14-mile radius of the assumed center of the site.

There are no cities of 50,000 population or more within fifty miles of either site studied. In the Fort Peck area industrial activity is at a very low level, there being no significant industrial establishments within 200 miles of the site.

In the vicinity of the Pocatello Site industrial activity is confined largely to cities along the Snake River, where a number of fair-sized industrial plants are located. These, however, are more than fifty miles from the site.

2. SECURITY PROBLEMS

Problems of local security present no difficulties at either site. The Fort Peck Site is within 70 miles of the Canadian Border, while the Pocatello Site is more nearly centrally located within the borders of the United States.

3. CLIMATE

The climate at the Fort Peck Site is marked by the following general features:

(a) Abundant sunshine.
(b) Low relative humidity.
(c) Light rainfall confined largely to the warmer half of the year.
(d) Moderate wind movement.
(e) Large diurnal change in temperature and pronounced extremes ranging from 113° above to 56° below zero.
(f) Degree-day value is 8,500.
(g) Snowfall averages about 30 inches per year.

At the Pocatello Site the following are general features of the climate:

(a) Long growing seasons and abundant sunshine.
(b) Low relative humidity.
(c) Very light rainfall.
(d) Moderate wind movement.
(e) Extremes in temperature are 108° above to 45° below zero
(f) Degree-day value is 6,800.
(g) Snowfall averages 36 inches per year.

Summaries of climatological data for both sites are shown in Table III C-27.

4. GEOLOGY

Both areas studied present the appearance of a comparatively level plain, when viewed at some distance. The overburden at Fort Peck is impervious gumbo 4 to 20 feet deep. At Pocatello, Big Lost River Location, the topsoil consists of silt and gravel which in general varies in depth from a few inches to 8 feet. However, about 1/20 of the total area is devoid of topsoil and in local areas the depth of topsoil may exceed 8 feet. In the Alternate Location at Pocatello the land surface is somewhat irregular, more rolling, and there are numerous outcroppings of lava. The depth of the topsoil is much less than at the Big Lost River Location and approximately one fourth of the area is devoid of topsoil.

Below the overburden at Fort Peck lies the Bearpaw shale. While this material would require some special techniques in construction, it is satisfactory for loads in the order of 8,000 pounds per square foot. The basaltic lava at Pocatello offers excellent material on which to build heavy structures.

Both areas are considered geologically stable. Reinforced concrete buildings of sound engineering design would be safe in any earthquake that might reasonably be expected to occur at either site.

5. DRAINAGE

The soil at the Fort Peck Site is highly impervious and it is doubtful that contaminated liquids would infiltrate. Provision would have to be made for containing within the site any harmful radioactive wastes liberated in the event of a catastrophe. The escape of harmful radioactive wastes from this site would seem to present a potentially serious hazard to the important Missouri-Mississippi waterway.

Run-off from the Pocatello Site percolates into the lava and joins the underground flow. Assuming that no absorption of the contaminated material took place in the basaltic rock at the Pocatello Site, it would require many years for the contaminated waste to travel approximately 75 miles to the nearest known point of ground water discharge, and it would be diluted considerably in its course of travel. It is estimated that from 75 to 150 years would pass before any contaminated material would be discharged through these springs.

6. WATER SUPPLY SYSTEM

Ample water is available at either site. At Fort Peck the plant requirements would be taken from the Fort Peck Reservoir, while at Pocatello the supply would be from the underground water table. Both sources are adequate and thoroughly reliable. The cost of developing the water supply would be about the same at both sites.

There will be a charge for the use of water from the Fort Peck Reservoir. No firm figure is available at this time, but it is estimated that this charge will be between $0.01 and $0.15 per 1,000 gallons. On the basis of the lowest figure the daily and annual charge for water at Fort Peck are $230 and $69,000, respectively. The annual charge for pumping will be $92,000 at Fort Peck and $85,000 at Pocatello.

7. AVAILABILITY OF MANPOWER

It is likely that all classes of construction, operating, and supporting personnel would have to be imported from outside a 200-mile radius of the Fort Peck Site.

The Pocatello Site is surrounded by a number of fair-sized communities and Salt Lake City is within 215 miles of the site. While some labor can be drawn from these sources, a considerable quantity will have to be imported from distant points.

8. AVAILABILITY OF MATERIALS

Most items of equipment and materials of construction are in good supply at the present time. Steel pipe, structural shapes, plate, and reinforcing steel remain under voluntary allocation by the producers and delivery for these items remains critical.

Materials such as cement, aggregate, brick and clay products, lumber, valves, and fittings are in good supply. Electrical equipment and materials, except for conduit, certain wire, and high voltage transformers and switch gear, are in good supply. Delivery on the latter items remains at from 18 to 24 months or more.

In general, the sources and points of production of most items are much closer to the Pocatello Site. These items include cement, aggregates, steel and iron products, brick and clay products, and millwork. Transportation charges for such materials would be appreciably less. Supplies of electrical equipment would come from the same sources regardless of plant site.

Maintenance and repair facilities are available in

Pocatello, Idaho, and Salt Lake City, Utah, the first being close to the Pocatello Site. Similar facilities to serve the Fort Peck Site can be found only at much greater distances from Fort Peck. The Pocatello Site is fifty miles from Pocatello, Idaho, and 215 miles from Salt Lake City. Fort Peck is 276 miles from Great Falls and much farther from other cities which would have complete maintenance facilities.

9. POPULATION AND SOCIAL-ECONOMIC FACTORS

The proximities of the sites studied to cities and towns within the 50 and 100-mile radii are as follows:

	Fort Peck	Pocatello
Number of cities with population over 300 and within 50 miles	7	13
Number of cities with population over 1,000 and between 50 and 100 miles	5	12

At Fort Peck, other than the development of a complete new residential and shopping center, the assimilation of new construction and operating personnel must fall upon the towns of Glasgow, Nashua, and Fort Peck. Equal distribution of a new population on the order of 25,000 persons among the three towns would result in at least a doubling of the present population.

At the Pocatello Site, a concentration of cities and towns along the American Falls Reservoir and the Snako River provides a housing and population concentration which, within a radius of about 55 miles from the site, amounts to approximately 125,000 persons. Obviously, the assimilation of 25,000 additional people into this area is capable of accomplishment with far less economic dislocation than would be the case at Fort Peck, especially in view of the far better wholesale and retail market access. It is expected that from this area a considerable number of workers could be drawn, dimishing the labor problem by that number.

10. AVAILABILITY OF LAND

No difficulty is foreseeable in the initial acquisition of the land at either site.

Public lands at both sites are subject to grazing leases. Most such leases contain provisions covering the right to sell and assure possession, and are subject to the right of eminent domain. In the majority of cases this requires only advance rental payments for the immediate year of use. Local legal advice should be sought with regard to specific areas of land.

It is estimated that the average cost of the land at Fort Peck will be $3.75 per acre and at Pocatello $3.50 per acre. On the basis of 400,000 acres, land at Fort Peck will cost approximately $1,500,000 and at Pocatello $1,400,000.

11. CONSTRUCTION AND OPERATIONAL COSTS

It is estimated that construction costs at Pocatello will be approximately 9.5% less than at Fort Peck. Operating costs insofar as utilities are concerned will be less at the Pocatello Site by the following percentages.

Steam	33.5%
Water	47.2%
Electric Power	36.4%

12. TRANSPORTATION

The Fort Peck Site is served by highways and railroads only for east-west travel. Travel to the south can be made by the use of highway and rail connections only at considerable distances east and west of the site. Motor freight and passenger services are limited by the highway system. No scheduled airline services any city closer than 250 miles from the Fort Peck Site.

The highway system around the Pocatello Site in general circles the site and connections can be made in any direction. Rail connections to other parts of the county are readily available at Pocatello. This city is also served by two airlines providing service to the north, south, and west, as well as connections with other airlines. Pocatello is about 25½ hours from Chicago by rail and the site is about 27 hours from Chicago, including driving time from Pocatello to the site.

13. ELECTRIC POWER

Sufficient power is not now available at either site to meet the anticipated total requirements of the new project. It is apparent, however, that within the time available, adequate power could be made available at either site.

If the project were located at Fort Peck, the dam there would appear to be the logical source of electrical energy. However, commitments for power for present and future irrigation programs limit the quantity which would be available to about 17,000 KW. The balance of the requirements, over 40,000 KW, would have to come from the Montana Power Company and from Garrison Dam in North Dakota, which is now under construction. Power from the Garrison Dam, however, will not be available until about 1953. The distance from Fort Peck Dam to the plant site is about 27 miles. Transmission lines for construction and operation will have to be built for either site.

The utilities companies serving the Pocatello area do not have sufficient capacity at the present time to meet the full requirements of the project. It should be noted, however, that these companies will have sufficient combined capacity beginning in 1950 to carry their own loads as well as the initial requirements of the Reactor Testing Station without assistance from other private utilities. The experience of these companies, however, has been that given sufficient advance notice, they are able to develop new generating facilities to keep pace with the increasing load. Power for construction could be made available, although a transmission line approximately 25 miles in length would have to be constructed to serve the site.

The annual power requirement for the plant operation in the year 1955 is calculated as follows:

$$24 \times 50{,}000 \times 365 \times 0.90 = 394{,}000{,}000 \text{ K.W.H./yr.}$$

Assuming consumption of 400,000,000 K.W.H. per year of purchased power, the total yearly cost would be $2,200,000 at Fort Peck and $1,400,000 at Pocatello.

The influx of new people associated with this project would be more easily established in the Pocatello area than at Fort Peck. Cities in the former area are larger and better developed and electrical service could be had with much less new construction and cost than would be the case at Fort Peck.

14. FUEL AVAILABILITY AND COSTS

Suitable fuel for the generation of steam is available for either site. Based on the production of 200,000 pounds of to meet the anticipated total requirements of the new project. It is apparent, however, that within the time available, adequate power could be made available at either site.

If the project were located at Fort Peck, the dam there would appear to be the logical source of electrical energy. However, commitments for power for present and future irrigation programs limit the quantity which would be available to about 17,000 KW. The balance of the requirements, over 40,000 KW, would have to come from the Montana Power Company and from Garrison Dam in North Dakota, which is now under construction. Power from the Garrison Dam, however, will not be available until about 1953. The distance from Fort Peck Dam to the plant site is about 27 miles. Transmission lines for construction and operation will have to be built for either site.

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The annual power requirement for the plant operation in the year 1955 is calculated as follows:

$$24 \times 50{,}000 \times 365 \times 0.90 = 394{,}000{,}000 \text{ K.W.H./yr.}$$

Assuming consumption of 400,000,000 K.W.H. per year of purchased power, the total yearly cost would be $2,200,000 at Fort Peck and $1,400,000 at Pocatello.

The influx of new people associated with this project would be more easily established in the Pocatello area than at Fort Peck. Cities in the former area are larger and better developed and electrical service could be had with much less new construction and cost than would be the case at Fort Peck.

14. FUEL AVAILABILITY AND COSTS

Suitable fuel for the generation of steam is available for either site. Based on the production of 200,000 pounds of steam per hour, the most economical sources of fuel for each site give daily fuel cost as follows:

Fort Peck	\$2,800
Pocatello	\$2,000

This is for coal from Carbon County, Montana, to Fort Peck and for coal from Carbon County, Utah, to Pocatello.

The use of fuel oil or gas for either site would result in the following daily costs:

	Fuel Oil	Gas
Fort Peck	\$3,620	\$3,160
Pocatello	\$3,590	not available

I C. EVALUATION OF SITE CHARACTERISTICS

1. GENERAL

The evaluation of site characteristics can be accomplished in several ways, either qualitatively, as for instance good or poor, or quantitavely, on a numerical basis. Were all the factors considered within this report susceptible to absolute numerical treatment the evaluation of the sites would be a relatively simple matter. However, not all factors can be evaluated numerically and, in the case of some, sufficient information is not available for a comprehensive evaluation on any basis. Particular reference in this connection is made to such factors as Isolation, Security, and Drainage

2. QUALITATIVE EVALUATION

In the tabulation which follows each of the sites has been graded, on the basis of the information available for this report, on a qualitative scale ranging from poor to very good. The last column indicates which site is preferred with respect to each of the factors studied.

Factor	Site		Preferred
	Fort Peck	Pocatello	
Isolation	Very Good	Good	Fort Peck
Security	Good	Very Good	Pocatello
Climate	Poor	Fair	Pocatello
Geology	Good	Good	Pocatello ✓
Drainage	Fair	Good	Pocatello ✓
Water Supply	Very Good	Very Good	---
Manpower	Poor	Fair	Pocatello
Materials	Fair	Good	Pocatello
Social Factors	Poor	Good	Pocatello
Land	Very Good	Very Good	----
Costs	Fair	Good	Pocatello
Transportation	Poor	Good	Pocatello
Electric Power	Very Good	Very Good	Pocatello
Fuel	Fair	Good	Pocatello

While the geological conditions at both sites are considered good, the Pocatello Site offers somewhat better foundation conditions and is preferred. In the case of electric power, the Pocatello Site is preferred because of the lower rate.

On the basis of this qualitative evaluation of the data presented in the report, it is concluded that the Pocatello Site is to be preferred.

3. NUMERICAL EVALUATION

Certain of the factors and characteristics studied in this survey are susceptible to a numerical analysis. It is possible to estimate the annual operating charge for fuel, water, and electric power. An estimate can also be made as to the capital investment which will be required for the erection of similar facilities at each of the sites. Based on a consideration of the social qualities of each of the sites, an estimate can be made as to the number of homes which will have to be furnished for the plant employees.

In Table I C-1 an analysis of the plant costs is presented. For each of the items listed an estimate is made as to the annual operating cost which will be experienced at each site. In order to bring all costs to a yearly basis it was assumed that the annual charge against capital investment would be 6.07% of the investment. This allows for the retirement of the investment within a 20-year period and pays interest at the rate of 2.0% per year on the principal. The item for Plant Construction is intended to include the cost of the entire plant and service facilities. Housing for employees is presented as a separate item and the amounts are based on providing 1,000 homes at the Fort Peck Site and 700 at the Pocatello Site.

TABLE I C-1

NUMERICAL EVALUATION

Item	Site			
	FORT PECK		POCATELLO	
	Capital Investment	Annual Charge	Capital Investment	Annual Charge
Water Supply System	(1)	$ 161,000	(1)	$ 85,000
Housing	$ 21,250,000	840,000 (2)	$ 13,460,000	546,000 (2)

I C. EVALUATION OF SITE CHARACTERISTICS (Cont'd.)

(Table I C-1: Cont'd.)

Item	FORT PECK Capital Investment	FORT PECK Annual Charge	POCATELLO Capital Investment	POCATELLO Annual Charge
Land	$ 1,500,000	$ 30,000 (3)	$ 1,400,000	$ 28,000
Electric Power	(1)	2,200,000	(1)	1,400,000
Fuel		840,000		600,000
Plant Construction	500,000,000 (4)	30,350,000	452,000,000 (4)	27,440,000
Total	$522,750,000	$34,521,000	$466,860,000	$30,099,000

Notes:

(1) Capital investment for water supply and electric power is included in the plant construction item.

(2) Includes interest, retirement of principal, and all other operating costs (schools, police, fire department, etc.) less rental payments of $80 per month per unit. It is estimated that the total cost for providing all community services and retiring the principal plus interest will amount to $150 per month per unit at Fort Peck and $145 at Pocatello.

(3) Includes interest at the rate of 2.0% per year on the investment.

(4) The total estimated plant construction cost is $500,000,000 on the basis of the Fort Peck Site and the cost of construction will be 9.5% less at Pocatello. This item takes into account all aspects of construction cost such as availability and cost of manpower and materials, climate, and so forth.

For the items listed in Table I C-1 the total project investment and the annual operating costs are:

	Project Investment	Annual Operating Costs
Fort Peck	$522,750,000	$34,521,000
Pocatello	466,860,000	30,099,000
Difference	$ 55,890,000	$ 4,422,000

It should be noted that the annual operating costs include only fuel, water, electric power, and capital charges.

Many other items such as salaries and wages for personnel, operating materials and supplies, maintenance, miscellaneous services such as automobiles, telephone, freight charges, and so forth, cannot be evaluated on the basis of information available for this report. Similarly, the social characteristics of the areas, and their effect on employees, cannot be evaluated completely.

The differences in both project investment and annual operating cost, in so far as these items can be developed at this time, favor the Pocatello Site.

I D. SITE LOCATION

1. THE FORT PECK SITE

The site area at Fort Peck is defined in Plate I D-1 and the arrangement of the reactors within this area presents no serious problems. Were this site developed, consideration would have to be given to the several creeks which run through the area and to the hills which lie along the southern edge. However, these should not limit greatly the possibilities of reactor arrangement.

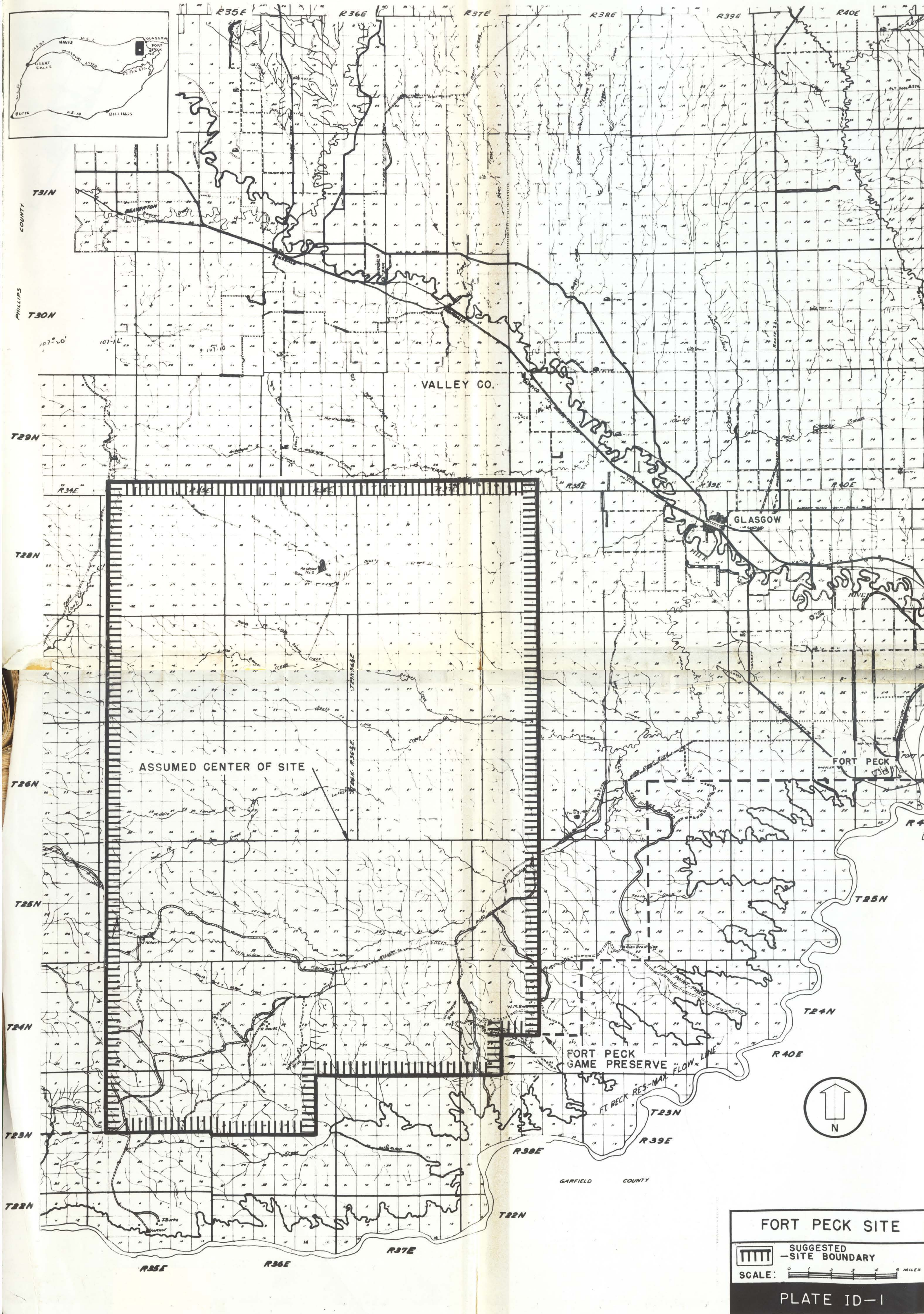
2. THE POCATELLO SITE

In Plates I D-2 and I D-3 the Big Lost River Location and the Alternate Location at the Pocatello Site are shown. Both of these locations fulfill in general the requirements established for the reactor testing station. However, the Big Lost River Location has certain advantages which indicate that it is preferable.

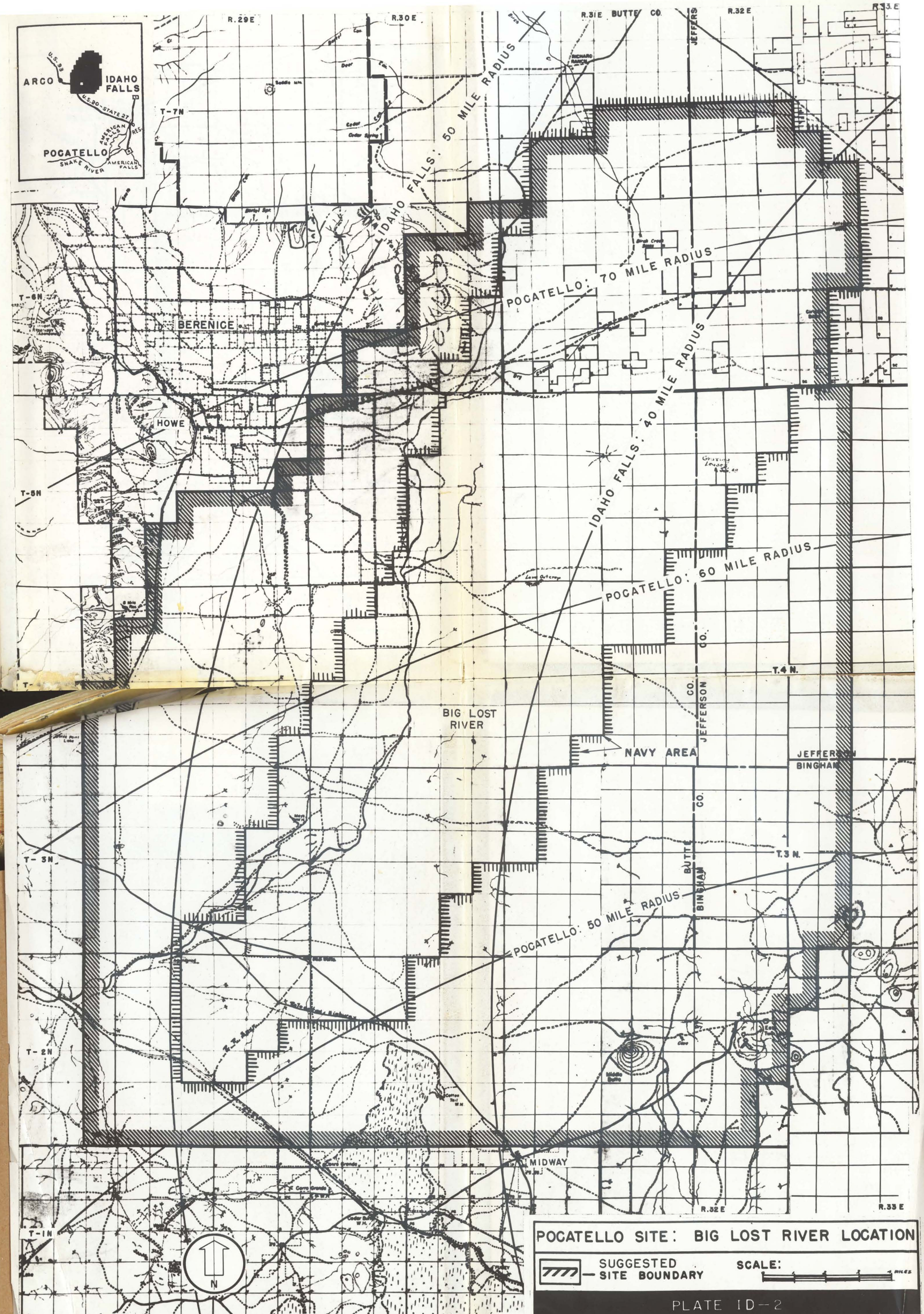
A comparison of these locations follows.

(a) Within the Big Lost River Location, which lies to the north of the railroad and highway between Blackfoot and Arco, is the U.S. Naval Proving Ground. The Proving Ground, consisting of approximately 173,000 acres, extends roughly along the channel of the Big Lost River. This area has a number of improvements which could be of considerable value in establishing the construction program for the Reactor Testing Station and getting underway with field work. These improvements include:

8.7 miles of railroad track and siding,
two wells,
electric power (450 KVA),
6.3 miles of roads,
five storage buildings,
barracks,
28 residences, and
material handling equipment.

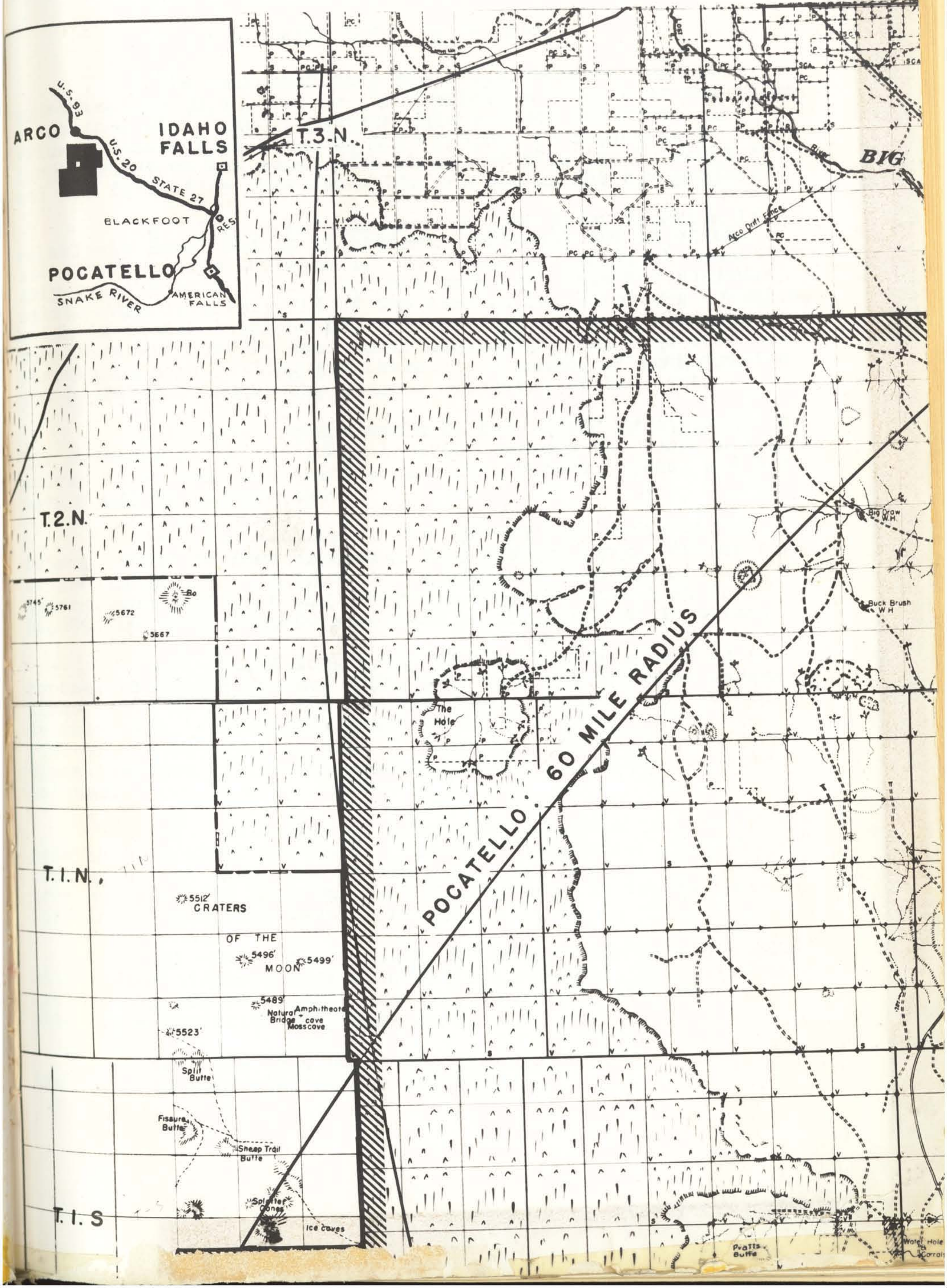


R35E
R36E
R37E
R38E
R39E
R40E
T31N
T30N
T29N
T28N
T26N
T25N
T24N
T23N
T22N
PHILLIPS COUNTY
VALLEY CO.
GLASGOW
FORT PECK
ASSUMED CENTER OF SITE
FORT PECK
GAME PRESERVE
FT. PECK RES-MAX FLOW LINE
GARFIELD COUNTY
GREAT FALLS
HAVRE
BUTTE
BILLINGS
FORT PECK SITE
SUGGESTED
-SITE BOUNDARY
SCALE:
PLATE ID-I



POCATELLO SITE: BIG LOST RIVER LOCATION

PLATE ID-2



U.S. 93
ARCO
IDAHO FALLS
U.S. 20
STATE 27
BLACKFOOT
RES
POCATELLO
SNAKE RIVER
AMERICAN FALLS
T.3.N.
BIG
Arco Drift Fence
Big Draw W.H.
Buck Brush W.H.
T.2.N.
5745'
5761
5672
5667
POCATELLO: 60 MILE RADIUS
The Hole
T.1.N.
5512'
CRATERS OF THE MOON
5496'
5499'
5489'
Natural Bridge
Amphitheate cave
Mosscave
5523'
Split Butte
Fissure Butte
Sheep Trail Butte
Spatter Cones
Ice caves
T.1.S
Pratts Butte
Water Hole

I D. SITE LOCATION (Cont'd.)

It is estimated that these improvements are worth approximately $2,000,000 to the Commission because of the value which they will have in getting this project underway. The value of these facilities to this project is dependent to a large extent on the speed with which the site can be vacated and the facilities made available for use in the new project.

(b) The terrain of the Big Lost River Location is relatively level and it is estimated that all but 1% of the area is covered with topsoil. The depth of topsoil is considerably greater in this location and much less lava outcroppings exist. Approximately 25% of the area in the Alternate Location, which is to the south of the railroad and highway, consists of bare lava without any soil cover whatsoever. In this site the terrain is more rolling and there are a number of buttes rising 100 to 200 feet above the general elevation of the area.

(c) More freedom would be had in the arrangement of the reactors in the northern location because the land is more nearly level and less interference with buttes, hills, and bare lava would be experienced.

(d) The running of underground pipe lines through topsoil would be less expensive than through lava. On the basis of preliminary information, it is expected that installing underground piping at the Alternate Location will cost from $1,000,000 to $2,000,000 more than at the northern location.

(e) Foundations would be more easily placed in the northern location because of the ease with which deeper excavations could be made. This factor cannot be accurately evaluated at this time, since sufficient information is not available. However, it is expected that from $500,000 to $1,500,000 additional expense will be experienced if the Alternate Location is used.

(f) The number of permanent residents in each of the locations is about the same. The best information available indicates that there are no permanent residents in the southern area and not more than two resident families in the northern location, other than Naval personnel.

(g) While the population distribution within a 200-mile radius of these locations differs somewhat, the differences are not significant. Reference may be made to the summary of site characteristics for these data.

(h) The land ownership characteristics of each of the sites is approximately as follows.

	Public	State	Private
Big Lost River Location	93%	3%	4%
Alternate Location	90.5	5	4.5

A consideration of the differences existing between the locations at the Pocatello Site indicate that the Big Lost River Location is preferable. The economic advantages accruing to this location are considered to be as follows.

Value of Navy improvements	$2,000,000
Saving in excavation for pipe lines	$1,000,000 to $2,000,000
Saving in excavation for building footings and foundations, fences, towers, etc.	$ 500,000 to $1,500,000

The total saving arising in the use of the Big Lost River Location as compared to the Alternate Location is estimated at from $3,500,000 to $5,500,000.

In either the Big Lost River Location or the Alternate Location, it may be necessary to secure an easement for the well field and pipe line serving the project.

The use of the Big Lost River Location for the Reactor Testing Station is recommended.

II. INTRODUCTION AND STATEMENT OF PROBLEM

A. Scope of Survey and Sites Studied

B. Project Requirements

C. Program of Procedure

II A. SCOPE OF SURVEY AND SITES STUDIED

1. GENERAL

This survey has been prepared on order of the United States Atomic Energy Commission and was started on January 6, 1949. Two sites have been studied as possible locations for a Reactor Testing Station. While only two general areas have been considered within this report, the Commission itself had made a preliminary study of approximately twenty sites. Of these, two were considered as possessing to the highest degree the characteristics necessary for the development under consideration. These sites have been designated as the Fort Peck Site and the Pocatello Site and are the subject of this survey.

Work on this project was to be undertaken promptly and conducted with all possible speed. It was contemplated that a preliminary report would be submitted to the Commission within thirty days after the date of the agreement covering this work. This Interim Report was completed on February 5, 1949, and was submitted for review by the Commission on February 7, 1949. The Interim Report contained all pertinent data which could be obtained within the time available and included a preliminary evaluation of the sites.

2. SCOPE OF SURVEY

The scope of this survey was defined in the agreement with the Commission, from which the following is quoted:

"1. The Commission is considering the possibility of constructing laboratory and experimental facilities for the development of nuclear energy reactors on one of two sites (hereinafter called the Pocatello Site and the Fort Peck Site) and desires urgently to obtain a comparative survey of these sites in order to ascertain which one will most advantageously meet its requirements. The precise location of these sites and the scope of the survey have been described to you more specifically by the Commission both orally and in documents.

"2. In view of the foregoing, the Commission hereby places an order with Smith, Hinchman & Grylls, Inc. (hereinafter called the "Contractor") to do all things necessary to perform the following work, subject to the approval of the Commission:

"a. Conduct a comparative survey including the following characteristics of the Pocatello Site and of the Fort Peck Site:

(1) Hydrological - including availability and quality of water supply for operation and community use.

(2) Meterorological - including conditions affecting operations and habitability.

(3) Geological - including physical features of land, soil conditions and drainage as they affect construction, operations and habitability.

(4) Area-logical - including population distribution, accessibility to centers of supply, availability of manpower of required skills, and description of neighboring communities and availability of housing.

(5) Transportation - including location and characteristics of available railways, highways and airways.

(6) Utilities - including availability and competition for electric power, coal, oil, gas, telegraph and other similar facilities, supplies or services.

(7) Any other characteristics which in the judgment of the Contractor or the Commission have a bearing upon the suitability of the proposed sites to meet the requirements of the Commission.

"b. The Contractor will conduct the foregoing work with key members of its staff under the immediate direction of one of its corporate officers.

"c. Subject to the approval or direction of the Commission, the Contractor will obtain such expert or technical assistance and services as may be necessary or advisable for the prosecution of the work. In view of the urgency of the work the Commission desires that the Contractor make full use of such expert and technical assistance and services as are available.

"d. Subject to the approval or direction of the Commission, the Contractor will let such subcontracts for the exploration of the sites or any characteristics of the sites, as may be necessary or advisable for the prosecution of the work.

"e. The Contractor will present the findings of the comparative survey in a report which shall be made available to the Commission in the shortest time feasible, but not later than April 1, 1949. Upon request by the Commission the Contractor will furnish interim reports of the data as collected. The Commission will furnish the Contractor with a statement of the Commission's requirements in such detail as may be necessary to conduct the survey and complete the reports to the Commission."

3. SITES STUDIED

The Fort Peck Site is considered to be in the general area of the Fort Peck Reservoir, lying southwest of Glasgow, Montana, and west of the Fort Peck Dam. For purposes of this report a point at the southwestern corner of Township 26N, Range 36½E in Valley County, Montana, was designated as the center of the reactor array. This site is considered to include the area bounded by longitudes 106° 49' on the east and 107° 16' on the west and by the 48° 15' parallel of north latitude on the north and by the Fort Peck Game Reserve on the south. Within this area a total of 441,000 acres is included.

The Pocatello Site was not specifically defined beyond that it would be in the Snake River Lava Plain and that the reactor array would be approximately fifty miles from Pocatello, Idaho, and approximately forty miles from Idaho Falls, Idaho. From preliminary studies it became apparent that two general areas fulfilled these requirements and met generally the other requirements specified for the reactor testing station. One of these areas lies to the north of the Mackay branch of the Union Pacific Railroad and includes the U.S. Naval Proving Ground. This area, referred to as the Big Lost River Site, contains approximately 415,000 acres and includes approximately Township 2N to 7N, inclusive, and Range 29E to Range 32E, inclusive. The other area lies to the south of the railroad and between Big Southern Butte and the Craters of the Moon National Monument. This alternate area contains approximately 425,000 acreas and includes Township 2N to 3S, inclusive, and Range 25E to Range 29E, inclusive. The Fort Peck Site and both sites at Pocatello are defined by Plates I D-1, I D-2, and I D-3. For purposes of this report a point in the northern site in Section 22, Township 4N, Range 30E, Butte County, Idaho, was used as the center of the reactor array for the Pocatello Site.

II B. PROJECT REQUIREMENTS

The following is a brief summary of the site requirements for the Reactor Testing Station. The order in which they are discussed here follows that in which they are presented in the body of this report.

1. ISOLATION

It is desired that the Testing Station be located at some distance from large population centers and industrial developments. A minimum distance of 50 miles from cities of 50,000 or more population has been specified.

2. SECURITY

The possibility of the need for defense is recognized, although a detailed consideration of this phase of the problem was specifically excluded from this survey by the Commission.

3. CLIMATE

Extremes of temperature that may effect operations or restrict design should be avoided. Moderate wind movement and uniform direction of prevailing wind is desired.

4. GEOLOGY

The geology of the area selected should be stable and the risk from earthquakes should be small. Some topsoil is desired and the subsurface conditions should be suitable for loads of 8,000 pounds per square foot.

II B. PROJECT REQUIREMENTS (Cont'd.)

5. DRAINAGE

The topography and geology of the area should be such that the escape of harmful radioactive wastes would not endanger large population or industrial centers.

6. WATER SUPPLY

The plant operations will require approximately 23 million gallons per day of cooling water. This should be clear, cold water of good quality and the supply must be reliable.

7. AVAILABILITY OF MANPOWER

An area where constructional and operational manpower are available would be preferable. The manpower requirements are stated in Item 9, Population and Social-Economic Factors.

8. AVAILABILITY OF MATERIALS

The area selected should have construction materials and operational supplies within easy reach.

9. POPULATION AND SOCIAL-ECONOMIC FACTORS

The area selected should possess social and cultural qualities as would permit it to absorb the influx of people which will be associated with this project.

It is anticipated that approximately 25,000 operators, service personnel, construction workers, and their families will be involved in this project at the peak of employment. This figure is developed as follows for the peak year:

Plant Personnel	
Operators	1,000
Service and Administrative	1,000
Construction	5,600

II B. PROJECT REQUIREMENTS (Cont'd.)

Families and Supporting Personnel

Plant Employees		5,400
Construction		11,200
	Total	24,200

It is desired to avoid the establishment of any permanent community completely owned and operated by the Commission, and proximity to existing communities capable of absorbing the influx of personnel becomes an important consideration.

10. AVAILABILITY OF LAND

The project will require an area of approximately 400,000 acres, half of which will be designated as the inner plant area and will be enclosed in a fence. A site which contains a high percentage of public lands is preferable and it should be capable of later expansion. It is desirable that a minimum of private installations exist within the site.

11. CONSTRUCTION AND OPERATIONAL COSTS

An area which will involve no penalty in construction and operational costs is desired.

12. TRANSPORTATION

The area selected should be served by existing railroad, highway, and airline facilities, and should be not more than approximately one day's travel by rail from Chicago, Ill.

13. ELECTRIC POWER

An adequate and reliable source of power is essential. It is expected that the demand for electric power will build up to a maximum of 70,000 KW within six years.

14. FUEL

An adequate source of fuel within reasonable shipping distance is required. The steam demand is estimated at 200,000 pounds per hour.

II C. PROGRAM OF PROCEDURE

1. GENERAL

Following the establishment of the scope of this survey, the sites to be studied, and the factors to be considered, a program of procedure was evolved to meet the requirements of the problems of site consideration and selection.

The initial need for defining the requirements and organizing the material in a logical sequence was met by the master outline of this study in which material for use in evaluating each site was classified according to characteristics. As noted from the outline, the study has been divided in four sections: the conclusions and recommendations, the introduction and statement of the problem, physical and safety characteristics, and the administrative and other characteristics. Each section has been divided into a series of basic factors from which the final conclusions and recommendations as to site consideration and selection were evolved. These factors were discussed in the preceding pages of this report.

2. FIELD WORK

Gathering of data, its interpretation, and analyses were accomplished by assigning to qualified individuals these factors for separate study. In order to obtain the most recent data and to avoid the use of unsubstantiated information, the individuals assigned to the studies personally undertook field trips to the areas under consideration where all available information on the subjects was gathered.

3. ORGANIZATION OF REPORT

With the completion of the field work, data on the basic factors were organized, screened to eliminate that which was not pertinent to the study, and checked for reliability. Following this, the individuals who originally gathered the data then developed the information into separate reports. The conclusions derived from the interpretation and analysis of data on the factors studied were arrived at independently by each of the individuals assigned to the study. This procedure was followed in order to assure a substantiated study and set of conclusions for the basic factors.

These individual studies were then correlated into one master study and edited from two series of standpoints: for technical accuracy and independent opinion; and for composition, clarity, and continuity. From this form, the individual conclusions were considered, evaluated, and evolved into a general summary of conclusions and recommendations for site selection.

4. THE INTERIM REPORT

In accordance with previous agreements, an Interim Report was prepared from the completed field reports which were available and submitted to the Atomic Energy Commission for review within one month following the start of the project. This report included conclusions and recommendations in regard to site selection as evolved from the preliminary studies. As previously noted, studies on some of the basic factors were not completed at that time, but the data available provided a means of judging the progress, completeness, and accuracy of the study. During the presentation and review, both the Commission and the Contractor made comments and suggestions to be included in the final study, plus those studies not included at this time. Following the discussion and review, the final study was commenced.

5. PRESENT STUDY

The study of the two sites in its present form has resulted from the complete review of the individual studies and those of the consultants engaged on this project. Certain new material was added following further study of the two sites under consideration. Additional field trips were undertaken to check data and to gather new information, and conferences with representatives of the Commission were held prior to the final reproduction of the report in order to assure complete coverage of all phases of the study as defined by the contract and outlined at the start of this study.

III. PHYSICAL AND SAFETY CHARACTERISTICS

A. Isolation

B. Security Problems

C. Climate

D. Geology

E. Drainage

F. Water Supply System

III A. ISOLATION

1. THE FORT PECK SITE

Population Distribution and Industrial Activity:

14-Mile Radius: Approximately 30 people live within a 14-mile radius of the center of this site, and these are scattered throughout the area. No industrial activity exists in this area.

50-Mile Radius: Approximately 22,000 people live within this area. There are no industrial plants employing more than 25 people each, with the exception of the Fort Peck Dam. Glasgow has a population of 5,000 and is the largest town in the area. There are six industrial establishments here employing a total of 78 persons, among which are two machine shops, a broom factory, and a tin shop. The Fort Peck Dam and Reservoir, having a potential electrical output of 105,000 KW, are adjacent to this site. The City of Fort Peck has a population of 4,000.

Plans for irrigation of about 140,000 additional acres within the 50-mile radius are expected to be accomplished within the next year or two. This will add an estimated 1,600 farm families to the lands which are between the 14 and 50-mile radii.

Other towns in this area are: Fraser with 300 people, Nashua with 1,000, Hinsdale with 325, Saco with 452, and Jordan with 677 people. Employment in these towns is confined to farming, livestock raising, and retailing and similar pursuits.

100-Mile Radius: Approximately 34,000 people live in the area between the 50 and 100-mile radii. The total labor employed in this area is approximately 12,000, of whom about 9,000 are employed in industry.

No industries employing more than 25 people each were noted in this area. There are only 5 towns of over 1,000 population: Scobey with 1,300, Wolf Point with 1,900, Malta with 2,215, Harlem with 1,166, and Poplar with 1,442. The primary activities in this area are farming, livestock raising, and agricultural product processing, with employment being seasonal.

III A. ISOLATION (Cont'd.)

200-Mile Radius: Approximately 140,000 people live in the area between the 100 and 200-mile radii. The total employed labor in this area is 51,000 of whom about 25,000 are employed in North Dakota.

Industrial activities are confined largely to: Miles City, Lewiston, Havre, Great Falls, and Billings, in Montana, and Williston, North Dakota. Between the 100 and 200-mile radii there are 19 cities having a population of more than 1,000 each.

Additional information concerning industrial activities in these cities is contained in IV C, Population and Social-Economic Factors.

It should be noted that the 100 and 200-mile radii extend into Canada, regarding which there is no information included in this report. In general, this part of Canada is sparsely populated, although Regina, with a population of 58,000, and Moose Jaw, with a population of 21,000, are located between the 100 and 200-mile radii.

2. THE POCATELLO SITE

Population Distribution and Industrial Activity:

14-Mile Radius: Approximately 110 people live within the 14-mile radius, none of whom is closer than 10 miles from the center. No industrial activity exists in this area.

50-Mile Radius: Approximately 68,000 people live in this area in which there are no plants employing more than 500 people each. Only two employ more than 250 people each, and only 36 employ from 25 to 250 people each. Nine of these are seasonal in operation. The majority of these plants are 30 miles or more from the site and are mostly feed processing plants subject to seasonal fluctuations. The two employing over 250 persons each are sugar plants and are also seasonal in operation.

Of the people living in this area, the majority is concentrated in the region between the 40 and 50-mile radii. There are only about 4,600 persons living in that area represented by the 40-mile radius. The remaining people are concentrated in the region along the Snake River and American Falls Reservoir in towns 40 to 50 miles from the site.

The following are towns having populations of more than 300 and lying within the 50-mile radius:

Idaho Falls	19,000	Iona	518
Blackfoot	5,500	Ucon	449
Rigby	1,978	Menan	432
Shelley	1,800	Lewisville	371
Aberdeen	1,500	Roberts	319
Mackay	776	Moore	300
Arco	548		

Within a 50-mile radius of the site and lying along the south side of American Falls Reservoir approximately 40,000 additional acres are planned for irrigation. This will bring approximately 500 additional families within the 40 to 50-mile zone within the next few years.

100-Mile Radius: Approximately 111,000 people live in the area between the 50 and 100-mile radii. The total labor employed in this area last year (1948) was 14,380 persons, of whom 1,996 were engaged in manufacturing. In this area, there are 65 industrial plants employing 25 or more persons each, and 16 of these employ more than 100 persons each. These industrial plants are located in the following cities: Pocatello, American

Falls, Hailey, Rupert, Burley, St. Anthony, and Rexburg, Idaho.

The following are towns having a population of more than 1,000 and lying between the 50 and 100-mile radii:

Pocatello	31,000	Hailey	1,443
Burley	6,500	American Falls	1,439
Alameda	2,691	Shoshone	1,366
Rexburg	4,200	Ashton	1,203
Rupert	3,167	Soda Springs	1,087
St. Anthony	2,719	Driggs	1,040

200-Mile Radius: Approximately 815,000 persons live in the area between the 100 and 200-mile radii. The total labor employed in industry in 1948 was 110,076 persons, of whom 5,087 were employed in manufacturing in Idaho. The total employment in manufacturing and industry for this area, exclusive of Salt Lake City, was 54,922. Salt Lake City lies just outside the 200-mile radius and contains the only heavy concentration of industry in the area. Other industry is largely confined to feed, meat processing and packing, and lumber products.

Industrial activities are confined largely to: Boise, Buhl, Caldwell, Cascade, Council, Emmett, Jerome, Nampa, Payette, Twin Falls, Wendall, and Weiser, Idaho; Anaconda, Butte, and Bozeman, Montana; and Logan and Ogden, Utah. There are 39 towns with a population of 1,000 or more which are located between the 100 and 200-mile circles.

3. SUMMARY

Within a 200-mile radius of the Fort Peck Site there is no concentration of industrial activity or population. There are no industries of any size closer to the site than 150 miles and such industries as there are within the 200-mile radius are almost wholly connected with the products of farms or mines. However, some 7,000 additional persons may be expected within the 50-mile area upon completion of irrigation projects within a short time. It should be noted that Fort Peck is located approximately 70 miles from the Canadian border and that the 200-mile radius includes Regina and Moose Jaw, Saskatchewan.

Within a 50-mile radius of the Pocatello Site there are approximately 68,000 people. Of this number all but 4,600 live within the area between the 40 and 50-mile radii. There are plans for the irrigation of approximately 40,000 additional acres within the 50-mile radius but this work will all be close to the outer edge of the 50-mile circle.

Within the 200-mile radius, industrial development is confined largely to cities along the Snake River from Rupert and Burley to St. Anthony. It should be noted that Salt Lake City lies just outside the 200-mile radius.

The following is a tabulation of population distribution in the areas surrounding each of the sites:

Population Within:	Fort Peck	Pocatello
14 miles	30	110
14 to 50 miles	25,000	68,000
50 to 100 miles	34,000	111,000
100 to 200 miles	140,000	815,000

With respect to both sites there are no significant population concentrations within 50 miles on the downstream side of the prevailing wind.

In preparing this analysis it was necessary to determine definitely the center of the plant site for both locations being studied. It is possible to reach somewhat different results as to population distribution and industrial activity within the areas by moving the mid-point only a few miles.

III B. SECURITY PROBLEMS

1. GENERAL CONSIDERATIONS

It is not within the scope of this survey to analyze the possibility of attack or the manners in which such attack might be made. The problems of security and the ability of the Armed Forces to protect from land or air attack whatever site chosen present an important factor in the selection of the site. Therefore, it is recommended that the Atomic Energy Commission obtain such an analysis from competent authority which is available to the Commission.

It is desired, however, to present at this time certain aspects of local and regional protection for the plant site as may come within the scope of the present study of this problem.

2. LOCAL SECURITY

Problems of local security include those presented by the casual seeker of information and by organized espionage activities. Protection of the physical plant against these dangers is usually maintained by the following:

(a) Fences and fence lighting;
(b) Watch towers;
(c) Road patrols;
(d) Entrance and building guards and escorts;
(e) Screening of personnel;
(f) Identification badges;
(g) File cabinets, safes, and vaults; and
(h) Proper disposal of classified material.

It is believed that either the Pocatello or Fort Peck Site can be adequately protected by these means. The site chosen at Pocatello is in an open plain where visibility would be better and road patrols could be used more effectively than at Fort Peck where there are numerous small gullies and some hills.

3. REGIONAL SECURITY

The possibility of attack by the Armed Forces of a foreign power must be the subject of a detailed study by the military authorities. In this regard consideration should be given to the following points:

(a) Vulnerability to long-range bombing and airborne invasion;
(b) Air defense installations available for the protection of the site;
(c) Vulnerability to ground attack;
(d) Location of Army combat troops; and
(e) Physical characteristics of the site such as roads, terrain, rail communications, and obstacles.

The Fort Peck Site presents some special problems because of its proximity to the Canadian border. While no concern is had for the attitude of the government of the Dominion of Canada in regard to their agreement with the United States on problems of defense or atomic energy development, consideration should be given to Canadian defense installations which might be called upon to intercept any attack from the north. In this regard the Pocatello Site is better located than the site at Fort Peck.

III C. CLIMATE

1. THE FORT PECK SITE

Available recorded information on climate regarding the communities and stations listed below was used in compiling this report.

Glasgow	Telegraph Creek
Malta	Fort Peck
Jordan	Havre
Sentinel Butte Pass	Williston, N. D.

There are no weather records for the Fort Peck Site itself, but a summation of the reports for surrounding towns indicates that the proposed site has the same weather conditions which generally prevail throughout the area from the Rocky Mountains eastward through North Dakota.

No first order weather stations are maintained in northeastern Montana. The proximity of Havre on the west and Williston, North Dakota, on the east permit in most instances the use of their records of climatic data for comparative purposes. Tabular presentations of weather data which follow in this section were taken from records of the Weather Bureau, U.S. Department of Commerce. These records are based on observations taken over periods of 8 to 55 years at the various stations.

Precipitation:

Average precipitation in this area is about 13 inches yearly, half of which falls in the months of May, June, and July. June is the wettest month, with an average of 3.29 inches, while November is the driest month, having an average of .49 inches.

There have been few heavy rains recorded, although in June, 1921, there was a fall of 16.79 inches at Circle (about 25 miles southeast of Fort Peck). In this case, 11.5 inches fell in a 24-hour period, this being the heaviest rainfall recorded in Montana. The greatest fall at Havre or Williston was 4.5 inches in 72 hours. These heavy rains, generally local, are rare but in the western plains they may strike anywhere, even where it has never been known to occur previously. Reference may be made to Tables III C-1, III C-2, and III C-3 for summaries of precipitation.

Snow falls in all months of the year except June, July, and August and averages 30 inches per year. December through March is the period of greatest snowfall, with about 5 inches in each of those months. Snows in this area are usually light and with little water content. These snows seldom remain, being blown into the depressions by the frequent winds or melting rapidly from "Chinook" winds. Chinook winds are the result of a warm air mass from the Pacific Ocean. A summary of snowfall is shown in Table III C-4.

Wind:

The average hourly wind velocity in the area from Havre to Williston, North Dakota, is 9 mph (miles per hour). December, the windiest month, has an average of 10.2 mph. August, the least windy, has an average of 8 mph. The highest wind recorded in this area was 56 mph. West winds are regarded as prevailing by the Weather Bureau, although the Glasgow weather station records show considerable variation for the years 1944-45-46, giving southeast as the prevailing direction for the year 1944. In 1944-45-46, the summer months had east and southeast winds and the winds during the winter were from southwest to northwest. The frequency of wind speeds are as follows:

0 - 3 mph	6 - 10%
4 - 15 "	70 - 80%
16 - 31 "	10 - 20%
over 32 "	0 - 2%

Wind summaries are shown in Tables III C-5, III C-6, III C-7, and III C-8. Prevailing wind directions for stations in this general area are shown in Plate III C-1.

Fog and Cloudy Days:

There is some fog around the area, mostly from October to March. Glasgow records show an annual average of:

Light fog:	23 days.
Medium fog:	15 days.
Heavy fog:	11 days.
Cloudy:	180 days.
Partly cloudy:	120 days.
Clear:	77 days.

See Tables III C-9 and III C-10 for fog and cloudy day summaries.

Temperature:

The highest temperatures reported in this area range from 106° at Jordan and Malta to 113° at Glasgow, with an area average of 108°.

The lowest temperatures range from -37° at Sentinel Butte Pass to -56° at Glasgow. The winter climate is influenced by polar air masses moving down from Canada, resulting in very low temperature at times.

The yearly average maximum temperature ranges from 54.6° at Glasgow to 56.8° at Jordan, while the yearly average minimum temperature varies from 26.7° at Glasgow to 32.7° at Sentinel Butte Pass. The annual average temperature at Glasgow is 40.6°, and the degree-day value is 8,500.

Summaries of temperatures are indicated in Tables III C-11 and III C-12.

Humidity:

Humidity is fairly low in northeastern Montana, ranging from 25 to 30% in summer to 65 to 70% in winter. Information on humidity is shown in Table III C-13.

Dust:

Being semi-arid, the area is subject to occasional severe droughts and considerable "soil-blowing" takes place, resulting in dust storms over large areas. There are also numerous "dust devils" or small twisters which, although local, sometimes carry considerable dust several hundred feet into the air. This dust may settle many miles away when the force of the "devil" is spent or broken.

TABLE III C-1

PRECIPITATION - AVERAGE MONTHLY & ANNUAL INCHES

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow	.57	.46	.85	.96	2.24	2.81	1.40	1.17	1.13	.76	.51	.57	13.4
Malta	.50	.38	.45	.78	2.21	3.59	1.93	1.11	1.41	.60	.39	.49	13.8
Jordan	.74	.61	.58	.76	2.16	2.77	1.70	1.10	.78	.58	.24	.61	12.6
Sentinal Butte	.50	.38	.54	1.02	3.01	3.91	1.54	1.10	1.64	1.04	.65	.67	16.0
Telegraph Creek	.34	.25	.51	.82	1.75	3.42	1.04	1.24	.92	.83	.51	.45	12.0
Fort Peck	.38	.27	.50	1.08	1.30	3.25	1.48	.96	.64	.75	.47	.28	11.4

TABLE III C-2

PRECIPITATION - AVERAGE NO. DAYS WITH .01 INCH OR MORE - MONTHLY & ANNUAL

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow	5	4	4	6	9	10	6	6	5	4	4	5	68
Malta	5	4	4	5	8	11	6	5	6	4	4	5	67
Jordan	5	2	3	4	6	7	4	4	4	4	2	4	49
Sentinal Butte	6	6	6	6	9	11	7	5	6	6	5	6	79
Telegraph Creek	NO RECORD												

TABLE III C-3

PRECIPITATION - GREATEST NO. INCHES IN 24 HRS. (1944-45-46)

STATION	J	F	M	A	M	J	J	A	S	O	N	D	MAX.
Glasgow	.23	.28	.44	.43	.56	2.08	2.83	3.29	.73	.39	.39	.29	3.29

TABLE III C-4

SNOWFALL - MONTHLY & ANNUAL AVERAGE INCHES

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow	5.5	4.2	6.4	2.4	.1	0	0	0	.2	1.7	3.7	5.6	29.8
Malta	5.8	4.4	2.9	2.1	T	0	0	0	.1	.7	3.1	5.7	24.8
Jordan	7.5	5.2	5.0	3.7	.1	0	0	0	1.5	2.6	2.9	3.8	32.3
Sentinal Butte	5.3	3.4	4.8	2.6	1.2	0	0	0	.6	3.2	5.3	7.5	33.9

TABLE III C-5

WIND - PREVAILING DIRECTION

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow													
To 1930													
Incl.	W	W	W	W	W	W	W	W	NW	W	W	W	W
1946	NW	E	SE	W	E	E	SE	E	NW	W	NW	NW	NW
1945	NW	NW	NW	NW	SE	E	SE	SE	SE	W	E	NW	NW
1944	NW	SE	SE	SE	SE	E	W	NW	SE	SE	E	NW	SE
Malta	W	W	W	W	W	W	W	W	W	W	W	W	W
Jordan	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
Sentinal													
Butte	W	W	W	W	W	NW	W	W	NW	NW	W	W	W

TABLE III C-6

WIND - MAXIMUM RECORDED

STATION	
Glasgow	56 M.P.H.
Havre	57 M.P.H.
Williston, N. D.	56 M.P.H.

TABLE III C-7

WIND - AVERAGE HOURLY VELOCITY

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Havre	9.5	9.1	9.4	9.5	9.4	8.7	7.8	7.5	8.2	8.6	9.2	9.9	8.9
Williston,													
N. D.	8.6	8.9	9.7	10.4	10.5	9.5	8.7	8.3	8.8	8.9	8.5	8.5	9.1

TABLE III C-8

WIND - MAX. VELOCITY, (MPH) DIRECTION & DATE

STATION	J	F	M	A	M	J	J	A	S	O	N	D	MAX.
Havre													
MPH	47	56	47	49	49	57	46	47	44	47	47	56	57
Direction	SW	NW	NW	W	NW	W	W	SW	SW	SW	NW	SW	W
Date	23	12	8	10	11	12	26	29	29	13	10	21	6/12
Williston, N.D.													
MPH	51	56	47	51	51	50	50	52	47	47	47	47	56
Direction	NW	NW	NW	NW	E	NW	W	W	NW	NW	NW	W	NW
Date	6	4	24	2	22	14	6	25	1	24	18	3	2/4

No wind summaries were available at the site but wind conditions are nearly always general all across the plains from Havre to Glasgow to Williston, North Dakota.

TABLE III C-9

FOG - AVERAGE DAYS

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow													
Light 1944	7	2	4	2	0	7	0	2	0	1	11	1	37
Light 1945	5	0	0	1	0	0	0	0	2	0	3	2	13
Light 1946	3	2	1	0	0	0	0	0	0	0	4	7	17
Med. 1944	4	1	1	1	0	0	0	2	0	1	10	1	21
Med. 1945	4	0	0	1	0	0	0	0	1	0	2	2	10
Med. 1946	3	0	1	0	0	0	0	0	0	0	2	7	13
Heavy 1944	3	1	0	0	0	0	0	1	0	1	10	1	17
Heavy 1945	2	0	0	0	0	0	0	0	0	0	2	2	6
Heavy 1946	1	0	0	0	0	0	0	0	0	0	2	7	10

TABLE III C-10

CLOUDY DAYS - MONTHLY AVERAGE

STATION		J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow														
Clear	1946	2	3	5	5	5	3	9	14	7	4	5	2	64
Clear	1945	4	4	7	2	7	1	15	16	8	13	5	4	86
Clear	1944	9	5	1	0	3	7	15	11	10	14	2	5	82
Part Cl.	1946	14	12	8	12	9	11	19	11	9	9	4	8	162
Part Cl.	1945	7	12	8	10	7	11	12	6	8	8	6	3	98
Part Cl.	1944	7	11	8	7	10	5	11	6	7	7	9	12	100
Cloudy	1946	15	13	18	13	17	16	3	6	14	18	21	21	175
Cloudy	1945	20	12	16	19	17	18	4	9	14	10	19	24	181
Cloudy	1944	15	13	22	23	18	18	5	14	13	10	19	14	184

TABLE III C-11

TEMPERATURE - HIGHEST & LOWEST DEGREES

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow													
High	62	63	81	90	98	109	113	110	100	89	76	62	113
Low	-56	-53	-45	-91	15	24	36	28	14	-8	-41	-47	-56
Malta													
High	63	65	80	92	97	105	106	105	98	90	72	60	106
Low	-56	-49	-30	4	18	28	36	26	16	-13	-25	-44	-56
Jordan													
High	62	66	81	91	94	108	107	104	100	92	75	59	108
Low	-51	-55	-34	3	19	29	38	32	23	-14	-31	-33	-55
Sentinal Butte													
High	57	65	80	88	94	97	106	106	98	86	74	60	106
Low	-37	-28	-15	8	23	33	42	39	15	-7	-14	-32	-37

TABLE III C-12

TEMPERATURE - AVERAGE MAX., AVERAGE, & AVERAGE MIN. DEGREES

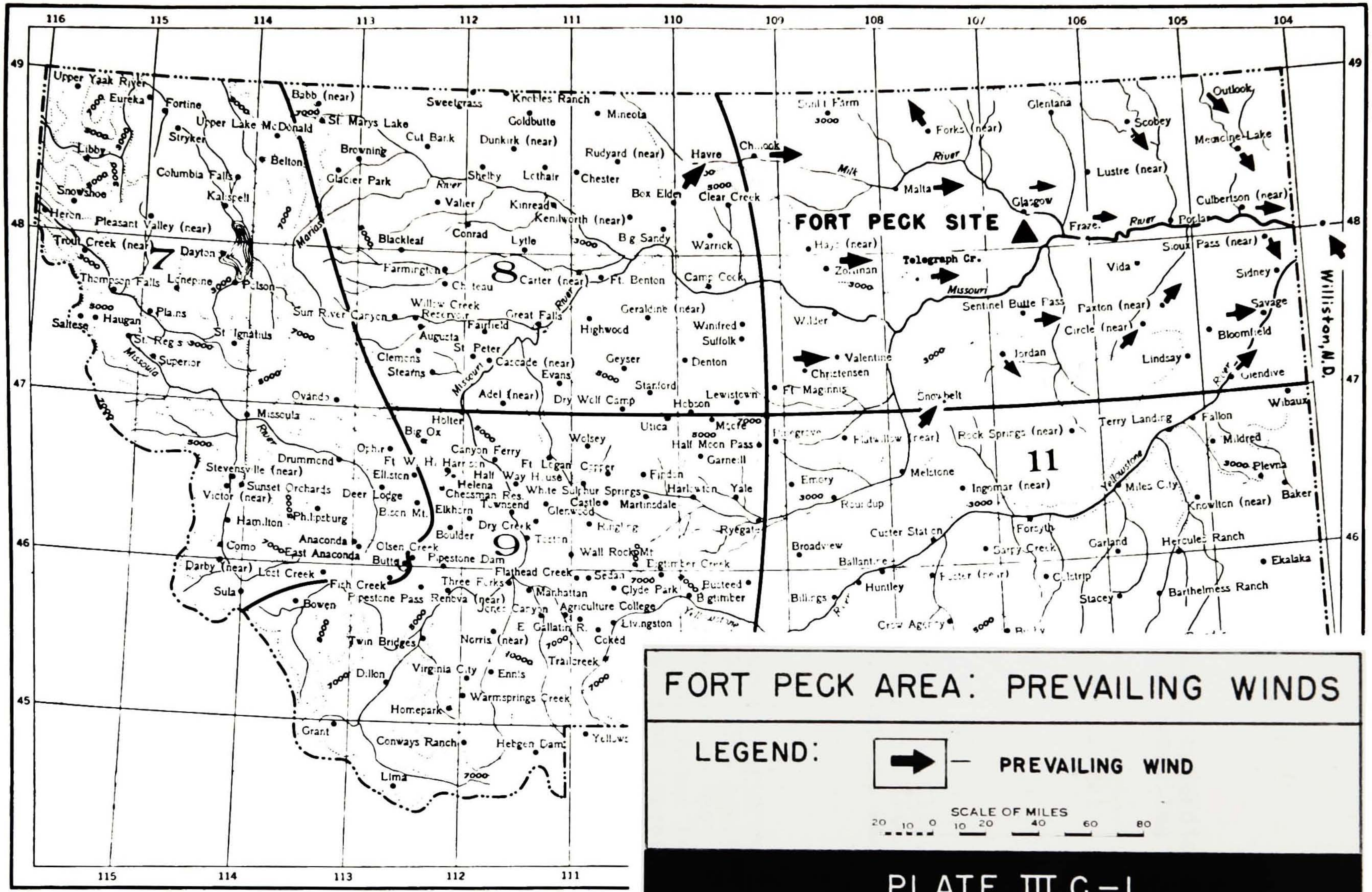
STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow													
Aver. Max.	20.3	24.8	37.0	58.0	69.4	77.8	86.6	84.6	72.1	58.3	39.9	26.3	54.6
Aver.	8.0	11.8	24.5	44.2	54.9	63.6	70.5	68.2	56.5	43.8	27.4	14.4	40.6
Aver. Min.	-4.2	-1.2	12	30.4	40.4	49.4	54.4	51.8	40.9	29.2	14.8	2.4	26.7
Malta													
Aver. Max.	21.4	25.4	38.0	57.2	67.9	76.6	85.2	83.9	72.0	58.3	41.6	26.0	54.5
Aver.	10.2	14.1	27.0	44.1	54.4	63.4	70.2	68.1	56.8	44.4	29.6	14.8	41.4
Aver. Min.	-1.0	2.7	16.0	31.0	40.8	50.3	55.1	52.3	41.7	30.4	17.5	3.7	28.4
Jordan													
Aver. Max.	27.0	29.2	42.7	56.7	64.8	77.2	88.6	85.7	74.3	59.7	44.3	31.3	56.8
Aver.	13.2	16.6	29.6	42.9	51.8	62.8	72.0	69.0	57.4	44.6	30.6	19.2	42.5
Aver. Min.	-.5	4.1	16.4	29.1	38.9	48.3	55.4	52.2	40.4	29.4	17.0	7.1	28.2
Sentinel Butte													
Aver. Max.	25.2	33.6	43.1	57.1	66.6	74.6	85.9	84.2	70.9	58.3	44.5	29.5	56.1
Aver.	15.7	23.6	32.2	45.2	54.5	62.6	71.9	69.8	57.8	46.4	33.6	19.7	44.4
Aver. Min.	6.2	13.7	21.3	33.2	42.4	50.5	57.9	55.5	44.6	34.5	22.8	9.9	32.7

DAYS (ANNUAL AVERAGE)	90° or above	32° or below	0° or below
	30	185	35

TABLE III C-13

HUMIDITY - AVERAGE RELATIVE % - 8AM

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Glasgow	80	76	68	54	55	64	51	54	59	61	80	82	65
Havre	86	87	86	82	81	65	79	80	83	82	83	84	82
Williston, N. D.	85	85	82	77	75	79	77	78	80	80	81	84	80



FORT PECK AREA: PREVAILING WINDS

PLATE III C-1

III C. CLIMATE (Cont'd.)

2. THE POCATELLO SITE

Available recorded information on climate regarding the following communities or stations was used in compiling this report.

Pocatello	Shoshone
Blackfoot	Gooding
Idaho Falls	Twin Falls
Arco	Burley
Martin	American Falls
Richfield	Mackay

These points surround the proposed Pocatello Site. While there is no recorded weather information for the site itself, the data for the points listed indicate that the whole area has similar weather conditions.

Precipitation:

Average yearly precipitation in the area ranges from 9.58 inches at Arco to 13.41 inches at Pocatello. The greatest precipitation is in the winter months from November to May. Precipitation varies in wet to dry years from 15-20 inches to 5-10 inches in Pocatello itself, but the general area average is 10.4 inches annually, taken over periods of 20 to 30 years. The maximum precipitation in one month was approximately 2.6 inches, in 24 hours 2/3 inches, and in one hour 1/2 inch. This indicates that it is unlikely that floods would occur in the area because of heavy rains. See Tables III C-14, III C-15, and III C-16 for summaries of precipitation.

While snow has fallen in all months except August in this area, practically none has occurred from June through September. The average annual fall ranges from 25.7 at Twin Falls to 44.3 inches at Pocatello. The area average yearly snowfall is 35 inches, with the largest snowfall occurring to the north and east of the site.

The maximum snowfall in one month was 26 inches. Maximum depth on the ground at one time was 19 inches, while the greatest fall for a single storm was 15 inches. The greatest number of consecutive days with 1 inch or more snow on the ground was 68 days. Information on snowfall is summarized in Tables III C-17 and III C-18.

Wind:

Quite a local variation in direction of surface winds is noted for the stations listed because of the topography. However, the prevailing winds are from the southwest and west directions, except for Mackay.

The strongest winds registered were 68 mph at Burley and 56 mph at Pocatello. Winds from 34 to 44 mph were registered in every month of 1946.

Average surface speed is 8-10 mph, with the stronger winds occurring in the winter. The following frequency of surface wind speeds may be expected:

0 - 3 mph	10 - 20%
4 - 15 "	60 - 70%
16 - 31 "	10 - 20%
32 - 47 "	1 - 2%
over 47 "	less than 1%

Upper air movements to 3,000 feet follow closely the surface winds. From 3,000 to 25,000 feet winds are predominately from the west, but are slightly southwesterly in summer and slightly northwesterly in winter. Average wind speed is 15-25 mph. See Tables III C-19, III C-20, and III C-21 for summaries of wind data. Prevailing wind directions for stations in the general area are shown in Plate III C-2.

Fog and Cloudy Days:

Fog is considered to be mild generally at the Weather Bureaus in towns and stations listed in the report. However, Mr. E. H. Jones, Director of the Weather Bureau at Boise, gave information based on personal observations and data from others that a cloud condition exists south of Arco during the winter months. At times, this cloud condition drops to the ground. This condition prevails from late November to late February, lasting from about midnight until noon.

Information from airline pilots (Stewart and Cole of Empire Air Lines) indicated that from November to March there is almost nightly a fog from about 6:30 P.M. to 10 or 11 A.M. in an area extending from Lake Walcott Reservoir to American Falls Reservoir and northward forty to fifty miles. The fog is usually a few hundred feet above ground, but is too low for aircraft to fly under it with safety.

The Commanding Officer at the U.S. Naval Proving Ground reported that clouds were common in that vicinity at night during the winter months, but that they seldom dropped below the peaks of the Twin Buttes and that they were not accompanied by a calm. He further stated that fog was very rare and that the Navy stored buoys on the Proving Ground because there is very little tendency for them to rust, indicating dry ground conditions north of the Mackay-Blackfoot branch of the Union Pacific Railroad.

Information received from residents of Arco indicate that clouds exist almost nightly from November through March but that wind invariably accompanies them and they are usually 1,500 feet or so above the ground. These clouds usually disappear around 10 A.M. except in the vicinity of Big Southern Butte. In the winter a cloud often caps the Big Butte all day or until late afternoon. These conditions existed daily during the final field trip to the site from March 10th through the 14th, 1949. On March 13th, the cloud around the Big Butte was observed from a plane. It seemed to form on the windward side of the Butte, move past it, and disappear on the lee side.

The combined information given above together with the fact that most of the precipitation and the strongest winds occur in the winter indicate that the clouds which exist above the whole area between Arco and the Snake River are not accompanied by a calm, as was supposed in the Interim Report.

Temperature:

The highest temperatures recorded in this area range from 99° at Idaho Falls to 106° at American Falls, with an area average of 104.3°, while the lowest temperature ranges from -22° at Pocatello to -41° at Arco. The winter climate is tempered somewhat by warm air currents originating in the Pacific Ocean.

The yearly average minimum temperature ranges from 30.2° at Richfield to 36.5° at Pocatello, while the annual average maximum temperature ranges from 62.1° at Twin Falls to 56.4° at Arco.

The yearly average temperature ranges from 41.2° at Arco to 48° at Burley and the degree-day value is 6,800. See Tables III C-24 and III C-25 for temperature summaries.

Humidity:

Humidity ranges from 54 to 80% in the morning, 27 to 71% at noon, and from 24 to 73% in the evening at Pocatello. The highest humidity occurs in the winter months. Information on humidity is summarized in Table III C-26.

Dust:

There are no recorded data showing dust storms but local observers report occasional "dust devils" or small twisters which wend a zig-zag course across the Snake River Plain. These have a strong twisting force but not enough to damage buildings and other structures. However, these storms sometimes carry dust several hundred feet into the air. In dry years there is some "soil-blowing" resulting in dust storms over considerable areas.

TABLE III C-14

PRECIPITATION - AVERAGE MONTHLY & ANNUAL INCHES

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Pocatello	1.30	1.15	1.31	1.42	1.43	1.06	.76	.78	.96	1.12	.98	1.14	13.41
Blackfoot	.95	.79	.89	.92	1.37	.83	.70	.66	.83	1.04	.77	.85	10.60
Idaho Falls	1.34	1.05	1.19	.99	1.43	1.22	.61	.79	.88	1.11	.84	1.13	12.58
Arco	1.04	.57	.87	.67	1.32	1.14	.58	.60	.57	.71	.63	.88	9.58
Martin	2.02	1.28	3.14	.91	2.16	.80	.20	.32	.77	.63	1.79	1.54	15.60
Richfield	1.34	.96	.65	.91	1.14	.73	.27	.19	.61	.95	.99	1.09	9.83
Shoshone	1.37	1.10	.68	.88	1.01	.57	.20	.31	.53	.94	1.38	.99	9.96
Gooding	1.23	1.10	.68	.94	.83	.50	.34	.26	.50	.94	1.44	.96	9.72
Twin Falls	1.21	.96	.88	1.03	1.11	.81	.39	.26	.64	.99	1.12	.98	10.38
Burley	.88	.77	.65	1.43	1.03	.85	.38	.71	.63	1.02	.90	.88	10.13
Amer. Falls	1.47	1.12	1.38	1.33	1.64	.94	.64	.54	.70	1.22	1.20	1.17	13.35
Mackay	.88	.77	.92	.68	1.16	1.00	.87	.88	.89	.69	.52	.74	10.00

TABLE III C-15

PRECIPITATION - AVERAGE NO. DAYS WITH
.01 INCH OR MORE - MONTHLY & ANNUAL

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Pocatello	11	10	10	10	10	7	6	6	5	7	8	10	100
Blackfoot	7	6	5	6	6	4	3	4	4	5	5	6	61
Idaho Falls	9	6	8	7	8	7	4	5	5	5	6	8	78
Arco	5	4	4	4	6	6	4	3	3	3	4	4	50
Martin					NO RECORD								
Richfield	8	5	5	5	5	4	2	2	3	4	5	6	54
Shoshone	9	8	5	6	6	4	2	2	3	5	7	7	64
Gooding	8	7	6	7	6	4	2	2	3	5	8	7	65
Twin Falls	8	8	6	7	7	5	3	3	3	5	7	8	70
Burley	9	7	5	7	5	5	3	4	3	5	7	7	67
Amer. Falls	6	6	5	7	7	4	4	4	5	5	5	6	64
Mackay	6	5	4	4	6	6	4	5	4	4	4	6	58

TABLE III C-16

RAINFALL - GREATEST INCHES IN 24 HRS.

STATION	J	F	M	A	M	J	J	A	S	O	N	D	GREAT-EST
Pocatello													
Amount	1.46	1.07	1.61	1.25	1.64	1.60	1.75	1.90	2.60	.95	1.01	1.15	2.60
Burley													
Amount	1.47	.84	.73	.80	1.10	1.68	.71	2.09	1.37	.94	.75	.67	2.09
Arco													
Amount	.94	.87	1.10	1.00	1.35	1.05	1.32	.92	1.16	1.05	1.13	.99	1.35

TABLE III C-17

SNOWFALL - MONTHLY & ANNUAL AVERAGE INCHES

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Pocatello	9.9	8.4	7.0	5.0	.7	.1	T	.0	.1	1.2	2.9	9.0	44.3
Blackfoot	9.1	6.4	3.9	1.7	.1	T	.0	.0	T	1.3	2.6	7.4	32.5
Idaho Falls	18.4	6.5	6.4	1.6	.5	T	.0	.0	T	1.6	3.6	10.6	49.2
Arco	11.8	6.6	8.2	1.2	.5	.1	.0	.0	.1	.9	4.4	8.6	42.4
Martin					NO RECORD								
Richfield	12.8	8.4	3.2	2.0	.2	.1	.0	.0	T	.6	4.3	7.8	39.4
Shoshone	10.7	7.2	1.8	1.5	.3	T	.0	.0	T	.1	1.9	7.4	30.9
Gooding	11.2	6.3	1.2	.9	.2	.0	.0	.0	.0	.3	1.6	6.2	27.9
Twin Falls	7.4	5.5	1.6	1.5	.4	T	.0	.0	.0	.4	2.1	6.8	25.7
Burley	7.7	4.0	2.3	2.1	.5	.0	.0	.0	T	2.3	1.7	6.6	27.2
Amer. Falls	9.0	6.8	3.8	.5	T	T	.0	.0	.3	1.0	3.3	6.4	31.1
Mackay	10.0	7.8	4.0	1.6	.6	.6	.0	.0	T	.9	2.5	7.5	35.5

TABLE III C-18

SNOWFALL - GREATEST NO. INCHES IN 24 HRS.

STATION	J	F	M	A	M	J	J	A	S	O	N	D	GREAT-EST
Pocatello													
Amount	8.9	10.0	14.6	14.0	7.2	1.0	T	.0	1.2	9.0	8.2	12.0	14.6

TABLE III C-19

WIND - PREVAILING DIRECTION

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Pocatello	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Blackfoot	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Idaho Falls	S	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Arco	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Martin					NO RECORD								
Richfield	NE	NE	NE	SW	W	W	W	W	W	W	NE	NE	W
Shoshone	NE	W	W	W	W	W	W	W	W	W	W	W	W
Gooding	E	E	W	W	W	W	W	W	W	W	W	W	W
Twin Falls	W	W	W	W	W	W	W	W	W	W	W	W	W
Burley	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Amer. Falls	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Mackay	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW

TABLE III C-20

WIND - TRUE VELOCITIES (MPH) - HOURLY AVERAGE

STATION	J	F	M	A	M	J	J	A	S	O	N	D	YR.AV.
Pocatello To 1930 Incl.	9.8	9.8	10.1	9.6	9.2	8.7	9.1	8.7	9.3	9.2	9.6	10.2	9.4
1939 to 1946 Incl.	8.4	9.6	10.2	10.7	10.4	10.2	9.1	8.9	9.1	8.7	8.4	8.8	9.4

TABLE III C-21

WIND - TRUE VELOCITIES (MPH) - MAXIMUM, DIRECTION & DATE

STATION	J	F	M	A	M	J	J	A	S	O	N	D	MAX.
Pocatello To 1930 Incl.													
Mi. per Hr.	40	38	40	37	46	32	42	38	38	41	38	41	46
Direction	S	W	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Date - May -	18	11	30	15	6	18	29	12	7	8	16	11	6
Year	1921	1900	1917	1927	1916	1901	1899	1921	1908	1919	1926	1919	1916
Pocatello 1939 To 1946 Incl.													
Mi. per Hr.	56	42	44	38	39	40	42	47	40	40	49	45	56
Direction	SW	SW	W	W	W	E	W	NW	W	S	W	SW	SW
Date	1943	1945	1946	1939	1940	1944	1946	1945	1941	1945	1942	1939	1943
Days of 32 MPH and Over in 8 Years from 1939 to 1946	2	2	2	2	2	2	2	1	1	1	1	2	TOTAL 28

TABLE III C-22

FOG - OCCURRENCE & DURATION (DAYS)

STATION	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Pocatello													
Light Fog	2	1	*	*	0	0	0	0	*	*	1	2	6
Heavy Fog	1	*	*	0	0	0	0	0	*	*	*	*	1

1939 to 1946 inclusive weather record average
* Less than 1/2 Day.

TABLE III C-23

CLEAR & CLOUDY DAYS

STATION	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Pocatello													
Clear	5	6	7	8	9	13	16	17	16	13	9	6	125
Partly Cloudy	9	8	11	11	13	12	12	11	9	9	9	9	123
Cloudy	17	14	13	11	9	5	3	3	5	9	12	16	117

1939 to 1946 inclusive weather record average.

STATION	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Arco													
Clear	12	12	15	13	11	11.5	16	14	13	9	9	8.7	114
Partly Cloudy	10.5	11	10	9	16	11.5	15	12	6.5	15	13	13	142
Cloudy	8	5	6	8	4.5	7	3	5	4	7	8	9	74

1941 - 1945 - 1946 - 1947 weather record average.

TABLE III C-24

TEMPERATURE - AVERAGE MAX., AVERAGE & AVERAGE MIN. DEGREES

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Pocatello													
Aver. Max.	33.7	37.8	46.9	57.0	66.3	76.6	86.5	84.1	73.6	60.9	47.5	34.7	58.8
Aver.	25.7	29.8	37.8	46.1	54.3	63.0	71.7	69.6	59.8	48.9	37.9	26.9	47.7
Aver. Min.	17.7	21.8	28.8	35.3	42.2	49.5	56.9	55.1	46.0	37.0	28.4	19.0	36.5
Blackfoot													
Aver. Max.	30.7	35.9	46.6	59.1	68.0	78.4	86.9	84.5	73.0	59.4	45.2	32.0	58.3
Aver.	20.9	26.0	35.0	44.3	53.0	61.4	68.4	66.2	56.3	45.2	34.2	22.6	44.4
Aver. Min.	11.1	16.0	23.3	29.5	38.0	44.4	49.8	47.9	39.6	31.0	23.1	13.3	30.6
Idaho Falls													
Aver. Max.	29.6	35.7	46.5	59.0	68.1	76.8	86.0	81.4	73.6	61.8	45.8	32.2	58.0
Aver.	20.0	25.7	35.1	45.1	53.4	60.8	68.8	65.0	56.8	46.6	34.4	22.6	44.5
Aver. Min.	10.3	15.7	23.7	31.2	38.6	44.9	51.6	48.7	40.0	31.4	23.2	12.9	31.0
Arco													
Aver. Max.	27.8	34.2	43.3	56.8	65.8	73.2	83.8	82.6	72.7	60.0	45.2	31.2	56.4
Aver.	14.1	20.4	30.6	42.7	51.0	56.4	65.6	64.4	54.7	44.4	31.6	18.6	41.2
Aver. Min.	10.3	15.7	23.7	31.2	38.6	44.9	51.6	48.7	40.0	31.4	23.2	12.9	31.0
Richfield													
Aver. Max.	30.2	34.7	46.2	59.1	68.9	78.9	89.9	88.2	77.2	63.7	47.6	34.3	59.9
Aver.	19.7	24.3	34.4	44.6	53.0	61.4	70.2	68.2	58.6	47.6	35.0	24.0	45.0
Aver. Min.	9.2	13.9	22.6	30.1	37.1	43.8	50.4	48.2	39.9	31.5	22.5	13.6	30.2
Shoshone													
Aver. Max.	32.6	37.5	49.4	60.6	69.4	82.4	93.2	86.7	75.7	62.5	48.0	34.6	61.0
Aver.	23.6	28.4	37.6	46.5	54.4	64.5	73.8	73.8	59.0	48.0	36.8	25.9	47.6
Aver. Min.	14.6	19.3	25.9	32.4	39.3	46.6	54.4	60.8	42.3	33.6	25.5	17.2	34.3
Gooding													
Aver. Max.	32.8	39.1	52.1	61.9	71.3	80.5	90.4	88.2	76.9	63.5	47.5	35.8	61.7
Aver.	22.8	29.0	39.0	46.9	55.2	63.2	71.6	68.8	59.3	48.0	36.2	26.0	47.2
Aver. Min.	12.9	19.0	25.8	31.9	39.1	45.8	52.7	49.5	41.7	32.4	25.0	16.1	32.
Twin Falls													
Aver. Max.	36.1	42.1	52.2	62.1	70.5	79.4	89.3	86.9	76.8	64.6	50.3	34.6	62.
Aver.	26.4	32.4	39.7	47.6	58.4	62.5	70.6	68.2	58.8	48.7	37.7	26.2	47.
Aver. Min.	16.6	22.8	27.2	33.0	39.2	45.6	52.0	49.4	40.8	32.8	25.1	17.8	33.
Burley													
Aver. Max.	36.1	42.3	51.0	59.4	70.4	80.4	90.6	87.1	76.5	63.5	49.4	37.7	62.
Aver.	25.6	32.0	39.0	46.0	55.6	64.1	72.6	69.6	59.3	48.4	37.1	25.5	48.
Aver. Min.	15.1	21.7	26.9	32.7	40.7	47.8	54.7	52.2	42.1	31.3	24.8	17.3	34.
American Falls													
Aver. Max.	34.5	38.4	46.7	59.6	69.4	79.9	89.6	88.1	76.7	62.7	47.9	35.5	60.
Aver.	24.5	27.8	35.6	45.3	53.6	62.2	70.0	68.4	58.2	46.8	35.4	24.9	46.
Aver. Min.	14.5	17.2	24.5	31.0	37.9	44.4	50.4	48.6	39.8	30.9	22.9	14.5	31.
Mackay													
Aver. Max.	29.2	33.5	43.6	56.1	65.6	75.1	85.4	82.8	72.4	59.4	44.1	39.9	56.5
Aver.	16.8	21.4	31.2	42.0	50.8	58.9	67.2	64.6	55.	44.6	32.8	19.8	42.2
Aver. Min.	4.5	9.3	18.9	28.0	36.1	42.7	49.1	46.4	38.3	29.8	21.4	8.8	27.8

DAYS (ANNUAL AVERAGE)	90° or above	32° or below	0° or below
	21	137	5

TABLE III C-25

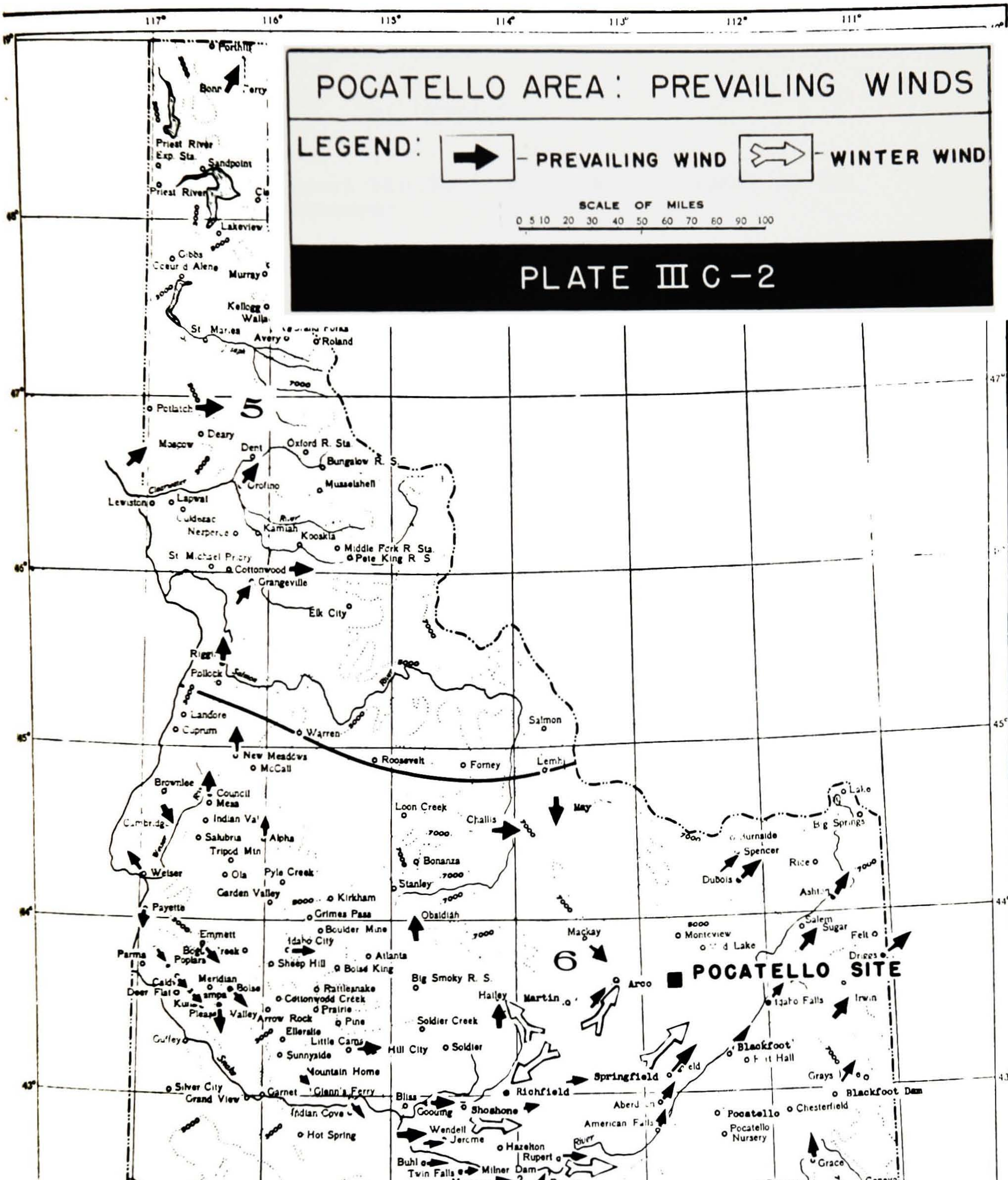
TEMPERATURE - HIGHEST & LOWEST DEGREES

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Pocatello													
High	57	61	70	84	94	99	104	100	94	86	71	61	104
Low	-22	-20	12	11	24	29	36	28	18	13	-3	-20	-22
Blackfoot													
High	54	64	79	85	95	108	103	101	92	88	71	59	108
Low	-39	-32	-24	3	19	20	30	23	12	4	-28	-30	-39
Idaho Falls													
High	51	59	74	86	95	98	99	97	91	85	70	61	99
Low	-34	-32	-26	11	20	24	32	22	15	1	-26	-24	-34
Arco													
High	52	54	70	85	95	95	101	97	101	85	69	52	101
Low	-38	-41	-20	-3	15	20	14	23	11	8	-17	-25	-41
Richfield													
High	60	61	71	88	97	101	105	103	99	88	72	60	105
Low	-36	-25	-18	0	17	24	31	25	20	9	-14	-30	-36
Shoshone													
High	60	62	79	88	97	102	102	104	95	90	92	62	104
Low	-34	-20	-14	12	20	27	32	30	17	12	-8	-20	-34
Gooding													
High	59	61	77	94	102	103	105	104	96	91	71	60	105
Low	-27	-18	-8	12	18	26	31	30	18	11	-8	-24	-27
Twin Falls													
High	64	66	80	91	98	104	103	102	96	91	74	68	104
Low	-30	-14	-3	12	23	27	31	31	14	10	-8	-19	-30
Burley													
High	62	68	81	86	95	102	105	103	97	88	72	66	105
Low	-35	-17	-7	14	22	27	36	32	16	9	-11	-28	-35
American Falls													
High	58	69	72	84	99	103	106	106	100	88	71	57	106
Low	-27	-28	-16	10	13	19	27	26	15	6	-27	-26	-28
Mackay													
High	56	67	67	81	96	96	99	100	95	85	70	55	100
Low	-23	-20	-14	6	20	21	27	22	15	3	-4	-29	-29

TABLE III C-26

HUMIDITY - AVERAGE RELATIVE (%)

STATION	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
Pocatello													
8 AM	80	79	73	69	67	60	55	54	59	68	73	79	68
Noon	71	67	56	45	38	31	27	29	32	47	60	70	48
8 PM	73	67	54	42	37	30	24	25	30	45	60	72	47



POCATELLO AREA : PREVAILING WINDS
LEGEND:
- PREVAILING WIND
- WINTER WIND
SCALE OF MILES
0 5 10 20 30 40 50 60 70 80 90 100
PLATE III C-2
117°
116°
115°
114°
113°
112°
111°
47°
45°
44°
43°
42°
5
6
POCATELLO SITE
Priest River Exp. Sta.
Sandpoint
Priest River
Lakeview
Gibbs
Coeur d Alene
Murray
Kellogg
St. Maries
Avery
Roland
Potlatch
Deary
Moscow
Dent
Oxford R. Sta.
Bungalow R. S.
Orofino
Musselshell
Lewiston
Lapwai
Nezperce
Kamiah
Kooskia
Middle Fork R. Sta.
Pete King R. S.
St. Michael Priory
Cottonwood
Grangeville
Elk City
Pollock
Landore
Cuprum
Warren
Salmon
New Meadows
McCall
Roosevelt
Forney
Lemhi
Brownlee
Council
Mesa
Cambridge
Indian Val
Salubria
Alpha
Tripod Mtn
Weiser
Ola
Pyle Creek
Garden Valley
Loon Creek
Challis
May
Bonanza
Stanley
Kirkham
Grimes Pass
Obsidian
Payette
Emmett
Boulder Mine
Idaho City
Atlanta
Sheep Hill
Boise King
Parma
Poplars
Meridian
Boise
Deer Flat
Rattlesnake
Cottonwood Creek
Prairie
Arrow Rock
Pine
Ellerslie
Little Camas
Sunnyside
Hill City
Soldier
Mountain Home
Big Smoky R. S.
Hailey
Martin
Soldier Creek
Mackay
Arco
Montview
Burnside
Spencer
Dubois
Rice
Big Springs
Lake
Ashton
Salem
Sugar
Felt
Driggs
Idaho Falls
Irwin
Blackfoot
Fort Hall
Grays
Blackfoot Dam
Chesterfield
Pocatello
Pocatello Nursery
Grace
Geneva
Montpelier
Downey
Paris
Lifton
Malad
Preston
Guffey
Silver City
Grand View
Garnet
Glenn's Ferry
Indian Cove
Hot Spring
Bliss
Gooding
Shoshone
Richfield
Springfield
Aberdeen
American Falls
Wendell
Jerome
Hazelton
Rupert
Buhl
Twin Falls
Milner Dam
Murtaugh
Hollister
Milner
Burley
Albion
Rosworth
Oakley
Almo
Bostetter R. S.
HB

3. SUMMARY

The climate at the Fort Peck Site is marked by the following general features:

(a) Abundant sunshine.
(b) Low relative humidity.
(c) Light rainfall confined largely to the warmer half of the year.
(d) Moderate wind movement.
(e) Large diurnal change in temperature and pronounced extremes ranging from 113° above to 56° below zero.
(f) Degree-day value is 8,500.
(g) Snowfall averages about 30 inches per year.

At the Pocatello Site the following are general features of the climate:

(a) Long growing season and abundant sunshine.
(b) Low relative humidity.
(c) Very light rainfall.
(d) Moderate wind movement.
(e) Extremes in temperature are 108° above to 45° below zero.
(f) Degree-day value is 6,800.
(g) Snowfall averages 36 inches per year.

Summaries of climatological data for both sites are shown in Table III C-27.

TABLE III C-27

SUMMARY OF CLIMATOLOGICAL DATA

FOR THE FORT PECK AND POCATELLO AREAS

SURFACE WINDS	FORT PECK	POCATELLO
Prevailing surface wind direction	West	SW to W
Frequency of wind speeds		
0 - 3 mph	6 - 10%	10 - 20%
4 - 15 "	70 - 80%	60 - 70%
16 - 31 "	10 - 20%	10 - 20%
32+	0 - 2%	1 - 2%
Season of strongest winds	Winter-Spring (Blizzards and Chinooks)	Winter-Spring
Season of calm and 1-3 mph winds	Winter & Spring	Winter
Surface wind directions accompanying majority of precipitation	W to NW	S-SW
UPPER WINDS		
Lowest 3,000 feet Most frequent wind direction	E and NW	SW thru SE
3,000 feet - 25,000 feet Most frequent wind direction	SW-NW	Westerly
Remarks	SE-NE rare	
Average speed 10,000 feet	20 mph	15-25 mph
PRECIPITATION		
No. days of .01 in precipitation annually	50-80 days	70-90 days
Range of total annual precipitation	11-17 in.	9-15 in.
Average annual precipitation	10.4 in.	13.4 in.
Rainiest month(s)	June (May to August)	April & May June to August

TABLE III C-27 (Cont'd).

	FORT PECK	POCATELLO
Greatest precipitation	Summer	Winter
Average total precipitation October to March	3.7 in.	7 in.
Average total precipitation April to September	9.7 in.	6.4 in.
Wet/Dry year precipitation	20 in./10 in.	15 in./9 in.
Max. precipitation in		
1 month	5-10 in.	
1 day	3.29 in.	2.6 in.
1 hour	1-2 in.	
Months of no snowfall	June-August	August
Range of annual snowfall	20-60 in.	35-40 in.
Average annual snowfall	30 in.	35.5 in.
1" or more snow cover on ground	100-120 days	80-100 days
Days of snowfall	71	60-70
Max. snowfall in 24 hours		
Havre	24.8 in.	14.6 in.
Williston	10.0 in.	
Thunderstorms	20-25 per year	25-35 per year
Months of max. frequency	June	June-July
Hail, % of thunderstorms	10%	15%
TEMPERATURE		
January		
Daily average maximum	12^{o}	30^{o}
Daily average minimum	0^{o}	10^{o}
July		
Daily average maximum	$80-90^{o}$	Mid 80's
Daily average minimum	$50-60^{o}$	Low 50's
Maximum temperature	113^{o}	108^{o}
Minimum temperature	-56^{o}	-45^{o}
Degree days	8,500	6,800

TABLE III C-27 (Cont'd).

	FORT PECK	POCATELLO
First killing frost	Sept. 10-20	Sept. 10-20
Last killing frost	May 10-20	May 10-30
Days (Annual Average)		
90° or above	30	21
32° or below	185	137
0° or below	35	5
Frost penetration	40 in.	25-35 in.
HUMIDITY		
Average relative humidity		
Summer noon	35-40%	25-30%
Winter noon	70-75%	65-70%
Average July wet-bulb temp.	55°	33°
CLOUDINESS		
Average no. clear days	120-140 days	120-130 days
Cloudy days	80-100 days	100-110 days
% of total possible sunshine		
Winter	50-60%	51%
Summer	70-80%	72%
FOG		
Light	25 days	6
Moderate	15 days	No data
Heavy	11 days	1

III D. GEOLOGY

1. GENERAL

The nature of the project under consideration requires that the site selected be geologically stable. A brief statement of the geological features which are desired follows:

(a) Seismic activity should be at a minimum and the absence of destructive earthquakes should be indicated.
(b) Foundation conditions should be adequate for loads in the order of 8,000 pounds per square foot.
(c) Water supply should be reliable and adequate for the requirements of 23 million gallons per day.
(d) Topography and geology should be such as to permit adequate control of drainage.
(e) Topsoil should be of sufficient depth to provide cover for underground lines, should be noncorrosive to piping materials, and should support vegetation.
(f) Topography should be relatively flat so as to minimize site grading.
(g) Floods should be unlikely.

Certain of the features listed, including the first four, are of prime importance.

In connection with these studies the services of Mr. Harold T. Stearns and Professor J. Stewart Williams, consulting geologists, were secured. Mr. Stearns reported on the general geological conditions at both sites, whereas Professor Williams limited his study to seismic activities.

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2. THE FORT PECK SITE

Overburden and Topography:

The Fort Peck area is everywhere covered with a gumbo topsoil (weathered Bearpaw shale) 4 feet to 20 feet deep. In the northernmost section along the Milk River Valley and extending 6 to 20 miles southward lies a gently rolling plain of glacial till, and in the Willow Creek plain is an alluvial deposit. The glacial till sheet is made up of somewhat gritty clay with numerous included pebbles and cobbles. The sheet is about 8 to 10 feet thick. The alluvium of Willow Creek throughout the greater part of the plain is dark gray to black clay, appreciably plastic and impermeable to water. The alluvium has a known thickness of at least 20 feet and the maximum thickness might be in the order of 50 feet.

In the flat lands the soil is strongly alkaline and vegetation is dwarfed brush and sparcely scattered grass. The soil in the hills along the reservoir is a sandy texture. A few willows and small scrub pines grow near the Fort Peck Reservoir.

The terrane is that of broad open valley with numerous small gullies and Willow, Brazil, Beaver and Larb creeks recessed in its flood plain. The area bounded by the glacial till on the north, Willow Creek on the south, and the divide of the Willow Creek on the west is a moderately rolling plain which slopes southeastward about 20 to 25 feet in a mile. Flat-topped hills and ridges form a divide between Willow Creek and the Fort Peck Reservoir.

The streams which drain the interior are all intermittent with little or no flow except during March, April, or May, when because of seasonal thaws, flows approach and exceed one thousand second feet. During the periods of high flow it is likely the streams overflow their channels and flood their plains.

Soil erosion is rapid in this area, and in recent years some terracing has been done on the site to check rapid run-off and to conserve the soil.

The average altitude of the general area is 2,575 feet above sea level, varying from about 2,150 feet in the plains area to about 2,900 feet in the hills.

No national forest or commercial timber land exists within 50 miles of the site.

III D. GEOLOGY (Cont'd.)

Geological History:

The three types of rock formation common to this area are Lance formation, Bearpaw shale, and Judith River formation.

Lance formation consists of a yellowish drab sandstone with some interbedded shale and is estimated to be about 300 feet thick. In this area it appears confined to the capping of the hills and ridges between Willow Creek and the Fort Peck Reservoir. Underlying the Lance formation and forming the land surface of most of the site is Bearpaw shale. This material is a dark gray to black marine clay and shale containing bentonite, and is comprised of beds commonly 3 to 10 feet thick. The total thickness of the formation is 800 to 1,000 feet where not deeply eroded, as in the section between the Willow Creek plain and the Fort Peck Reservoir. In the vicinity of the spillway and power house at Fort Peck the Bearpaw shale is displaced by many faults of irregular pattern, and it is assumed that a similar condition exists throughout the area. One of the characteristics of the shale is that it dries out and disintegrates rather rapidily upon exposure to air. This phenomenon is chiefly responsible for the gumbo topsoil of this area. Below the Bearpaw shale is the Judith River formation which is made up of interbedded drab sandstone and shale. In this area the formation crops out only in the valley of Larb Creek and farther north.

No mines are shown on the maps within 50 miles of the site and no evidence of mining activities was observed.

Ground Water:

The following rock formations in this area are water bearing:

(a) The glacial till is slightly permeable and supplies a few low-yielding farm wells.

(b) The Lance formation yields water through hillside springs and seeps.

(c) The Judith River formation supplies flowing wells east of the site in the Milk River Valley below Glasgow, and downstream along the Missouri River Valley. However, this water is not potable.

Reference is made to III F, Water Supply Systems.

Seismic Activity:

The recorded earthquake history of Montana is relatively short, but since 1869 many hundreds of earthquakes have been recorded. Of these, approximately thirty-five have had an intensity of V or more with destructive quakes (intensity VIII or more) occurring in 1925 and 1935. With the exception of one quake in 1943 having its epicenter near Plentywood, Sheridan County, Montana, all the recorded quakes have originated in the western part of the State. The epicenters are confined in a narrow belt running from northwest Wyoming to Helena, Montana, along the eastern edge of the Rocky Mountains.

Montana has been little affected by earthquakes originating outside the State except for one earthquake in Saskatchewan, Canada, in 1909. This shock probably affected the Fort Peck area more than any other recorded earthquake.

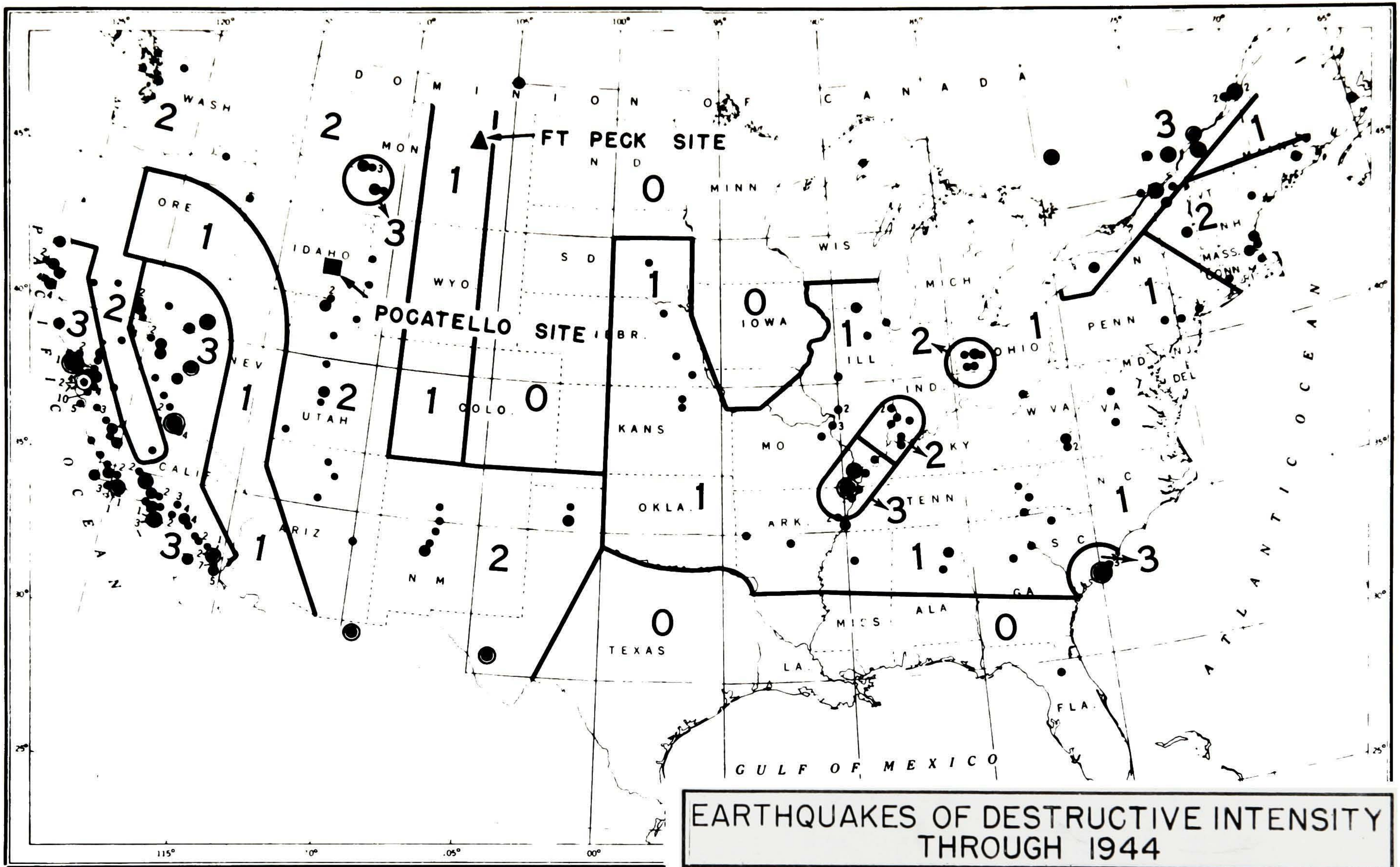
Following in Table III D-1 is a list of the major earthquakes, taken from the reports of U.S. Coast and Geodetic Survey, that have occurred in Montana and adjacent areas and which were probably felt at the Fort Peck Site.

TABLE III D-1

FORT PECK SITE
EARTHQUAKE OCCURRANCES IN MONTANA AND ADJACENT AREAS

Date	Origin (Epicenter)	Epicenter Intensity	Area Affected 1,000 Sq. Mi.
1872 Dec. 10	Near Helena	VII-VIII	Unreported
1909 May 15	Saskatchewan, Canada	VIII-IX	500
1925 June 27	Near Menard	IX-X	310
1935 Oct. 12	Near Helena	VIII	70
1935 Oct. 18	Near Helena	VIII-IX	230
1935 Oct. 31	Near Helena	VIII	140
1935 Nov. 28	Near Helena	VI-VII	90
1943 June 24	Near Plentywood	VI	Reported as local

The Rossi-Forel Scale of intensity was used to rate all of the quakes in the above table for ease of comparison, although this scale was replaced after 1930 by the Modified Mercalli Scale. The difference in the two scales is not great, but the Modified Mercalli is more modern and possibly a little more scientific. The chief differences between the two are in the high intensities of the scales. The Rossi-Forel Scale does not account for modern building construction and underground systems, nor does it distinguish between poorly and well constructed buildings. Severe quakes using this scale would be given a rating of X whereas with the Modified Mercalli a rating of X, XI, or XII could be used depending upon the type of buildings damaged. An equivalent rating of the two scales is given in Professor Williams' report included in the appendix.



EARTHQUAKES OF DESTRUCTIVE INTENSITY THROUGH 1944

LEGEND Numbers Denote Intensity

Statute Miles 100 50 0 100 200 300 400

PLATE III D — I

III D. GEOLOGY (Cont'd.)

The experience gained in the construction of the Fort Peck Dam and related structures indicated that the first two problems mentioned could be solved by special construction techniques. It was found necessary to seal the freshly-exposed surfaces of shale to prevent loss of moisture and to provide weather protection for excavations to prevent moisture pick-up. It is expected that the expansion of the shale following removal of the overburden will present no problem in this case. Because of the relatively high bearing loads to be imposed by the structures under consideration, some compression of the shale might be expected, resulting in minor settlement of the structures which this is not considered to be serious.

The Bearpaw shale provides a satisfactory foundation material suitable for loads in the order of 8,000 pounds per square foot, provided proper procedure is followed during construction. Before designs are prepared, proper field load tests should be made. A thorough study should be conducted of the special techniques employed in the construction of the Fort Peck Dam and related structures and a thorough investigation made into the causes of movement and settlement reported in connection with these structures.

Well No. 2	0 - 1	feet	Sandy gravel
	1 - 5	"	Clay
	5 - 12	"	Sand and gravel
	12 - 14	"	Clay
	14 - 50	"	Cracked lava
	50 - 68	"	Clay
	68 - 105	"	Lava

In the Big Lost River site at Pocatello, similar conditions may be expected to exist. In the alternate site, the mantle is composed almost entirely of wind-blown materials and the depth to solid lava is expected to be much less.

Vegetation is sparsely scattered grass and dwarfed brush. A national forest exists 35 miles west and north of the Big Butte. Some of the forest is listed as saw timber, and several sawmills are operated within a radius of 50 miles of the site. These mills are all very small in size and it is doubtful if much commercial timber exists within the 50-mile radius.

Geological History:

The general rock structure in the mountains on each side of the lava plains is Pre-Miocene, Rhyolitic, and Challis volcanics. Large areas of deep alluvium occur in the valleys between the mountains.

The rock structure in the lava plain is lava flows of undifferentiated basalt of early and late Pleistocene which rest on older volcanic or sedimentary rock. The basaltic lava fills a structural depression the depth of which is unknown. At least 1,000 feet of it has been penetrated by wells. The surface of the lava, which is very permeable, is clinkery, spiny basalt with deflated vesicles resulting from the loss of temperature and gases. A detailed stratigraphic section showing the character and thickness of the rock between King Hill and Blackfoot is given in Water-Supply Paper 774 (pp. 29 to 32) published by the U.S. Geological Survey (1938). Additional information was obtained from well logs in the site area. (See report of H. T. Stearns).

The fresh lava flows surrounding the Craters of the Moon are black basalt. The surface here is ropy or billowy with round vesicles, lava tubes, and pressure ridges.

Vesicles formed by the expansion of gases as the lava cooled as well as tunnels and caves, open spaces at contacts, shrinkage cracks, tree molds, and porous, clinkery rock accommodate the storage and flow of a tremendous quantity of water.

Mines are numerous at distances greater than 50 miles to the north, northeast, and northwest. No mining activity is indicated within the 50-mile radius on maps of the Snake River Basin. Some phosphate deposits are found 50 miles and more southeast of the site.

Ground Water:

The permeable rock contains a plentiful supply of ground water as is indicated by the large capacities of wells and the many springs along the Snake River. Wells in the U.S. Naval Proving Ground and adjacent areas show the water table to be 400 to 500 feet below the surface, depending on the elevation where the well is located. A large quantity of water from the Snake River enters the lava flows before the river reaches the American Falls Reservoir. Big Lost River and Little Lost River contribute approximately 100 second feet to the ground water in this area, although the Big Lost River is largely diverted for irrigation before it reaches the lava plains.

It is estimated that 1,500 to 2,000 second feet of ground water moves through the area at an average velocity of one-half mile per year. The openings which allow the ground water to flow through the lava are listed in approximate order of usefullness as follows:

(a) Large open spaces at the contact of one lava flow with another.
(b) Interstitial openings in the lava.
(c) Open spaces in the joints formed by shrinkage of the basalt in cooling.
(d) Tunnels and caves produced by molten lava flowing out from under a hardened crust.
(e) Vesicles and cavities formed during the cooling of the lava.
(f) Tree molds, resulting from lava surrounding a tree and solidifying before the tree had burned away.

The water flow leaves the lava bed through many springs below the American Falls Reservoir and rejoins the Snake River. The nearest known point of discharge is more than seventy-five miles away from the site.

The lava flows are so highly permeable that all surface water percolates through the lava and joins the ground water below. In some places, particularly around the Craters of the Moon National Monument, there are lenses of impervious material that may impede the movement of water through the lava. These conditions do not appear to be extensive enough to form

TABLE III D-2 (Cont'd.)

Date	Origin (Epicenter)	Epicenter Intensity	Area Affected 1,000 Sq. Mi.
1914 Oct. 14 1 15	Utah - Idaho	VI-VII	Unreported
1915 Mar. 4	Montpelier, Idaho	Unreported	Unreported
1915 Oct. 2	Pleasant Valley, Nev.	IX	500
1916 May 12	Boise, Idaho	VII	50
1916 May 25	Idaho City, Idaho	V-VI	10
1916 Sept. 9	Near Hailey, Idaho	V	Local
1917 Apr. 19	Near Obsidian (Custer Co.) Idaho	V	Unreported
1917 Dec. 12	Near Wayan, Idaho	V	8
1922 Feb. 19	Wayan, Idaho	IV	Unreported
1924 Nov. 25	Near Nounan, Idaho	V	20
1925 June 27	Near Helena, Mont.	IX	310
1927 Aug. 7	Arco, Idaho	Unreported	Unreported
1933 Nov. 2 or 3	Gray, Idaho	V	Local
1934 Mar. 12	Kosmo, Utah (Hansel Valley)	VIII	170
1934 Mar. 15	Twin Falls, Idaho	IV	Local
1934 Apr. 6	Salt Lake City, Utah	III	Reported felt at Pocatello
1934 Apr. 14	Salt Lake City, Utah	III	Reported felt at Pocatello
1934 May 6	Salt Lake City & Preston, Idaho	VI-VII	17.5
1935 Oct. 12	Helena, Mont.	VIII	70
18	" "	IX	230
31	" "	VIII	140
1936 Jan. 14	Malad City, Idaho	Unreported	Local
1940 Mar. 28	Pocatello, Idaho	II-III	Reported as light shock
1942 Mar. 2	Clayton, Idaho	Unreported	Local reported light
1942 Apr. 18	Malad City, Idaho	Unreported	Local reported light
1944 July 12	Seafoam, Idaho	VII	70
1945 Feb. 13	Clayton, Idaho	VI	60

The quake which affected this area more than any other was the March 12, 1934, (Hansel Valley, Utah) quake, reportedly felt in the vicinity of the site with an intensity of III-IV. The shocks occurring in Idaho have been of moderate to strong intensity and while not damaging do indicate active seismic faults in the areas surrounding the lava plains.

The great Montana quakes of 1925 and 1935 apparently had little or no effect upon this area. Isoseismal maps of these quakes show the isoseismals bending inward toward the north to exclude the Snake River Plain. However, the isoseismals of the 1934 Utah quake sweep as widely across the lava plain as in any direction excepting the southwest, and as Professor Williams states, "It would be unsafe to assume that the lava plains will not transmit earthquakes."

Reference is made to Plate III D-1 which shows earthquake zones and earthquakes of destructive intensity through 1944. This map shows the Pocatello area in Zone 2, one of moderate damage.

Copies of the reports of Mr. Harold T. Stearns on the geologic and hydrologic features of this area which comments on earthquake hazard, and of Professor J. Stewart Williams on the earthquake risk at the Pocatello Site, are included in the appendix of this report, as previously mentioned.

The earthquake history of this site shows that while seismic activity is appreciable the intensities felt have not been great. The faulted areas surrounding the Pocatello Site are considered young geologically and can be expected to produce shocks as in the past, and there is the possibility of a greater shock occurring in any of the regions. No traces of recent faults are known to cross the Snake River Plain and, therefore, the probability of damage to underground systems is negligible.

After careful consideration of the seismic history of the area, including available isoseismal maps and the statements of the consultants, it is concluded that reinforced concrete buildings of sound engineering design and construction would be safe from earthquakes that might reasonably be expected to affect the Pocatello Site. Residential structures of good masonry and frame construction would be adequate.

<u>Foundation Conditions</u>:

The wind-blown silt and sand which covers most of this area to depths up to 8 feet is not suitable for heavy foundations. In most places the removal of this material would expose bed rock (basaltic lava) which is more than adequate for the loads to be imposed. In areas where the overburden is known to reach depths of from 50 to 60 feet or more, stratifications of gravel and clay alternately occur. This information is known by the logs of the Navy wells. The load bearing value of the gravel beds is believed to be adequate for loads of 8,000 pounds. In these areas it would be deemed unnecessary to go to rock for suitable foundations.

Where foundations are to be erected on the balsaltic formation no load bearing tests would be necessary. However, to safeguard against the possibility of subsequent failure because of large cavities charteristic of this formation, a number of test borings should be made within the area to be occupied by the structure, Load tests are recommended where foundations are to be erected on the gravel or clay beds.

4. SUMMARY

Both areas studied present the appearance of a comparatively level plain, when viewed at some distance. The overburden at Fort Peck is impervious gumbo 4 to 20 feet deep. At Pocatello the topsoil consists of silt and gravel which in general varies in depth from a few inches to 8 feet. However, about 1/20 of the total area is devoid of topsoil and in local areas anywhere through the site the depth of topsoil may exceed 8 feet.

Below the overburden at Fort Peck lies the Bearpaw shale. While this material would require some special techniques in construction, it is satisfactory for the loads in the order of 8,000 pounds per square foot. The basaltic lava at Pocatello offers excellent material on which to build heavy structures.

Both areas are considered geologically stable. Reinforced concrete buildings of sound engineering design would be safe in any earthquake that might reasonably be expected to occur at either site.

III E. DRAINAGE

1. GENERAL

In considering the drainage problem it has been assumed to be important primarily in case of a catastrophe and that the normal waste fluids will be rendered harmless before they are discharged from the site.

Whether any active components of the waste fluids, resulting from a catastrophe, would be extracted by the soils at either site is not known. It is recommended that tests be conducted on soil samples from each of the sites to determine their ability to absorb possible active components.

2. THE FORT PECK SITE

Nature of Soils:

In this area the soil cover is a clay gumbo from five to twenty feet thick in the flat lands. Here, the vegetation is dwarfed brush and there is a little grass which is sparsely scattered. The uplands in the hills are of a sandy texture. A few willow trees and scrub pine grow near the reservoir.

Beneath the soil cover lies a thick layer of Bearpaw shale, which is highly impervious. Reference is made to the section of this report on Geology for a more detailed description of the geological conditions.

Character of Drainage:

Drainage off the south side of the hills along the southern edge of the site area runs into the Fort Peck Reservoir. The major portion of the site is north of these hills and drains into Willow, Larb, Brazil, and Antelope creeks which discharge into the Milk River. Generally, the run-off is quite rapid and there are numerous small gullies which feed the creeks mentioned.

Since the gumbo topsoil and the shale beneath it are both impervious and since the land is relatively flat, large areas might be flooded at times. There is some evidence that such floods do occur.

The nature of the soil, the relatively flat character of the land, and the likelihood of floods would make it difficult to impound permanently the large quantity of contaminated water involved. While dams could be constructed on the creeks draining the area, they would be of doubtful value if a catastrophe were to occur while the area was flooded.

Drainage Basins:

This site is in the Upper Missouri River Basin. Waters from this area flow into the Missouri River which enters the Mississippi River at St. Louis, Missouri, and ultimately discharge into the Gulf of Mexico. This drainage system is used extensively for industrial and agricultural purposes and there are many large concentrations of population and industrial developments along the banks of the Missouri and Mississippi rivers. These rivers form the principal waterway of the United States.

While the occurrence of a catastrophe could produce a contaminated condition in the Missouri River below Fort Peck, it is not within the scope of this survey to evaluate this risk. No information is available as to the harmful qualities of the contaminants which might be present or what beneficial effect would be gained from the great dilution in the river as additional streams discharge into it below the Fort Peck Dam.

III E. DRAINAGE (Cont'd.)

3. THE POCATELLO SITE

Nature of Soil:

At the Pocatello Site wind-blown and steam-deposited silts and gravels provide cover over the lava in some parts of the area. This cover varies in depth from zero to approximately twenty-five feet. However, the depth generally does not exceed five feet, although in the area adjacent to the Big Lost River it may be greater. In the sinks formed by the Big Lost River and other nearby streams the depth of the gravel extends to several hundred feet.

Beneath the thin layer of topsoil there is the basaltic lava rock extending to depths of many hundreds of feet. Reference is made to the section of this report on Geology for a more detailed description of the geological conditions.

Character of Drainage:

The pervious nature of the topsoil and the lava underlying it provide surface water drainage by percolation into the ground. There is no evidence of gullies or erosion from surface water in the area of the site.

The Big Lost River flows generally north-northeast through the site and in case of a catastrophe this stream might become contaminated. This river sinks north of the site and could contaminate the underground stream flowing generally in a southerly direction. Since this ground water would be used to supply the plant, there is some danger that the plant water supply could become contaminated.

Drainage Basins:

The Pocatello Site lies in the Upper Snake River Basin. The Snake River discharges into the Columbia River below Pasco, Washington. This watercourse ultimately discharges into the Pacific Ocean. While certain areas along this river system are thickly populated and possess industrial and agricultural developments, the effects of a catastrophe on these areas would be delayed.

Since contaminated water would drain into the lava, such wastes would join the ground waters. It is estimated that these waters move through the lava at the average rate of about a half mile per year in a general southwest direction and ultimately join the Snake River. In local areas because of lava tubes and other openings, or because of perches and impervious zones in the lava bed, the speed might be greater or less than the value stated. The nearest known point of discharge is below American Falls Reservoir and is approximately seventy-five miles from the plant site. Hence, many years would elapse before any contamination would appear in the Snake River. Much dilution in the underground stream would occur during this time. It is estimated that 1,500 to 2,000 second feet of water flow through the lava in the entire area. The flow between Big Southern Butte and the Twin Buttes is considered to be about 100 second feet. The ground water drainage from the plant area would enter this latter stream.

It is possible that on the surface and below there might be small local areas of impervious material. It is believed that these will not impede to any extent the flow of surface drainage into the underground stream.

III E. DRAINAGE (Cont'd.)

4. SUMMARY

It is not known whether or not any of the contaminated material would be absorbed by infiltration into the earth at either site. Tests should be conducted on samples of the soil to determine their absorption ability.

Since the soil at Fort Peck is so impervious, it is doubtful if the contaminated liquids would infiltrate to any appreciable extent. Dams could be constructed across Willow Creek and other creeks draining the site to prevent contaminated water from leaving the area in case of a catastrophe, although such dams would be of doubtful value.

Assuming that no absorption of the contaminated material took place in the basaltic rock at the Pocatello Site, it would require many years for the contaminated waste to travel approximately 75 miles to the nearest known point of ground water discharge, and it would be diluted considerably in its course of travel.

Information is not available for this report on the amount of radioactive material which might be contained in the run-off from the site. Furthermore, there is not sufficient information available on the amount of dilution that would be required to bring the radioactive tolerance of the run-off within acceptable limits for re-use of the water downstream.

The escape of harmful radioactive wastes from the Fort Peck Site would seem to present a potentially serious hazard to the important Missouri-Mississippi waterway.

III F. WATER SUPPLY SYSTEM

1. REQUIREMENTS

The operation of the plant will require approximately 23 million gallons per day of cooling water. This should be clear, cold water of good quality and the supply must be reliable. Storage tanks should be provided having a volume equal to approximately one day's water requirements to insure against momentary failure of the primary water supply pumping system.

A small quantity of water will be required for special purposes in the plant operation. This quantity, amounting to 0.7 million gallons per day, will be required to meet the following analysis:

Turbidity	0.0 ppm
Iron	0.0 - 0.03 ppm
Chlorides	Not to exceed 2.0 ppm
pH	7.5 - 7.8
SiO_2	5 - 15 ppm

The chemical qualities of the major part of the water required should be such as would make the water suitable for use in a conventional industrial cooling system.

The communities in which construction workers, operators, and their families will live will require some expansion of their water distribution facilities. On the basis of a new population of 25,000 in the area where this plant is to be erected these requirements will be:

Construction Camp
13,000 x 145 g/day = 1.9 mg/d

Permanent Housing
12,000 x 500 g/day = 6.0 mg/d

It would be desirable that the plant water system be available for supplying the construction camp soon after the start of construction.

In connection with the water supply problem the firm

III F. WATER SUPPLY SYSTEM (Cont'd.)

of Alvord, Burdick & Howson, Consulting Engineers, Chicago, Illinois, was consulted and asked to submit a report on:

(a) The suitability of the water supply at each site.
(b) The availability of such supply.
(c) Means of bringing water to the plant, and expanding domestic systems.
(d) Cost of the water supply systems.

The report of Alvord, Burdick & Howson is made a part of this survey and may be found in the appendix.

2. THE FORT PECK SITE

Source and Reliability of Supply:

At the Fort Peck Site, water for operation of the plant would be taken from the Fort Peck Reservoir. This source of supply is adequate as the normal discharge of the reservoir is many times greater than the plant requirements of 23 million gallons per day. The reservoir, formed by Fort Peck Dam, is subject to some variation in level which would complicate the design of the water system, but introduces no insurmountable problems.

Domestic water for permanent housing would be met by the expansion of existing water distribution systems in the established communities, or by utilizing water from the Milk River. Both sources are adequate for the demand of 6 million gallons per day.

In the event of the failure of Fort Peck Dam, which is a remote possibility, serious interruption or actual stoppage of the plant water supply might occur.

Method and Cost of Distribution:

Three plans for developing a plant water supply system from the reservoir are proposed by the Consultants.

The first, Plan A, is based on taking water directly from the reservoir at the nearest suitable location, using a submerged intake below minimum pool level. This plan has the shortest pipe line route of the three, but does offer the greatest construction problems. Power costs would be high because of the head incurred in pumping water over the hills between the reservoir and Willow Creek plain. The estimated construction cost is approximately $10,427,000. At the time the Consultant's report was prepared it was assumed that power costs at Fort Peck would be 4.3 mills per kilowatt hour; however, more recent information indicates that power costs will be 5.5 mills per kilowatt hour. Annual charges for pumping on this basis will be about $92,000.

The second, Plan B, consists of taking water directly from the powerhouse penstock pipe below the dam, about 25 miles northeast of the Plan A intake. This does away with the necessity of constructing a separate intake, but increases the length of the transmission lines by about 10 miles. Power costs for pumping would be lower despite increased friction loss in supply lines, since the line would not cross as high a divide between

Willow Creek and the Reservoir as in Plan A. The estimated construction cost is $11,232,000 and annual pumping costs would be about $50,000.

Finally, there is Plan C, which is similar to Plan B except that the water would be taken from the tailrace of the powerhouse. This is offered as an alternate to Plan B as complications may arise in trying to connect to the penstock line. Power costs would be about the same as in Plan A. The estimated construction cost is $11,474,000.

Plate III F-1 shows the proposed methods of supplying water from the Fort Peck Reservoir. This plate was reproduced from the report of Alvord, Burdick & Howson.

The necessary 6 million gallons per day for domestic water supply would be developed by the addition of 3 wells to the facilities of the existing communities. The estimated cost is $65,000. The addition of an iron removal process to improve water quality would increase the total cost to about $582,000. An alternate system would use filtered Milk River water at an estimated construction cost of $625,000. The cost of a distribution system for either proposal is estimated at $380,000.

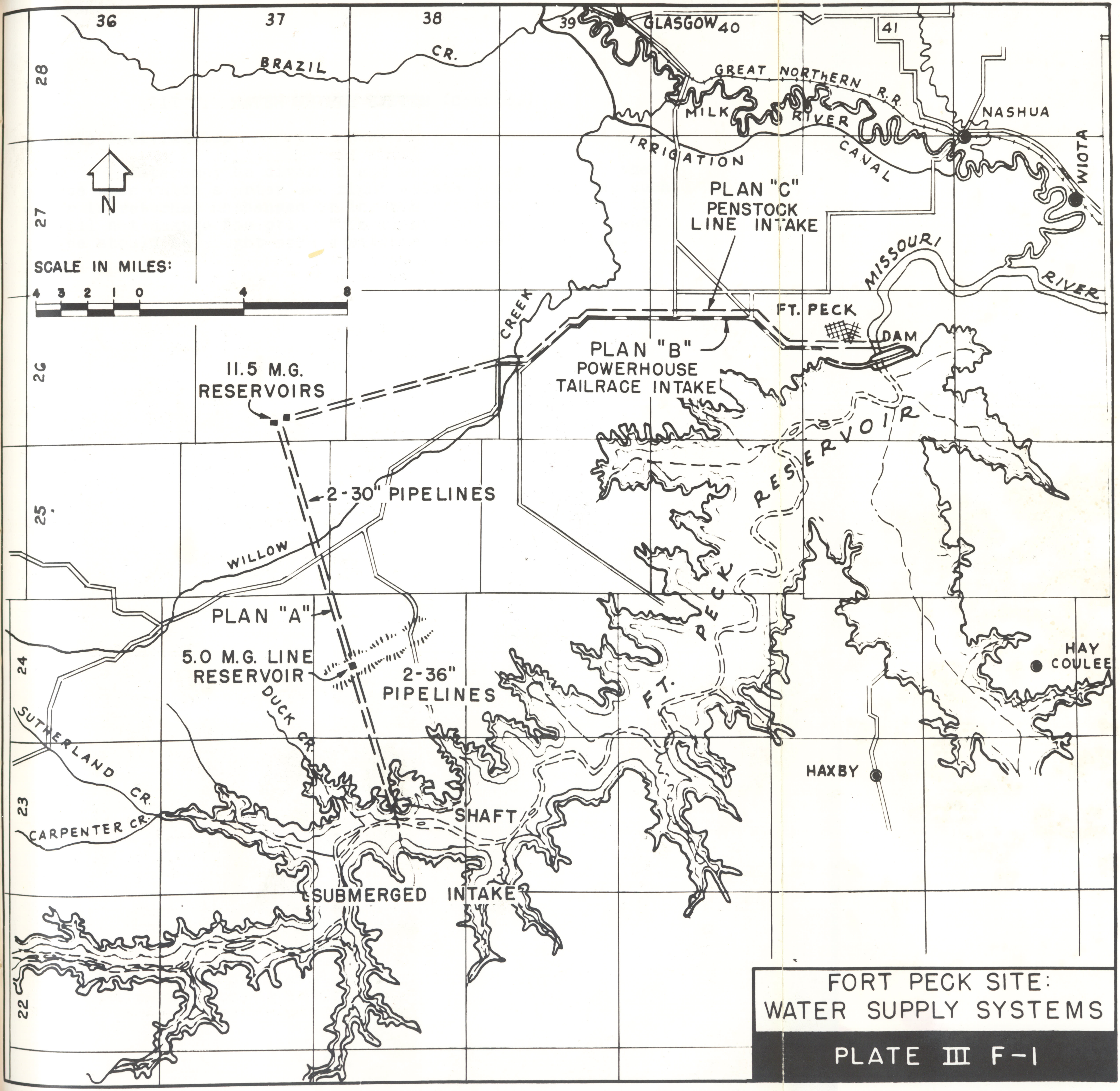
For a detailed description of the methods and costs of the proposed industrial and domestic water supply systems reference should be made to the report of Alvord, Burdick & Howson.

Special Problems:

Several problems exist in connection with the use of water from the Fort Peck Reservoir.

It is likely that some charge will be made by the Bureau of Reclamation for the water taken by the plant. A preliminary discussion of this point indicated that such charge would be between $0.01 per 1,000 gallons and $0.15 per 1,000 gallons. When it is considered that the plant will require 23 million gallons per day, the charge for water would become an appreciable item in the cost of plant operation. On the basis of $0.01 per 1,000 gallons, the daily charge is $230, and at $0.15 per 1,000 gallons it becomes $3,050 per day.

In common with most western states, the State of Montana follows the "use right rule" under which water may be appropriated for use, providing only that such appropriation does not damage a prior "use right" holder. Montana has provided in its laws for water appropriation by the United States Government through the Secretary of the Interior, subject to the same general requirements that apply to appropriation by



FORT PECK SITE:
WATER SUPPLY SYSTEMS

PLATE III F-1

private individuals.

Water may be diverted and used and returned to the source upon which a prior use right exists providing that such water is returned unchanged or in such condition and quantity as will not damage the prior "use right" holder. Local legal advice should be sought upon questions of specific nature.

3. THE POCATELLO SITE

Source and Reliability of Supply:

At the Pocatello Site, the source of water for plant operation would be the large reserve of ground water contained throughout the lava flows. The presence of this large flow of ground water is evidenced by the many springs along the north side of the Snake River below American Falls, and by the numerous successful wells located throughout the plain.

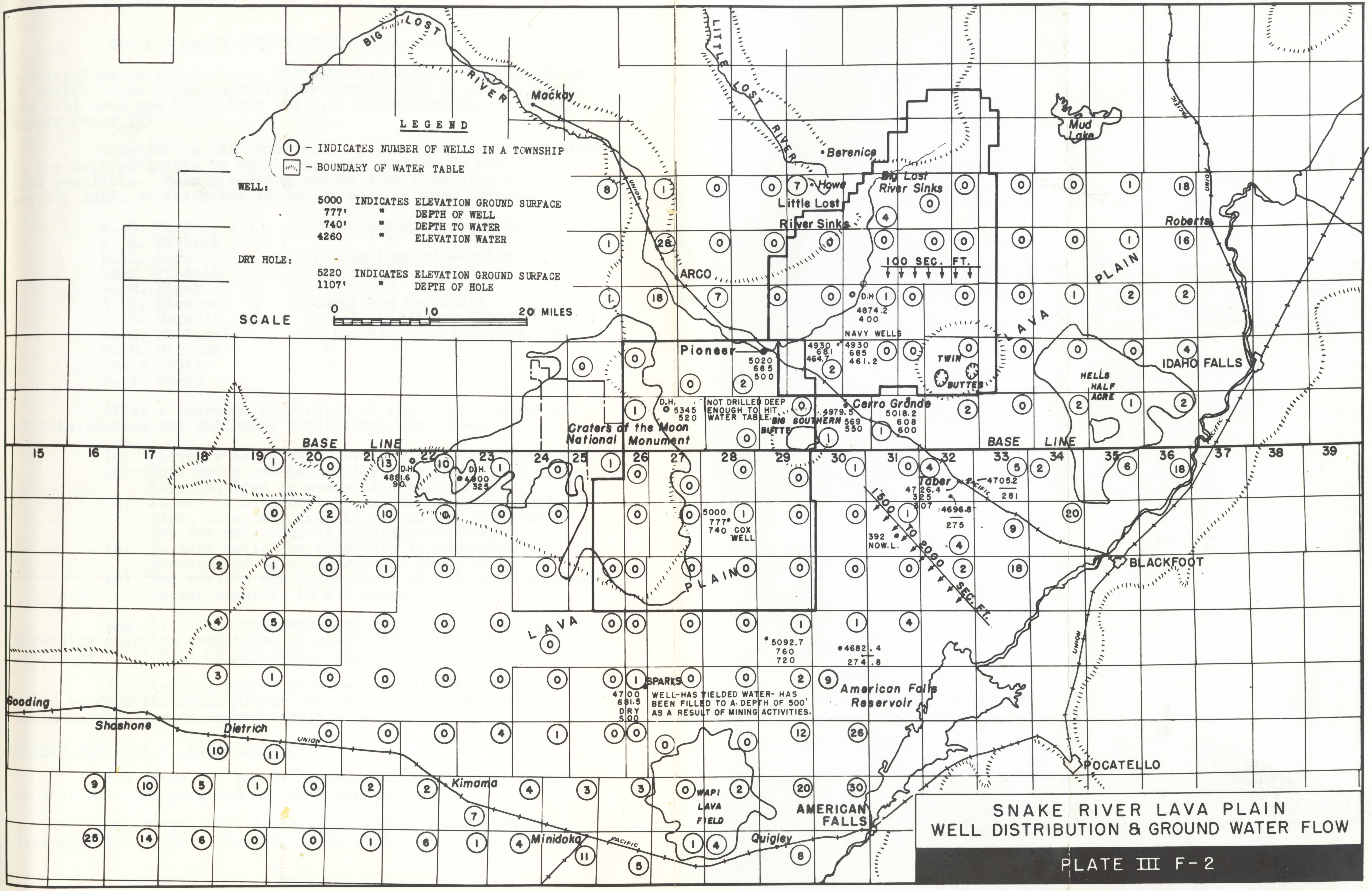
The form and altitude of the water table is fairly well defined except in the central portion of the plain which includes the Lost River and Alternate sites. The lack of well data does not permit a general description of the water table in these areas. However, wells on the Naval Proving Ground and others along the Mackay branch of the Union Pacific Railroad do indicate a definite water table as far northwest as the Proving Ground.

The source of ground water is largely infiltration from the Snake River and from extensive irrigation tracts in the northeastern and eastern portions of the plain above Idaho Falls. According to the best information available, it is conservatively estimated that about 1,500 to 2,000 second feet of water flow southward from this area, converging to pass largely between the Twin Buttes and the Snake River and moving generally southwestward beneath the south half of the lava plain. The amount of flow is believed to be relatively constant from month to month, but may fluctuate over a period of years. The main body of flow at the Twin Buttes is about 20 miles wide so that each mile of width passes 75 to 100 second feet on the average.

From the north, ground water derived from the sinks of the Little Lost and Big Lost rivers, and from Birch, Medicine Lodge, and Camas creeks flows southward, passing between Big Southern and Twin Buttes with some diversion west of the Big Southern Butte. This flow in excess of 100 second feet is distributed unevenly along a 50-mile front. The fluctuation of this ground water is much greater percentage-wise than the main ground water flow.

Some estimates place the total flow of ground water through the Lava Plain as high as 6,000 second feet. This estimate is based on an inventory of the supply and disposal of surface and ground waters in the plain.

Plate III F-2 shows the approximate flow of ground water with respect to the Pocatello Locations. The number of



SNAKE RIVER LAVA PLAIN
WELL DISTRIBUTION & GROUND WATER FLOW

PLATE III F-2

developed wells per township throughout the plain is also shown to assist in determining areas most productive of ground water. The well data was taken from the U.S. Geological Survey Water Supply Paper 775.

Considering the importance of the ground water problem it was felt advisable to hold a special meeting to review the data available. Such a meeting was held at Pocatello on January 17, 1949, at which the following persons were present:

R. S. Warner, Jr.	Atomic Energy Commission
J. K. Pickard	" " "
R. L. Nace	U.S. Geological Service
Lynn Crandall	" " "
A. M. Piper	" " "
H. T. Stearns	Consulting Geologist
D. H. Maxwell	Alvord, Burdick & Howson
W. S. MacKenzie	Smith, Hinchman & Grylls, Inc.
G. H. Giguere	" " " "
David Banta	" " " "
P. J. Cnare	" " " "

After a thorough discussion of the several aspects of this problem the following conclusions were reached:

(a) There is ample water available in the lava flows;
(b) This water can be readily obtained in the quantity required by means of a well field;
(c) It may be necessary to go some distance from the plant site, say five to ten miles, in order to tap the main body of underground flow;
(d) No test wells are necessary to establish the presence of this underground flow; and
(e) The quality and temperature of this ground water is satisfactory in all respects.

Domestic water for permanent housing would be met by expanding existing facilities of established communities affected by the influx of population due to the project.

An alternate source of water supply for the plant would be from the Snake River. The use of Snake River water would require a much longer supply line.

<u>Method and Cost of Distribution</u>:

Two plans for the development of plant water supply at this site are proposed by the consultants.

The first, Plan A, entails tapping the ground water resources of the lava plain by means of a well field. On the basis of a conservative estimate, 30 wells would be necessary to develop the required 23 million gallons per day. The wells would be arranged in two parallel lines approximately as shown in Plate III F-3. The average depth of well would be about 800 feet. The estimated construction cost of this project is $9,760,000, and the annual pumping cost is estimated at $85,000 based on a 600-foot lift and a power cost of 3.5 mills per kilowatt hour. At the time the Consultants' report was prepared, it was assumed that power costs at Pocatello would be 3.0 mills per kilowatt hour. However, more recent information indicates that power costs will be 3.5 mills per kilowatt hour.

Test drilling would be unnecessary, as it would be more economical to explore with wells of such size that could be utilized if a good water supply is tapped. Provision is made in the cost estimate for 30 dry or low-yielding wells.

The alternate, Plan B, is a system for pumping water directly from the nearest point on the Snake River, about 41 miles directly east of the site. The estimated construction cost would be about $20,130,000 and the annual pumping charges would be approximately $49,000.

Plate III F-3 shows both methods for supplying water at the Pocatello Site.

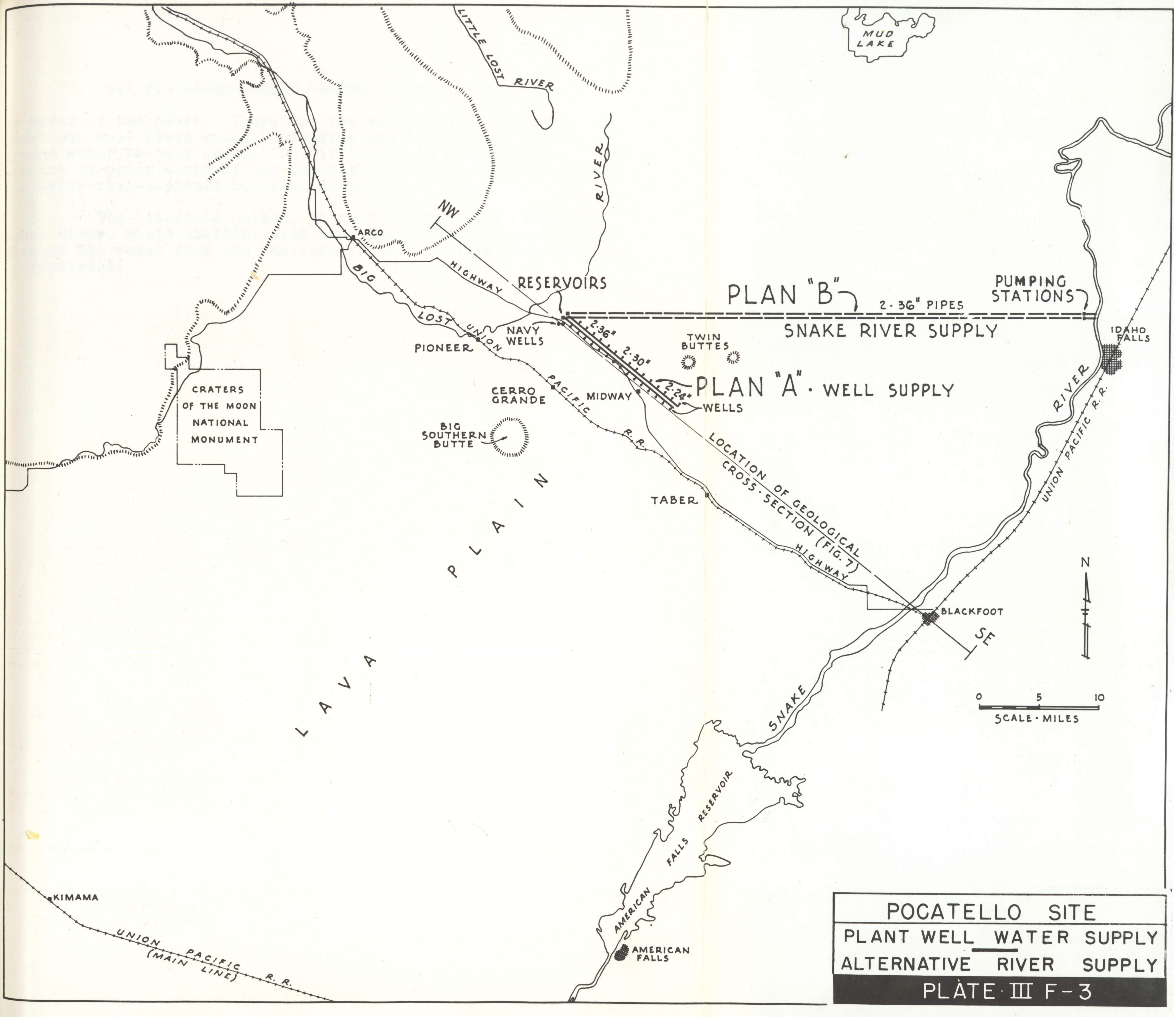
Mr. Harold T. Stearns suggests the use of one or more large shafts extending below the water table with its floor perforated with wells or with horizontal tunnels projecting out at the bottom sides into the main aquifer. Test wells should be drilled prior to shaft excavation to assure maximum yield and to locate as close to the site as possible. This plan probably presents the most economical system of water supply as a few higher capacity pumps would be capable of handling the total requirements.

The estimated cost of developing 6 new wells for the 6 million gallon per day domestic water supply requirement is about $131,000, with an additional $380,000 to cover cost of a distribution system.

For a detailed description of the proposed methods and costs of water supply at this site reference should be made to the report of Alvord, Burdick & Howson.

<u>Special Problems</u>:

Under the Idaho laws, if it is established that a later appropriator of ground water depletes the supply to which an earlier appropriator of either surface or ground water is entitled, the water being used by the later user can be cut off



POCATELLO SITE

PLANT WELL WATER SUPPLY

ALTERNATIVE RIVER SUPPLY

PLATE III F-3

by order of the court. There are few wells now in the area where the well field would be located and the flow of underground water is very great. No difficulty is expected on account of prior users of the underground water, although claims for water rights should be filed promptly.

The alternate method, that of taking water from the Snake River, would conflict with the rights of prior users since most of the water from the American Falls Reservoir is already appropriated.

4. SUMMARY

Ample water is available at either site. At Fort Peck the plant requirements would be taken from the Fort Peck Reservoir, while at Pocatello the supply would be from the underground water table. Both sources are adequate and thoroughly reliable.

The report of the Consultants on this problem indicates that the cost of developing the water supply will be slightly less at Pocatello than at Fort Peck.

The question of water rights and State and Federal laws relating to this point should be thoroughly studied before proceeding with the erection of a plant at either site. Application for water rights should be filed at both locations pending final selection of the site to be used.

There will be a charge for the use of water from the Fort Peck Reservoir. No firm figure is available at this time, but it is estimated that this charge will be between $0.01 and $0.15 per 1,000 gallons. On the basis of the lowest figure, the daily and annual charge for water at Fort Peck is $230 and $69,000 respectively. The annual charge for pumping will be $92,000 at Fort Peck and $85,000 at Pocatello.

IV. ADMINISTRATIVE AND OTHER CHARACTERISTICS

A. Availability of Manpower

B. Availability of Materials

C. Population and Social-Economic Factors

D. Availability of Land

E. Construction and Operational Costs

F. Transportation

G. Electric Power

H. Fuel Availability and Costs

IV A. AVAILABILITY OF MANPOWER

1. THE FORT PECK SITE

Construction Labor:

Within the area covered by a 200-mile radius, a total of 3,636 construction workers were resident employees in 1948. For the entire State of Montana a total of about 10,500 were employed in construction with such labor being in short supply. No easing of demand for this labor is foreseen, since projects under construction will require this many or more for the next several years. The Hungry Horse Dam project alone will require 4,000 workers shortly after the opening of the construction season in 1949. It is apparent that construction labor for a major project in the Fort Peck area would have to be recruited from labor sources outside Montana.

Operating Labor:

Of the total of 71,284 employed labor force in the State of Montana, it is estimated that 9,000 may be classified as nontechnical operators, a figure 5% below the national average and reflecting the lack of industrialization of the area. In the area close to the Fort Peck Site there are no industrial centers where such labor might be obtained. Operating labor would probably have to be drawn from distant points such as Spokane, Washington, and Minneapolis--St. Paul, Minnesota. The technical personnel required for the project would not be available locally, and recruitment would be necessary regardless of where the project is located.

Supporting Services:

The necessary doctors, policemen, tailors, barbers, and other supporting services would not be available locally and would have to come from outside the area.

2. THE POCATELLO SITE

Construction Labor:

Within the area covered by a 200-mile radius a total of about 15,000 construction workers were resident employees in 1948 with such labor being in short supply, requiring the importing of labor in some cases from distances of over 500 miles. No easing of this situation is foreseen in the immediate future by the State Employment Service or trade union heads. Several industrial projects as well as government and private utility dams are under construction or will be started in the near future. This construction would compete with a new project in the Pocatello area for construction labor. This labor would have to be recruited outside Idaho.

Operating Labor:

Of the total labor force of 234,000 in the State of Idaho, it is estimated that about 27,000 may be classified as nontechnical operators, a figure nearly 7% below the national average. It is estimated that about 20,000 of these may be classified as craftsmen, almost 3% below the national average. Because of the low degree of industrialization and the high degree of employment, it may be expected that difficulty will be encountered in recruiting operating labor from this area. The comment made regarding technical personnel for the Fort Peck Site applies also to this area.

Supporting Services:

The area surrounding the Pocatello Site contains a number of fair-sized communities, as discussed in IV C, Population and Social-Economic Factors. Supporting personnel, however, would be inadequate to serve the new population associated with this project, and additional doctors, lawyers, etc., would have to come from outside the area.

3. SUMMARY

It is likely that all classes of construction, operating, and supporting personnel would have to be imported from outside a 200-mile radius of the Fort Peck Site.

The Pocatello Site is surrounded by a number of fair-sized communities and Salt Lake City is within 215 miles of the site. While some labor can be drawn from these sources, a considerable quantity will have to be imported from distant points.

IV B. AVAILABILITY OF MATERIALS

1. THE FORT PECK SITE

Construction Materials:

Materials in general are in better supply than at any time since the war. Manufacturers, jobbers, and suppliers are presently maintaining stock lists of all standard commercial building products with few exceptions. Some iron and steel products, nails, and cement are still in short supply.

Cement production remains critical due to heavy demands placed upon this industry by the Corps of Engineers, the Bureau of Reclamation, and private industry. This is particularly true of the areas being studied. The logical source for the Fort Peck Site is the Ideal Portland Cement Plant located at Trident, Montana, but previous commitments upon this plant by the Bureau leaves little surplus capacity for the ensuing two years. Ample supply, however, to meet the anticipated demands is available from Ideal Cement Company at Devil's Slide, Utah, and Idaho Portland Cement Company at Inkom, Idaho. Additional large production facilities are located at Mason City, Iowa, and Duluth, Minnesota, as well as plants at Spokane, Washington, and Eastern, Oregon.

Hydrated and quick lime are obtainable from the Ellison Lime Company at Helena and Hanover, Montana, and Evans Washington.

Lumber, of all commercial types and grades, is currently in good supply. This includes dimension and framing, structural, railroad ties, and manufactured plywood of all types. While there is no lumber production in the immediate area of Fort Peck, there is ample production of coniferous species, including Western and White Pine and Fir at Kalispell, Libby, and Missoula, Montana; and Emmett and Lewiston, Idaho. Practically limitless production of Douglas Fir, Hemlock, and Cedar is obtainable at Everett, Snoqualmie Falls, and Longview, Washington; and at Eugene, Springfield, and Klamath Falls, Oregon.

Finish wood products including trim, sash, frames, doors, and similar items, are readily obtainable from mills in Billings, Kalispell, Missoula, and Libby, Montana.

Some forty mills in northwestern Montana are currently producing railroad cross and switch ties of Larch, Douglas Fir, and Lodgepole Pine. Two creosoting plants, one in Paradise and the other at Somers, Montana, are currently pressure-treating ties.

Concrete aggregate for the construction of the Fort Peck Dam was obtained from stream deposits at Cole, Montana. These deposits contained well-rounded sand and gravel with some glacial rock 2 to 6 inches in size. This material is a mixture of igneous and limestone pebbles, three fourths of which are 2 inches in size and smaller. The Great Northern Railroad is currently screening and crushing the oversize for ballast. Cole, Montana, (Phillips County) is located on Whitewater Creek, 44 miles west of Glasgow. It is to be noted that this material contains a small percentage of ironstone concretions which are in evidence on exposed finished concrete surfaces at the Fort Peck Dam spillway.

Considerable tonnage of rip-rap facing on the upstream face of the Fort Peck Dam was quarried at Snake Butte, located south of Harlem, Montana. This material is an extrusive igneous rock, dark and fine-grained although somewhat porous. It is excellent material for oil-aggregate road construction and railroad ballast. There are numerous other gravel deposits of excellent quality but located at greater distances such as those at Grenora and Lignite, North Dakota.

Gravel terraces are found adjacent to the Missouri River and are composed largely of sand and gravel of the smaller sizes of gradation. These terraces are particularly well defined below the mouth of the Yellowstone River.

Granite of very excellent quality has been quarried for a great number of years in the St. Cloud, Minnesota, area. Two crushers are presently in production with a maximum potential of 3,000 yards per day. Excellent quality aggregates are available from producing plants at Detroit Lakes, Minnesota, and Sioux Falls, South Dakota.

Liquid asphalt materials for road construction are produced at Kevin and Cut Bank, Montana, known as the Kevin-Sunburst Field. This field is located about 300 miles west of Glasgow on the Great Northern Railroad. The Wasatch Oil Company also has a refinery at Great Falls.

Reinforcing steel production is still quite critical and remains in short supply. This shortage is universal throughout the industry. The best verbal commitment obtained was

1,000 tons on six-month delivery. Assuming the proposed project would qualify under the voluntary allocation program, then a rescheduling of commitments could ease this situation.

If it could be established that re-rolled rail steel could be substituted for new billet, this would also tend to improve the reinforcing steel supply as it has been determined that relatively heavy tonnages of this material are now committed to the defense program. Re-rolled rail steel currently is in better supply. Reinforcing steel normally would come out of the Chicago or Minneapolis-St. Paul areas for the Fort Peck Site.

The structural shapes and steel plate market situation with respect to delivery remains comparable to that of reinforcing steel. Here again, recourse to voluntary allocation quantities would have to be taken to meet the requirements of a construction schedule. In addition to the large eastern producers, Colorado Fuel and Iron at Pueblo, Colorado, Geneva Steel Company (U.S. Steel) at Provo, Utah, and Kaiser Steel Company at Fontana, California, should be considered. However, it is to be remembered that current production of the last three companies mentioned is limited to standard 15" I-beams and channels and 6" equal angles. There are no wide flange sections in current rollings.

Steel wire products remain in short supply although it is indicated that the situation is improving. All types of nails are in production by American Steel and Wire Company (U.S. Steel) at Duluth, Minnesota, which could serve the Fort Peck Site.

Chain link fence and accessories, barbed wire, and similar items, are in good supply in large quantities from reputable suppliers such as Cyclone (U.S. Steel), Colorado Fuel and Iron, and Page Fence.

Steel windows of standard types and sizes are in good supply. If stock sizes and special sizes are combined, carload shipments can be made on a 12-week basis.

Steel joists shipments can be made on 15-week delivery following approval of shop drawings.

Steel deck is considered in reasonably good supply. Shipments are available in from 12 to 14 weeks, following approval of shop drawings.

Brick and hollow load bearing and partition tile are not produced in the Fort Peck area. However, limited quantities are produced at Great Falls, Helena, Lewiston, and Billings, Montana, and there is sizeable production near Spokane, Washington. Salt-glazed partition tile is produced in the Spokane area on reasonably good delivery. It is recommended that designs minimize the use of these materials because of long shipping distances.

Asbestos products are in plentiful supply. Such products include asbestos flexboard, transite sheets both in flat (1/4" to 2") and corrugated (allotment basis), and asbestos shingles. These products, manufactured by Johns-Manville, would be shipped from their plant at Waukegan, Illinois, for the Fort Peck Site.

Asphalt shingles, rag and asbestos base roofing felts are available for sizeable shipments on short notice.

Rock wool insulation (vapor seal) and insulation boards (wood fibre) are in good supply at Waukegan, Illinois, and Natchez, Mississippi.

Wood and cane fibre tempered hardboards are in good supply for interior finish and concrete form lining.

Gypsum products, including plaster, partition tile, rock lath, and sheet rock, are in good supply. United States Gypsum Company, a large supplier of these products, has a plant at Heath, Montana.

All plumbing and heating supplies, including valves, fittings, fixtures, and brass goods, except steel and iron pipe, are in good supply. Many of the items in this category are either manufactured or well represented in the Chicago area. Materials of this nature for the Fort Peck Site would be ordered through or furnished from stocks within the Chicago area.

Steel pipe, including butt weld, seamless, and electric weld, both in galvanized and black, remains in a critical status. Here again, the larger producers including National Tube, Youngstown Sheet and Tube, Wheeling, U.S. Steel, Republic, and Jones and Laughlin are all currently operating under the voluntary allocation program with sizeable tonnages committed to governmental priority projects. Larger pipe size (over 24") deliveries would be contingent on delivery of plate.

Steel sheet in hot or cold rolled black or galvanized, as in the case of all allied steel products, remains in short supply.

As an alternate for steel sheet, particularly ventilation ducts, the substitution of aluminum sheet should be considered. This material offers some material advantages over steel as it is easier to fabricate, lighter in weight, less resistant to air flow, and generally requires no painting. It does have the disadvantage of lacking the strength of steel in comparable gauges and will require added stiffening members for structural stability.

The Henry J. Kaiser Company (Permanente Metals Corporation) Trentwood Rolling Mill located near Spokane, Washington, has a current estimated monthly production of 20 million pounds of sheet aluminum from .020" sheet to 1" plate. This firm is currently booking orders for 60 to 90-day delivery. It is also manufacturing corrugated sheet and some rolled sections in aluminum. This material would be quite readily available for direct rail shipments to Fort Peck as well as Pocatello. Added to this is the current potential of 50 million pounds per month from Alcoa's new plant at Davenport, Iowa.

Boilers and pumps, although somewhat dependent on steel production, are generally in good supply. Facilities for this type of production are located at Billings, Butte, Bozeman, and Helena, Montana; Spokane, Washington; Salt Lake City and Ogden, Utah; and the Chicago-Milwaukee areas.

Cast iron pipe and fittings for sanitary sewers and water distribution remain on the critical list. The availability of cast iron soil pipe and fittings in sizes 4" to 8" is improving but they are not at present in plentiful supply for quantity shipments.

The largest productive sources for this class of material are centered around Birmingham, Alabama. It is to be noted, however, that McWane Cast Iron Pipe Company (Pacific States Cast Iron Pipe Company) at Provo, Utah, is putting a new foundry into production for producing 4" to 24" centrifugal cast pressure pipe (water main) Type I, class 150 and class 250. This plant has a potential capacity of 100,000 tons per year and could ship 10 carloads per day. This is the only plant west of the Mississippi producing this type of material; it also produces cast iron brass-trimmed gate valves and fire hydrants.

Other large producers of pressure pipe include James B. Clow & Sons, U.S. Pipe and Foundry, Alabama Pipe Company, McWane Cast Iron Company, and American Cast Iron Pipe Company, all of which are located in the Birmingham area. These plants are capable of producing centrifugal cast pipe from 4" to 24" and pit cast from 4" to 84" in the 150 and 250-pound class. Deliveries vary from 4 to 14 months.

Precast concrete pressure pipe should be considered as a substitute for cast iron as this type of material is quite readily obtainable from Montana producers located in Billings, Great Falls, and Helena. This material should also be considered for sanitary and effluent sewer systems.

Railroad rail and accessories, including spikes, tie plates, angle bars, track bolts, and switches, remain on the list of critical steel items.

Electrical equipment in general is in good supply, except for high voltage sub-station equipment and some types of transmission conductors. Only one report will be made with respect to availability of electrical equipment, as all pertinent facts are equally applicable to both the Fort Peck and Pocatello Sites.

Wood transmission poles are in ample supply from many pole plants which are well distributed throughout the forest areas of western Montana and Idaho. The supply of timber of pole quality is far in excess of current demands. There are 10 nonpressure treating plants in Montana and one known full-pressure treatment plant at Libby, Montana.

Transmission wire of aluminum and steel is in short supply due to heavy demands of utilities companies. Alcoa is the principal producer of this material. Copper transmission cable, while more expensive, is in good supply. Anaconda Copper Mining Company operates a large rod and wire mill at Great Falls, Montana.

High tension insulators are in good supply as is generally true of the ceramic industry. Large producers of this type of commodity are the Locke Insulator Corporation, Baltimore, Maryland, and Ohio Brass Company at Mansfield, Ohio.

High voltage transformers and switch gear are currently on long-term delivery. The manufacturers are scheduling this type of equipment on 28-month delivery. Probably, equipment could be obtained from war surplus stocks or local power companies for supplying power during construction operations.

Electric wire and cable of all types including bare, weatherproof, and rubber-covered are in good supply. Large producers include General Electric, Rome Cable Corporation, and Anaconda.

Conduit in general is currently in short supply. Both Youngstown and Republic have allocated considerable quantities of this material for A.E.C. projects.

Fractional housepower motors are in good supply.

Motors of from 5 to 150 horsepower are on good delivery. Motors from 500 to 750 horsepower are currently on 24 to 30-week delivery.

Wiring devices of all types are currently stock items and in good supply. Commercial grades of lighting fixtures, including fluorescent, are in ample supply.

Explosion-proof wiring devices and fixtures, while slower on delivery, are not regarded as being critical. Principal producers of this equipment include Crouse-Hinds Company, Russel-Stoll, and Appleton Electric Company.

Operational Supplies and Maintenance Facilities:

It is not within the scope of this report to discuss or evaluate the availability of productive materials required for the operation of the plant.

Sources of nonproductive supplies and maintenance facilities have been explored and are as follows:

Castings; Gray Iron, Steel, and Patterns. The nearest gray iron foundries are located at Minot, North Dakota, 276 miles to the east, where castings up to 1,200 pounds can be poured; and at Great Falls, Montana, 276 miles to the west, where castings up to 3,000 pounds can be poured. At Butte, Montana, 446 miles to the west, 7,000-pound castings can be poured. For castings over 7,000 pounds and for steel castings, it is necessary to go to Minneapolis (760 miles), Salt Lake City (843 miles), or Portland (1,062 miles). Pattern shops are at Minneapolis and Butte.

Electrical; Motors, Supplies, and Contractors. Motors up to 200 horsepower can be repaired at Minot, North Dakota. Motors up to 600 horsepower can be repaired at Great Falls, Montana. Services for field repairing of large motors can also be secured from Great Falls. There are good stocks of electrical supplies and capable contractors in the distribution centers along the Great Northern Railroad, the nearest being 276 miles west at Great Falls, Montana.

Plumbing. There are ample stocks of plumbing supplies and capable contractors along the Great Northern Railroad, the nearest source being at Great Falls. The Crane Company maintains a branch warehouse in this city.

Hardware and Mill Supplies. Hardware and mill supplies for industrial purposes are stocked at distribution centers along the Great Northern Railroad, the nearest being Great Falls. For lesser quantities of small items such as would be used for household and commercial services there are local sources at Glasgow.

<u>Machine Shops</u>. There is a good light machine shop at Great Falls. The only heavy machine shops in this area are the railroad shops, the nearest being at Havre, Montana.

<u>Plate, Structural Steel, and Boiler Shops</u>. There are good stocks of material and boiler shop facilities at Great Falls. Other facilities are located at Billings, but these are considerably farther by rail from the plant site.

<u>Industrial Sheet Metal</u>. There are sheet metal shops and limited stocks of sheet metal at Great Falls and Billings.

<u>Oils and Lubricants</u>: At Minot, North Dakota, Great Falls, and Cut Bank, Montana, good stocks of oils and lubricants are maintained. The Standard Oil Company has a bulk plant at Glasgow.

The sources of the maintenance services and materials mentioned are summarized in Table IV B-1.

TABLE IV B - 1

SUMMARY OF MAINTENANCE SERVICES AND MATERIALS
THE FORT PECK SITE
(ALL DISTANCES AND EXPRESS TIMES ARE TO GLASGOW, MONTANA)

Location of Source Rail Express Time, Source, to Fort Peck Rail Distance, Source, to Fort Peck	Great Falls, Mont. 7 Hrs. 276 Miles	Minot, N. D. 5 Hrs. 15 Min. 276 Mi.	Helena, Mont. 10 Hrs. 40 Min. 374 Mi.	Butte, Mont. 13 Hrs. 15 Min. 446 Mi.	Livingston, Mont. 18 Hrs. 15 Min. 496 Mi.	Fargo, N. D. 9 Hrs. 10 Min. 509 Miles	Billings, Mont. 20 Hrs. 55 Min. 612 Miles	Spokane, Wash. 20 Hours 683 Miles	Minneapolis Minn. 15 Hrs. 25 Min. 760 Mi.	Portland, Ore. 31 Hrs. 30 Min. 1062 Miles
1. Castings and Patterns:										
Gray Iron	x	x	x	x	-	-	-	x	x	x
Max. casting - 1200#	-	x	x	-	-	-	-	x	x	x
Max. casting - 3000#	x	-	x	-	-	-	-	x	x	x
Max. casting - 7 Ton	-	-	-	x	-	-	-	x	x	x
Over 7 Ton	-	-	-	-	-	-	-	-	x	x
Steel	-	-	-	-	-	-	-	-	x	x
Pattern Shops	-	-	-	x	-	-	-	x	x	x
2. Electrical:										
Motor rewinding and repair										
Up to 200 HP	x	x	-	x	x	-	x	x	x	x
200 HP to 600 HP	x	-	-	x	x	-	-	x	x	x
Over 600 HP and in the field	x	-	-	-	-	-	-	x	x	x
Supplies	x	x	-	x	-	x	x	x	x	x
Contractors	x	x	-	x	-	x	x	x	x	x
3. Plumbing:										
Supplies	x	-	-	x	-	x	x	x	x	x
Contractors	x	x	-	x	-	x	x	x	x	x
4. Hardware and Mill Supplies:	x	-	-	x	-	x	x	x	x	x
5. Machine Shops:										
Light	x	x	x	x	x	-	x	x	x	x
Heavy	x	-	-	-	x	-	-	x	x	x
6. Plate, Structural & Boiler Shops:	x	-	x	x	x	-	x	x	x	x
7. Industrial Sheet Metal:	x	-	-	x	-	-	x	x	x	x
8. Oils and Lubricants:	x	x	x	x	-	x	x	x	x	x

2. THE POCATELLO SITE

Construction Materials:

Cement production at the Pocatello Site is more favorable from the standpoint of availability. The Idaho Portland Cement Company has a plant 12 miles south of Pocatello on the Union Pacific Railroad at Inkom. Present daily capacity is about 1,150 barrels; this plant is not faced with any heavy commitments.

The Ideal Portland Cement Company's plant at Devil's Slide, Utah, has capacity in excess of previous commitments. This plant now has a potential capacity of one and a quarter million barrels per year. Mr. Chris Dobbins, executive vice-president for Ideal, stated that his company could furnish a million barrels of cement over a three-year period for a new project located in the Pocatello area.

In considering the subject of concrete, particularly with respect to the Pocatello Site, engineers in recent years have become cognizant of concrete failures in the Snake River areas. These failures are attributed to the combining of high alkaline cements with reactive concrete aggregates.

It has been determined by the Bureau of Reclamation that use of puzzolanic materials will inhibit or reduce the expansion due to alkali-aggregate reaction. Serious consideration should be given to this problem with respect to any concrete structures contemplated within the Pocatello area.

Concrete aggregates for the Naval Proving Ground were produced in the Arco area. A visual inspection of this material indicates that the aggregates are of good quality and gradation. Large deposits of this material are plentiful within the area.

The Idaho Bureau of Highways staff commented that the quality and gradation of this material indicate it to be of good quality other than the possibility of reactivity previously mentioned. An examination of concrete structures at Arco gave no indication that reactions are taking place. It is conceivable that sufficient time has not elapsed to determine whether or not this material is reactive. Gravel-producing plant equipment would have to be established at the site for the production of the aggregates. Other gravel sources are at Carey, Blackfoot, Pocatello, and American Falls, but aggregates from these sources are likely to be reactive.

Lumber availability for Pocatello is essentially the same as for the Fort Peck Site, with the following exceptions. Considerable lumber production is available from Lewiston and Emmett, Idaho. Sizeable quantities of framing and dimension lumber are currently warehoused and wholesaled through Morrison-Merrill & Company in Pocatello.

Finish millwork including sash, frames, doors, and trim are readily obtainable through Morrison-Merrill & Company, located at Salt Lake City, who operate a sizeable stock and custom millwork factory. This is the largest lumber manufacturer which services this area.

Railroad cross and switch ties are in ample production in Western Idaho. Union Pacific operates a large pressure-creosoting plant in Pocatello.

Petroleum asphalt materials meeting Idaho Bureau of Highway specifications are produced by the Idaho Refining Company (Wasatch Oil Refining Company) in Pocatello. The products of this plant are in good supply with a potential capacity of six and one-half million gallons per year. This is the largest supplier of this commodity in the State.

Reinforcing steel availability for Pocatello is essentially the same as for the Fort Peck Site. A portion of the required tonnage of this commodity could possibly be obtained from the Colorado Fuel and Iron Corporation at Pueblo, Colorado.

Pocatello would be in a better position for the delivery of rail shipments of re-rolled rail reinforcing steel.

Statements relative to the availability of structural shapes and plate with respect to the Fort Peck Site are applicable to Pocatello.

However, Pocatello is much closer to productive capacity of the iron and steel industry located west of the Mississippi, including the Geneva Steel Company (U.S. Steel) at Provo, Utah; Colorado Fuel and Iron Corporation at Pueblo, Colorado; and steel plants in the Los Angeles and San Francisco areas of California. While the scope of these plants is limited with respect to range of sizes (15" I beams, 15" channel, and plate 3/16" to 1½"), their capacity is considerable.

Steel wire products are still regarded to be in short supply in large quantities. Production sources for nails would be the Colorado Fuel and Iron, Pueblo, Colorado, and Keystone Steel and Wire, Peoria, Illinois. The Colorado Fuel and Iron could supply a minimum quantity of two cars per month (40-50 tons).

Chain link fence, barbed wire, and accessories are in good supply with the closest source being Colorado Fuel and Iron, Pueblo, Colorado.

Steel sash, joists, and metal roof decks suppliers in this area are Ceco Steel Products, Detroit Steel Products, and Truscon Steel Company. As previously stated, these items are in good supply on short-time delivery.

Brick (common and face), load bearing and partition tile, fire brick, flue lining, vitreous pipe, and associated clay products have well-defined production in the Salt Lake City-Ogden areas and Denver, Colorado. It is indicated that products of these plants are in plentiful supply.

Designs involving masonry materials should be minimized because of material and transportation costs.

All asbestos products are in good supply. For immediate delivery, Johns-Manville would normally furnish the Pocatello Site from their plants at Waukegan, Illinois, and Pittsburg, California. All information on asbestos products previously mentioned with respect to Fort Peck would apply equally to Pocatello.

Gypsum products including accoustical materials, insulation, metal and rock lath, lime, partition tile, plaster, and gypsum plank are in good supply. U.S. Gypsum Company, largest supplier of these items, has plants at Sigurd, Utah, and Fort Dodge, Iowa.

All plumbing and heating supplies with the exception of steel and cast iron pipe are in good supply.

Steel pipe remains in a critical status and comments previously mentioned under Fort Peck would apply to Pocatello. The Pocatello branch of the Crane Company has a substantial stock of steel pipe up to 6" in black and to 4" in galvanized. This plant also has some Byers Genuine Wrought Iron Pipe.

Sheet metal availability for Pocatello is the same as for Fort Peck.

Cast iron pipe and fittings, as previously stated, remain in short supply. All statements relative to cast iron pipe and fittings for the Fort Peck Site are equally applicable to Pocatello, with few exceptions. Pocatello is much closer to the Pacific States Cast Iron Pipe Company at Provo, Utah.

There are reasonably good stocks of 4" and 6" soil pipe and fittings in Pocatello and Salt Lake City.

Rails and accessory statements relative to availability for the Fort Pock Site apply equally to Pocatello. However, Pocatello is much closer to the Colorado Fuel and Iron Company at Pueblo, Colorado. This company is currently committed to heavy tonnage under the voluntary allocation program. Rail switches are also produced in Pueblo by the Ramado-Ajax Company.

Operational Supplies and Maintenance Facilities:

Sources of nonproductive supplies and maintenance facilities have been explored and were found to be generally available in Pocatello, Idaho, except for certain items. For iron and steel castings and for patterns it is necessary to go to Salt Lake City, Utah; Butte, Montana; or Portland, Oregon.

Other sources of these materials and services are shown in Table IV B-2.

At Pocatello, a major railraod repair shop is operated by the Union Pacific Railroad. Arrangements can be made for the use of these facilities as may be required in plant maintenance work.

TABLE IV B - 2

SUMMARY OF MAINTENANCE SERVICES AND MATERIALS
THE POCATELLO SITE
(ALL DISTANCES AND EXPRESS TIMES ARE TO POCATELLO, IDAHO)

Location of Source Rail Express Time, Source, to Pocatello, Ida. Rail Distance	Pocatello, Idaho	Salt Lake City Utah, 5 Hrs. 10 Min.170 Mi.	Butte, Mont. 8 Hrs.5 Min. 263 Miles	Helena, Mont. 10 Hrs. 50 Min. 335 Miles	Portland, Ore 19 Hrs.45 Min 726 Miles
1. Castings and Patterns:					
Gray Iron	-	x	-	x	x
Max. casting - 3000#	-	x	x	x	x
Max. casting - 7 Ton	-	x	x	-	x
Over - 7 Ton	-	x	-	-	-
Steel	-	x	-	-	x
Pattern Shops	-	x	x	-	x
2. Electrical:					
Motor rewinding and repair					
Up to 200 HP	x	x	x	-	x
200 HP to 600 HP	x	x	x	-	x
Over 600 HP & in the field	x	x	-	-	x
Supplies	x	x	x	-	x
Contractors	x	x	x	-	x
3. Plumbing:					
Supplies	x	x	x	-	x
Contractors	x	x	x	-	x
4. Hardware & Mill Supplies:	x	x	x	-	x
5. Machine Shops:					
Light	x	x	x	x	x
Heavy	x	x	-	-	x
6. Plate, Struc. & Boiler Shops:	x	x	x	x	x

3. SUMMARY

Most items of equipment and materials of construction are in good supply at the present time. Steel pipe, structural shapes, plate, and reinforcing steel remain under voluntary allocation by the producers and delivery for these items remains critical.

Materials such as cement, aggregate, brick and clay products, lumber, valves, and fittings are in good supply. Electrical equipment and materials, except for conduit, certain wire, and high voltage transformers and switch gear, are in good supply. Delivery on the latter items remains at from 18 to 24 months or more.

In general, the sources and points of production of most items are much closer to the Pocatello Site. These items include cement, aggregates, steel and iron products, brick and clay products, and millwork. Transportation charges for such materials would be appreciably less. Supplies of electrical equipment would come from the same sources regardless of plant site.

Some concern is had for the concrete failures in the Pocatello area. These failures are attributed to the combining of high alkaline cements with reactive concrete aggregates.

The Bureau of Reclamation is using a low alkali Portland cement (type II) and adding puzzolanic materials at the mixer as a safeguard in the concrete used on the Hungry Horse Dam in Montana.

It is recommended that a similar procedure be followed on this project. Advice of the Bureau of Reclamation Laboratory, Denver, Colorado, should be sought in this connection, and they should be requested to test the proposed aggregates from the Arco area to determine if these materials are reactive.

Maintenance and repair facilities are available in Pocatello, Idaho, and Salt Lake City, Utah, both of which are close to the Pocatello Site. Similar facilities to serve the Fort Peck Site can be found only at much greater distances from Fort Peck. The Pocatello Site is fifty miles from Pocatello, Idaho, and 220 miles from Salt Lake City. Fort Peck is 276 miles from Great Falls and much farther from other cities which would have complete maintenance facilities.

IV C. POPULATION AND SOCIAL-ECONOMIC FACTORS

1. THE FORT PECK SITE

Proximity to Communities Within 100 Miles:

For purposes of this report, communities within 100 miles of the site have been divided into two groups, those within 50 miles and those located between the 50 and 100-mile circles around the Fort Peck Site. In the tabulation which follows, for communities within 50 miles of the site, all those communities having populations of 300 or more are included.

TABLE IV C-1

FORT PECK SITE
COMMUNITIES WITHIN 50-MILE RADIUS
(POPULATIONS OF 300 OR MORE)

Town	Population	Distance From Site (Miles)	Driving Distance (Miles)
Glasgow	5,000	30	40
Fort Peck	4,000	28	35
Nashua	1,000	37	54
Jordan	677	38	270
Saco	452	45	83
Hinsdale	325	39	69
Frazer	300	47	71

The following are communities having populations of 1,000 or more and lying between the 50 and 100-mile circles around the Fort Peck Site:

Harlem
Malta
Poplar
Scobey
Wolf Point

Characteristics of all towns with populations of more than 1,000 and within 100 miles of the site are presented in Table IV C-2.

TABLE IV C-2

FORT PECK SITE: CHARACTERISTICS OF COMMUNITIES WITH MORE THAN 1,000 POPULATION AND WITHIN 100-MILE RADIUS

	Glasgow	Nashua	Harlem	Poplar	Malta	Scobey	Fort Peck	Wolf Point
County	Valley	Valley	Blaine	Roosevelt	Phillips	Daniels	Valley	Roosevelt
Road Distance To Site	35	54	158	112	111	144	35	90
Population	5,000	1,000	1,166	1,442	2,215	1,300	4,000	2,000
Water System	Yes	N.F.	N.F.	N.F.	N.F.	N.F.	Yes	N.F.
Sewage System	Yes	N.F.	N.F.	N.F.	N.F.	N.F.	Yes	N.F.
Sewage Treatment	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.D.	N.F.
Gas Distribution	Yes	N.F.	Yes	N.F.	N.F.	N.F.	Yes	N.F.
Housing Units	1,694	438	N.D.	N.D.	N.D.	N.D.	Gov't. only	N.D.
Hotel Rooms	215	0	0	50	132	50	0	116
Schools: Grade	2	1	1	1	1	1	Gov't. only	1
Pupils	568		389	351	448	320	"	566
High	2	1	1	1	1	1	"	1
Pupils	456		127	39	187	150	"	206
Church Denominations	11	1	4	2	3	2	N.D.	3
Medical: Hospitals	1	0	1	(Gov't.)1	0	0	Gov't. only	1
Total Beds	60	0	47		0	0	"	18
Doctors	6	0	3	1	2	2	"	3
Dentists	3	0	0	0	0	0	"	0
Retail Stores	128	11	N.D.	N.D.	N.D.	N.D.	0	N.D.
Wholesale Establishments	16	0	0	0	0	0	0	0
Industries: Establishments	6	0	14	9	17	2	1	6
Recreation: Theatres	2	1	1	1	1	1	0	2
Total Seats	800	288	280	300	265	350	0	910
Other	Golf	None	None	None	None	None	None	None
Note: N.F. - No Facilities	Skeet	"	"	"	"	"	"	"
N.D. - No Data	Bowling	"	"	"	"	"	"	"
	Swimming	"	"	"	"	"	"	"
	Tennis	"	"	"	"	"	"	"
	Park	"	"	"	"	"	"	"

IV C. POPULATION AND SOCIAL-ECONOMIC FACTORS (Cont'd.)

Industrial, Economic, and Social Characteristics of Communities:

All of the area included within the site boundary lies within Valley County, which has an area of 5,072 square miles and a population of about 15,600. Of this population, approximately 10,000 live in the towns of Glasgow, Fort Peck, and Nashua, while the remainder are scattered on farms, ranches, and in small towns throughout the rest of the county. About 250 farm and 1,040 ranch operators live in Valley County. The average net buying income per family in 1947 for this county was $4,644. The total estimated labor force for the county in 1948, except farms, was 4,300.

In general, the area surrounding the site is very poorly developed industrially. There are no cities of more than 10,000 in population within 200 miles of the site other than Great Falls and Billings. Because of the limited transportation system, both of these cities are considerably farther away from a practical standpoint. The towns are generally of a rural character, and facilities such as hospitals, recreation, housing, wholesale, industry, and utilities are very limited or nonexistent. There are no wholesale centers within 100 miles. Secondary wholesale centers are located at Havre, 170 miles by rail; Great Falls, 276 miles; and Billings and Helena, 370 miles. The most readily accessible primary wholesale center is Minneapolis-St. Paul, approximately 525 miles by rail from Glasgow.

As previously noted, data are presented in Table IV C-2 showing the characteristics of principal communities located within 100 miles of the Fort Peck Site. Eight communities having populations of 1,000 or more are included in the tabulation. The largest of these, Glasgow, has a population of 5,000. Fort Peck, the second largest and with a population of 4,000, is a military establishment. Because of the nature of this town, it is not believed that any substantial population can or should be added here.

Within a radius of 50 miles of the site, parts of Valley, Garfield, and Phillips counties are included. The table on the following page is a summary of population, social, and economic characteristics for these counties.

Within these counties there are:

Schools - Public	18	Hospitals	2
Private	3	Doctors	one per 1,500 to 3,000 population
Teachers	146		
Pupils-Elementary	2,278	Churches	41
-High School	943	Theatres	7 (2,675 seats)

TABLE IV C-3

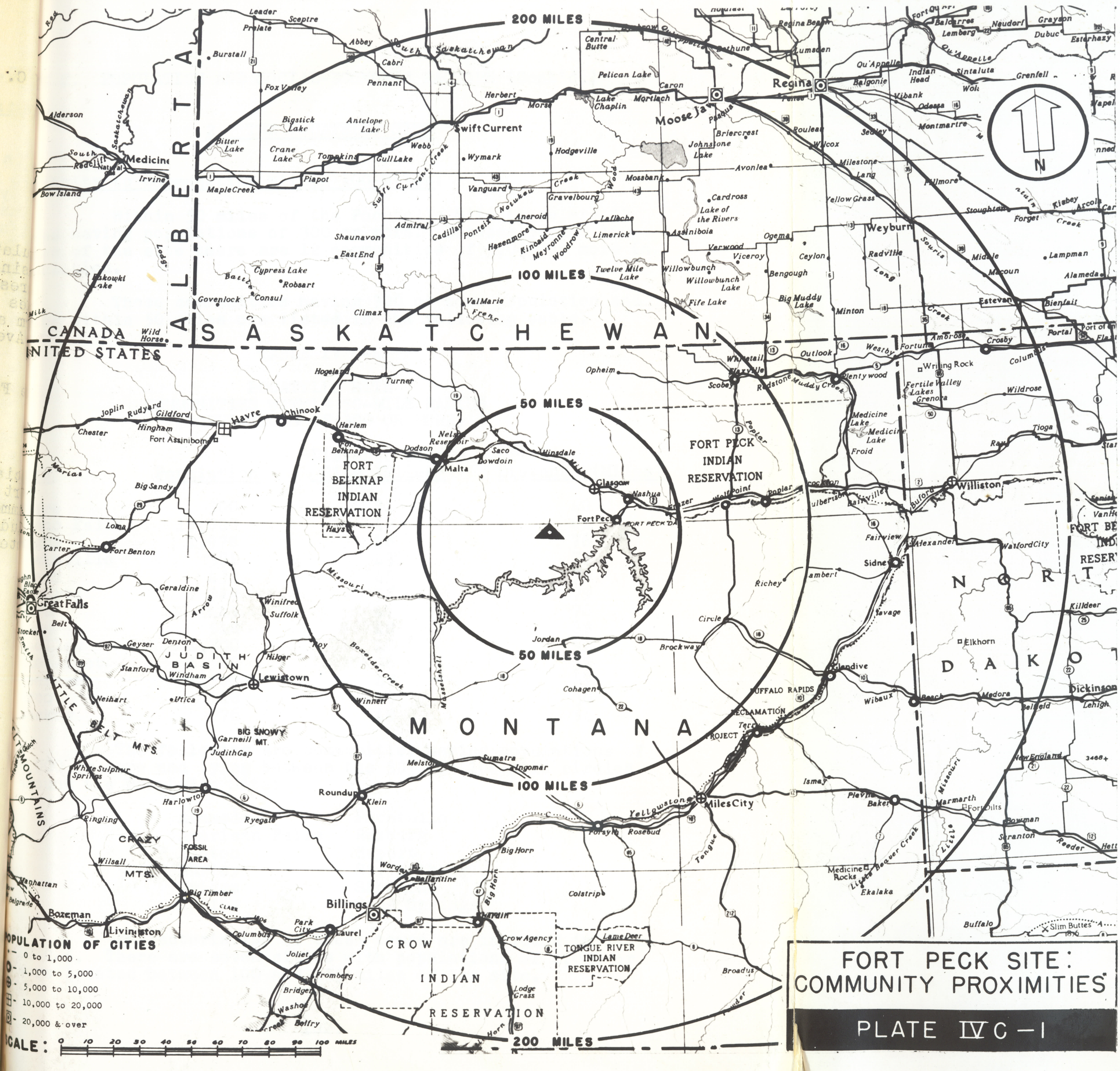
FORT PECK SITE
CHARACTERISTICS OF COUNTIES
WITHIN 50-MILE RADIUS

	Valley	Garfield	Phillips
Population	15,000	2,100	7,892
Housing Units	5,094	891	2,657
Stores	276	37	114
Sales (000's)	$13,726	$ 843	$5,774
Farm and Ranch Income - Total (000's)	$ 8,420	$2,674	$4,790
Average	$ 7,393	5,491	5,184

Plate IV C-1 shows the geographical relation between the Fort Peck Site and the surrounding area.

Montana has no state sales or income tax.

For additional detailed information on industrial and social characteristics of communities within 200 miles of the Fort Peck Site, reference may be made to the report of Mr. George Summerfield, Public Relations Consultant. This report is included in the appendix and is titled "Social and Economic Characteristics of the Fort Peck and Pocatello Sites."



FORT PECK SITE: COMMUNITY PROXIMITIES

PLATE IV C-1

2. THE POCATELLO SITE

Proximity to Communities Within 100 Miles:

Within 50 miles of the Pocatello Site there are 13 towns having populations of 300 or more. Between 50 and 100 miles of the site there are 12 communities of 1,000 or more in population.

Those communities having 300 or more population and lying within 50 miles are listed in the following table.

TABLE IV C-4

POCATELLO SITE
COMMUNITIES WITHIN 50-MILE RADIUS
(POPULATIONS OF 300 OR MORE)

Town	Population	Distance From Site (Miles)	Driving Distance (Miles)
Moore	300	31	40
Idaho Falls	19,000	42	61
Rigby	1,978	48	76
Lewisville	371	43	77
Menan	432	45	79
Roberts	319	38	79
Ucon	449	47	70
Iona	518	48	68
Shelley	1,800	40	52
Blackfoot	5,500	36	38
Aberdeen	1,500	47	67
Arco	548	26	30
Mackay	776	48	54

The following are communities having populations of 1,000 or more and lying between the 50 and 100-mile circles around the Pocatello Site:

Alameda	Pocatello
American Falls	Rexburg
Ashton	Rupert
Burley	St. Anthony
Driggs	Shoshone
Hailey	Soda Springs

Characteristics of these towns are included in Table IV C-5. There are seven cities with populations of 1,000 or more located between 100 and 125 miles of the site.

Industrial, Economic, and Social Characteristics of Communities

The area lying within the boundary of the Pocatello Site (Big Lost River location) includes parts of three counties Jefferson, Bingham, and Butte. Less than 26 per cent of the area lies within Jefferson and Bingham counties and none of the population or dwelling units in these counties are included in the site area. The remainder of the area in Butte County is sparsely populated, with the entire county having only 2,000 residents. Of this population, approximately 100 live in the vicinity of Howe and are adjacent to the site area. Within the site boundary there are not more than 2 dwelling units. For Butte County, the average net buying income per family was $2,444 for 1947. The total estimated labor for the county was 77, excluding farm labor.

The area lying within 100 miles of the Pocatello Site includes substantially all of the Snake River Lava Plain, which is practically uninhabitated. The Lava Plain is bounded by the Snake River on the east and south, and along the river a number of fair-sized communities have developed. Several of these, such as Pocatello and Idaho Falls, have appreciable industrial activity. Phosphate deposits near Pocatello are expanding in importance and several large plants are operating or are being constructed for purposes of exploiting this material. In general, however, the communities are essentially rural in character, having grown in size as the extent of irrigated lands along the Snake River has been increased.

Schools, hospitals, housing, recreational facilities utilities, and similar services are fairly well developed in the larger communities, but would not be adequate for the large population associated with this project. However, the services which now exist could probably be expanded to accommodate substantial increases if distributed among the several larger cities along the Snake River. The characteristics of the principal communities lying within 100 miles of the Pocatello Site (Big Lost River location) are presented in Table IV C-5, as previously mentioned.

Included in the cities listed in Table IV C-5 are 17 communities having populations of 1,000 or more. The largest of these is Pocatello, with 31,000. Idaho Falls, with 19,000 and Burley, with 7,000, are the second and third largest cities in this area. The site area is accessible to secondary wholesale centers at these cities and at Burley-Rupert as well. Boise and Salt Lake City are major wholesale distribution centers and are about 185 and 215 miles, respectively, from the site.

Parts of the following counties are within a radius of 50 miles of the site:

Bingham	Clark
Blaine	Jefferson
Bonneville	Madison
Butte	

Parts of Lemhi, Fremont, Bannock, and Custer counties are also included but their areas are not considered to be significant in this study. For the counties listed, the following table is a summary of population, social, and economic characteristics.

TABLE IV C-6

POCATELLO SITE
CHARACTERISTICS OF COUNTIES
WITHIN 50-MILE RADIUS

	Population	Housing Units	Stores	Sales (000's)	Gross Farm Income (000's)	Gross Income Per Farm
Bingham	20,100	5,328	214	6,814	12,278	5,354
Blaine	4,500	1,708	132	6,122	1,906	5,977
Bonneville	22,800	6,812	295	13,257	10,944	6,308
Butte	2,000	568	33	1,096	11,364	5,207
Clark	800	300	18	522	770	6,645
Jefferson	9,300	2,625	114	5,195	6,109	4,330
Madison	7,500	2,274	97	32,204	5,399	6,641

Within these counties are:

Schools -	Public	92	
	Private	2	
Hospitals		8	
Churches		36	(not including Morman Wards)
Theatres		22	

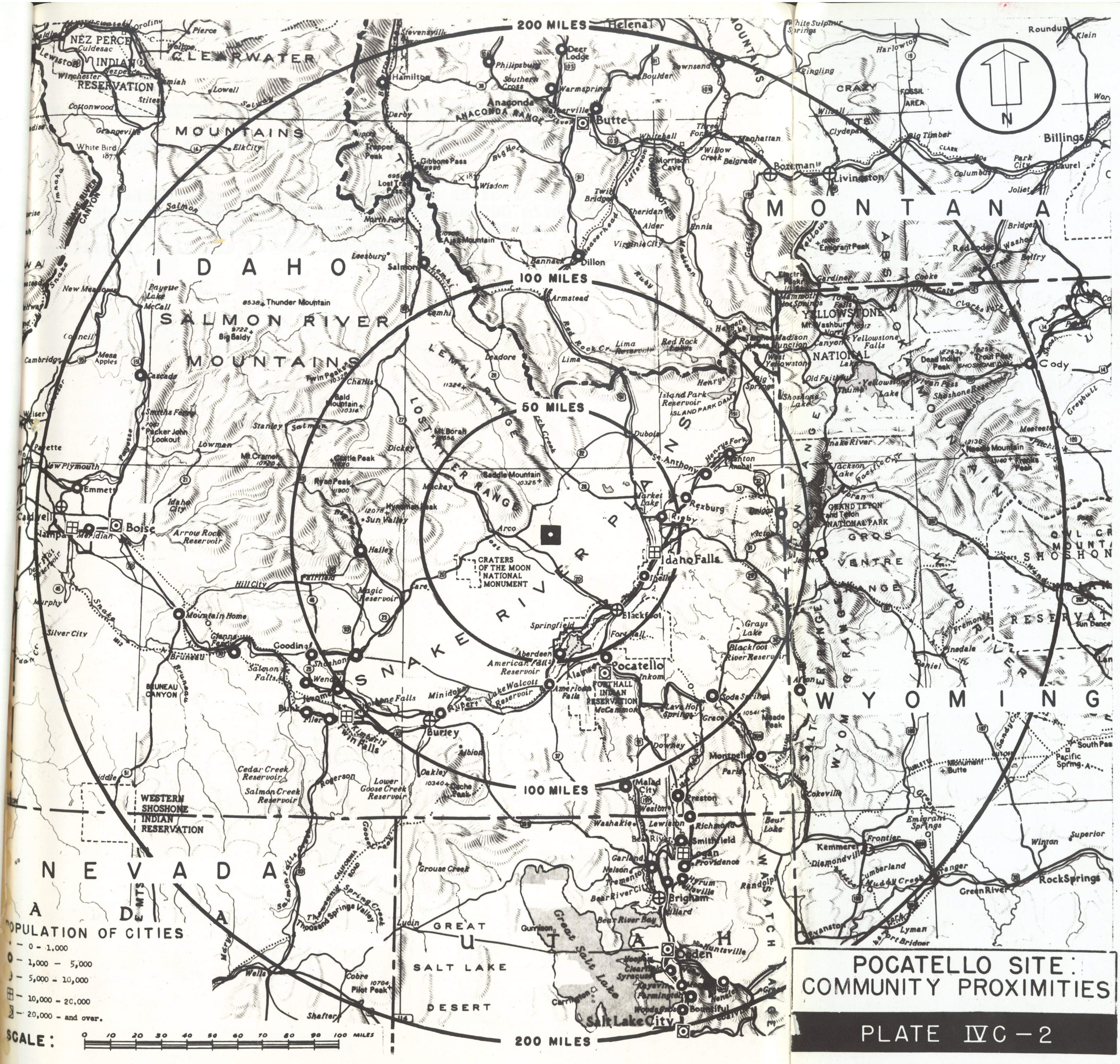
Plate IV C-2 shows the geographical location of the Pocatello Site and the cities and towns in the area around the site.

The Craters of the Moon National Monument lies about 45 miles west of the site. The park entrance is on U.S. Highway 20, about twenty miles from Arco. The accommodations are limited to three tourist cabins, a camp site, a cafe, and gasoline station, in addition to a registration building and headquarters building.

TABLE IV C-5

POCATELLO SITE: CHARACTERISTICS OF COMMUNITIES
WITH MORE THAN 1,000 POPULATION AND WITHIN 100-MILE RADIUS

	Pocatello	Idaho Falls	Burley	Blackfoot	Rexburg	Rupert	St. Anthony	Rigby	Shelley	Aberdeen	Hailey	American Falls	Shoshone	Soda Springs	Ashton	Driggs	Alamada
County	Bannock	Bonneville	Cassia	Bingham	Madison	Minidoka	Fremont	Jefferson	Bingham	Bingham	Blaine	Power	Lincoln	Cariban	Fremont	Teton	Bannock
Road Distance To Site	62	61	145	38	93	136	117	76	52	67	97	98	107	130	140	136	61
Population	31,000	19,000	6,000	5,000	3,500	4,050	2,800	1,978	1,800	1,500	1,443	1,439	1,366	1,087	1,203	1,040	2,691
Water System	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sewage System	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N.F.	Yes	N.F.	Yes	Yes	N.F.	Yes
Sewage Treatment	N.F.	N.F.	N.F.	N.F.	N.F.	Yes	N.F.	Yes	N.F.	Yes	N.F.	N.F.	N.F.	N.F.	Yes	N.F.	Yes
Gas Distribution	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.
Housing Units	5,700	4,165	1,445	1,181	894	957	741	529	432	N.D.	478	460	401	N.D.	314	N.D.	650
Hotel Rooms	774	400	85		70	50	60	50	0	0		44	50	80	75	26	0
Hotels	6	7	1	4	1	1	2	1	0	0	2	1	2	1	1	1	0
Schools: Grade	13	9	3	2	1	2	2	1	4	2	1	1	1	N.D.	1	N.D.	Incl. in Pocatello
Pupils	6,400	N.D.	N.D.	1,064	N.D.	N.D.	N.D.	N.D.	850	489	249	N.D.	N.D.	N.D.	N.D.	N.D.	"
High	1	1	1	1	1	1	2	1	1	1	1	1	1	N.D.	0	N.D.	"
Pupils	Incl. above	N.D.	N.D.	469	N.D.	N.D.	N.D.	N.D.	Incl. above	257	142	N.D.	N.D.	N.D.	0	N.D.	"
College Students	1,800	N.F.	One college	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.
Church Denominations	22	8	8	5	4	3	6		3	6	3	5	4	N.D.	3	N.D.	N.D.
Medical: Hospitals	2	2	1	2	1	0	0	0	0	0	1	1	0	1	0	0	0
Total Beds	175	139	32	N.D.	15	0	0	0	0	0	22	20	0	34	0	0	0
Doctors	36	23	7	13	4	6	4	5	3	2	2	3	4	3	2	0	1
Dentists	N.D.	N.D.	2	3	1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D	N.D.
Retail Stores	256	211	N.D.	67	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Whole Establishments	54	20	8	14	0	See Burley	0	0	N.D.	5	5	6	N.D.	N.D.	N.D.	N.D.	N.D.
Industries: Establishments	38	60	16	7	4	See Burley	14	6	0	7	3	6	0	0	0	0	Incl. in Pocatello
Recreation: Theatres	7	4		3	2	1	0	2	1	2	2	1	1	1	1	1	0
Total Seats	5,000	3,000		1,550	1,280	550	0	1,000	500	525	700	325	500	416	400	250	0
Other	Bowling	Zoo	Golf		City Park	City Park						City Park					
Note: N.F. - No Facilities	Baseball	Golf	Park														
N.D. - No Data	Skating	Parks															
	Golf																
	Ballroom																
	Boating																
	Concert																



POCATELLO SITE: COMMUNITY PROXIMITIES

PLATE IVC-2

Idaho has no state sales tax but has a state income tax.

Additional detailed information on industrial and social characteristics of communities within 200 miles of the Pocatello Site is also included in the report of Mr. George Summerfield, which is in the appendix.

3. SUMMARY

The proximities of the sites studied to cities and towns within the 50 and 100-mile radii are as follows:

	Fort Peck	Pocatello
Number of cities with population over 300 and within 50 miles	7	13
Number of cities with population over 1,000 and between 50 and 100 miles	5	12

Housing is in short supply in both areas, there having been little new construction in the past ten years. Schools are carrying almost the maximum load, requiring new facilities to serve any sizable new student body at both Fort Peck and Pocatello.

Doctors and hospitals are overburdened in these areas and are incapable of caring for any new load. There are enough churches in the areas to provide a nucleus around which could be built required additional facilities.

At Fort Peck, other than the development of a complete new residential and shopping center, the assimilation of new construction and operating personnel must fall upon the towns of Glasgow, Nashua, and Fort Peck. Equal distribution of a new population on the order of 25,000 persons among the three towns would result in at least a doubling of the present population.

The rapid accrual of 25,000 additional persons in an area where not more than 10,000 had resided previously cannot but set up a competitive price condition, especially in view of the still generally short supply of goods and the difficulty of obtaining increases in either wholesale or retail allotments. Such a condition would prevail at the Fort Peck Site, where access to either wholesale or retail markets is not convenient.

At the Pocatello Site, a concentration of cities and towns along the American Falls Reservoir and the Snake River provides a housing and population concentration which, within a radius of about 55 miles from the site, amounts to about 125,000 persons. Obviously, the assimilation of 25,000 additional people into this area is capable of accomplishment with far less economic dislocation than would be the case at Fort Peck, especially in view of the far better wholesale and retail market access. It is expected that from this area a considerable number of workers could be drawn, diminishing the labor problem by that number.

There are almost no recreational facilities in the Fort Peck area except of an outdoor character necessitating the provision of a full range of facilities. It is felt that no appreciable value attaches to the proximity of National Parks and Forests and similar outdoor recreation from the standpoint of labor recruitment and retention. Substantially the same remarks can be made about Pocatello.

IV D. AVAILABILITY OF LAND

1. THE FORT PECK SITE

Existing Installations:

Within the site boundary as defined in the introduction no private installations of any kind exist other than a dozen or so dwelling units. A bladed and graded county road crosses the southeastern portion of the site leading to Fort Peck. Other roads on the site are only time-worn prairie trails. A Federal game reserve exists between the southern boundary of the site and the Fort Peck Reservoir. No difficulty is anticipated in securing rights to install and maintain in the game reserve pipe lines and such other facilities as may be necessary between the plant site and the Reservoir.

Land Ownership Characteristics:

Within the site area, approximately 83.5% of the land is Federally owned; the balance is state, county, and privately owned and is of poor character and good only for upland summer grazing.

Residents of the area are ranchers, and building improvements are modest to very poor.

Much of the public land in the site area is leased under the Taylor Grazing Act. Ranch owners' rights to lease such public lands are usually included in the sale of fee-owned property and are made part of the consideration. Most such leases contain provisions covering the right to sell and assure possession, are subject to the right of eminent domain, and in the majority of cases require only advance rental payments for the immediate year of use. No portion of the area of the site is irrigated and it is not potentially irrigable.

Cost of Land:

Assessed valuation of the land under consideration averages about $2.75 per acre. In view of the advancing prices of the past several years, it is estimated that the total acquisition cost of this land will average $3.75 per acre.

2. THE POCATELLO SITE

Existing Installations:

Within the site area of the Big Lost River location as defined in the introduction the private installations include the few homes previously mentioned in the discussion on Population and Social-Economic Factors, an electric power transmission line which runs across the northern portion of the site, and the Mackay branch of the Union Pacific R.R. which cuts across the southwest corner of the site. Public installations within the area are confined to two highways and the Naval Proving Ground. U.S. Highway 20 runs across the southern portion of the site, and State Highway 22 runs along the western boundary. The Navy property covers 173,000 acres and includes 54 buildings, a railroad freight spur, two wells, and electrical services (450 KVA capacity) from the Utah Power and Light Company.

Land Ownership Characteristics:

Within the site area approximately 93% of the land is Federally owned, 3% is probably state owned, and the remaining 4% privately owned. The Public Lands within the area, except for part of the Navy site, are available for lease under the Taylor Grazing Act. There appears to be no prospect that immediately adjacent lands will become more valuable by reason of irrigation or other improvements.

Cost of Land:

It is estimated that the total acquisition cost of the Big Lost River Location will average $3.50 per acre. It is assumed that it will be possible to obtain the 173,000 acres now occupied by the Naval Proving Ground. If this land cannot be obtained the Alternate site discussed under "Site Location" (I D) should be considered. Approximately 90% of the land in the Alternate Location is Federally owned; there are not more than a dozen buildings of all kinds and no permanent residents in this area. The Mackay branch of the Union Pacific R.R. cuts across the northeast corner of the site.

It is estimated that the cost of this land will be about the same as the Big Lost River Location.

IV D. AVAILABILITY OF LAND

1. THE FORT PECK SITE

Existing Installations:

Within the site boundary as defined in the introduction no private installations of any kind exist other than a dozen or so dwelling units. A bladed and graded county road crosses the southeastern portion of the site leading to Fort Peck. Other roads on the site are only time-worn prairie trails. A Federal game reserve exists between the southern boundary of the site and the Fort Peck Reservoir. No difficulty is anticipated in securing rights to install and maintain in the game reserve pipe lines and such other facilities as may be necessary between the plant site and the Reservoir.

Land Ownership Characteristics:

Within the site area, approximately 83.5% of the land is Federally owned; the balance is state, county, and privately owned and is of poor character and good only for upland summer grazing.

Residents of the area are ranchers, and building improvements are modest to very poor.

Much of the public land in the site area is leased under the Taylor Grazing Act. Ranch owners' rights to lease such public lands are usually included in the sale of fee-owned property and are made part of the consideration. Most such leases contain provisions covering the right to sell and assure possession, are subject to the right of eminent domain, and in the majority of cases require only advance rental payments for the immediate year of use. No portion of the area of the site is irrigated and it is not potentially irrigable.

Cost of Land:

Assessed valuation of the land under consideration averages about $2.75 per acre. In view of the advancing prices of the past several years, it is estimated that the total acquisition cost of this land will average $3.75 per acre.

3. SUMMARY

No difficulty is foreseeable in the initial acquisition of the land at either site.

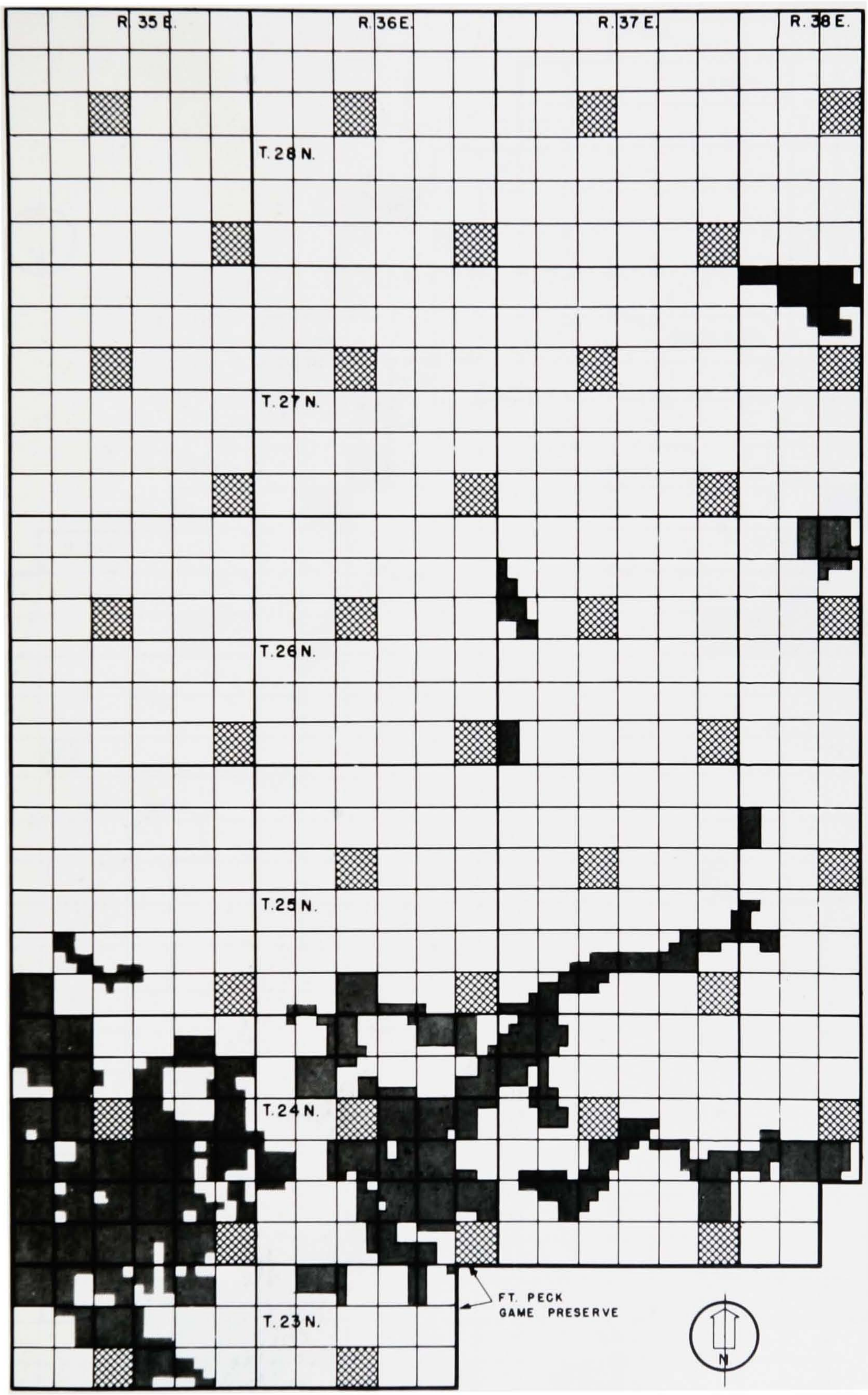
Public lands at both sites are subject to grazing leases. Most such leases contain provisions covering the right to sell and assure possession, and are subject to the right of eminent domain. In the majority of cases this requires only advance rental payments for the immediate year of use. Local legal advice should be sought with regard to specific areas of land.

It is estimated that the average cost of the land at Fort Peck will be $3.75 per acre and at Pocatello $3.50 per acre. On the basis of 400,000 acres, land at Fort Peck will cost approximately $1,500,000 and at Pocatello $1,400,000.

LAND OWNERSHIP CHARACTERISTICS

	FORT PECK	POCATELLO
Number of permanent residents	30	0 to 4
Federally-owned land	87%	93%
State-owned land	5%	3%
Privately-owned land	8%	4%

Plates IV D-1, IV D-2, and IV D-3 show ownership of land for the Fort Peck, Big Lost River, and Alternate locations, respectively.



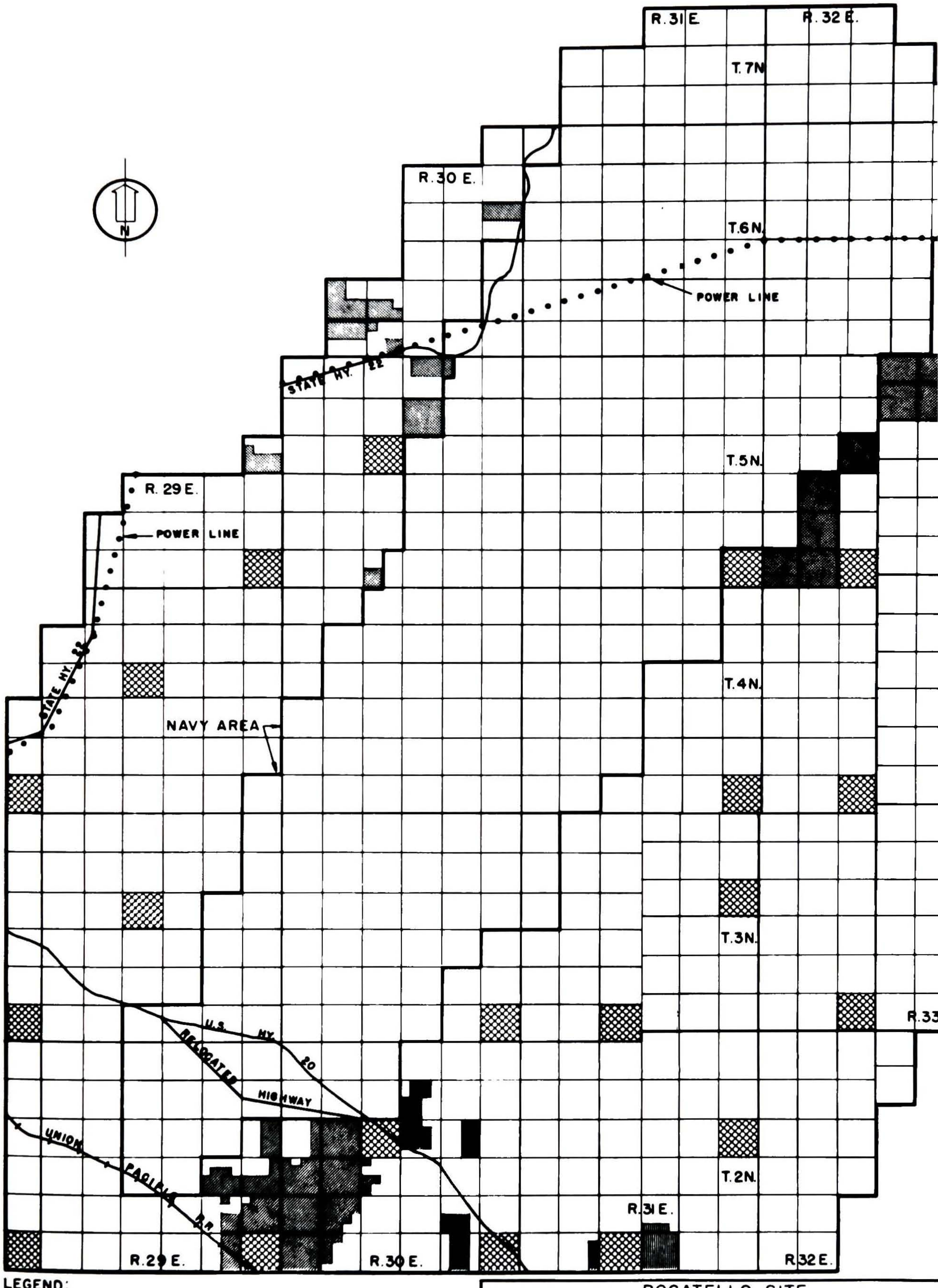
LEGEND:

-STATE OWNED -PUBLIC PROPERTY -PRIVATELY OWNED

SCALE: 0 1 2 3 4 5 MILES

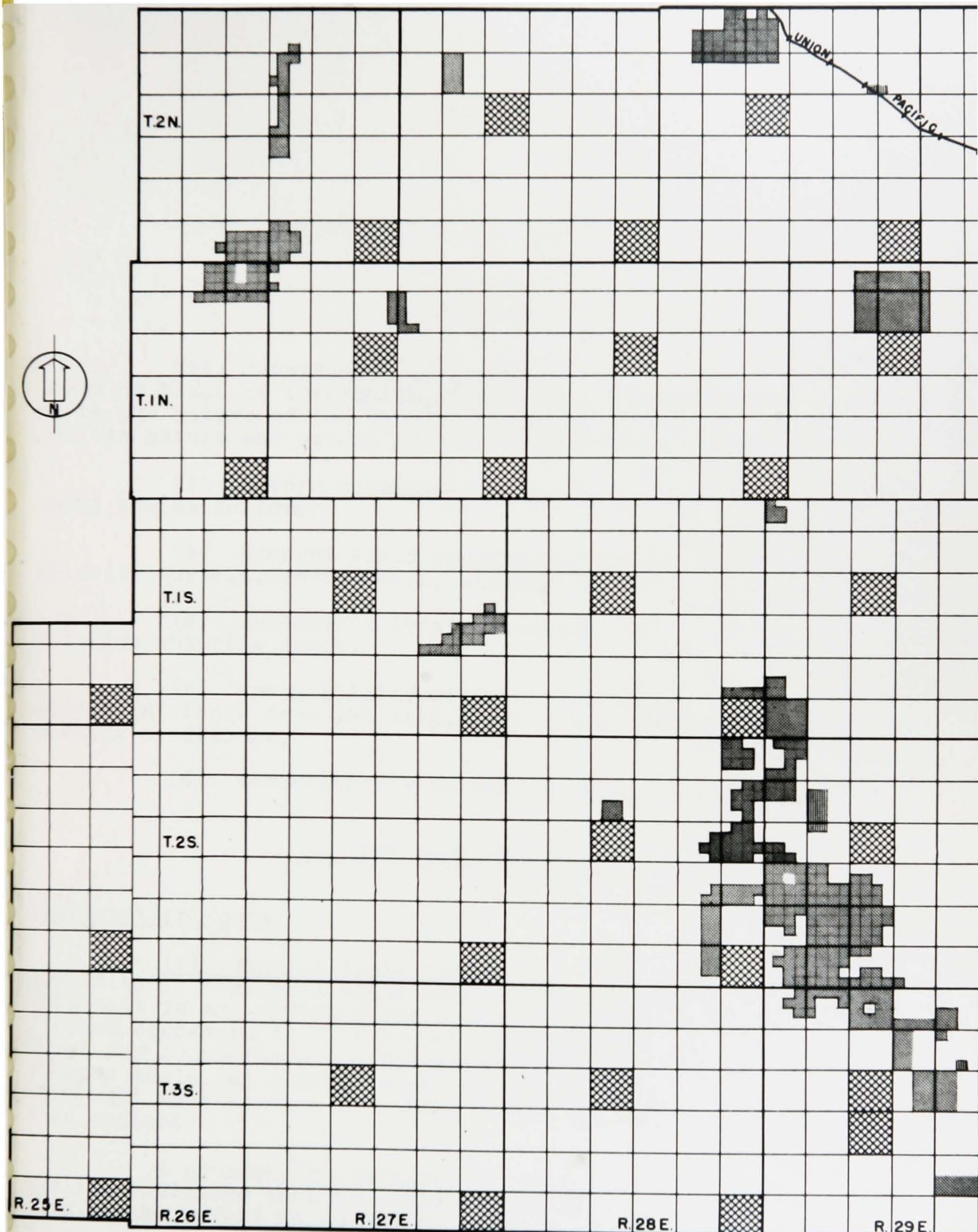
FORT PECK SITE LAND OWNERSHIP

PLATE IV D-1



POCATELLO SITE
BIG LOST RIVER LOCATION: LAND OWNERSHIP

PLATE IV D-2



LEGEND:

- STATE OWNED
- PUBLIC PROPERTY
- PRIVATELY OWNED

SCALE: 0 1 2 3 4 5 MILES

POCATELLO SITE:
ALTERNATE LOCATION: LAND OWNERSHIP

PLATE IV D-3

IV E. CONSTRUCTION AND OPERATIONAL COSTS

1. GENERAL

This consideration of construction and operational costs is based on information which is available for this report as to the nature of the facilities and services to be erected and the nature and extent of the operations to be conducted.

The factors considered in relation to construction costs are as follows:

(a) General Field conditions, including such items as soil, terrain, earthquakes, climate, etc.

(b) Accessibility of materials, as to source and relative shipping costs.

(c) Accessibility of labor, including available supply, distance from job site, wage rates, efficiency, and working conditions.

(d) Accessibility to railroads and highways.

2. THE FORT PECK SITE

Construction Costs:

(a) General Field Conditions: The soil at the Fort Peck Site is a glacial drift containing bentonitic clay (gumbo). This soil is not suitable for supporting heavy loads as explained elsewhere in this report, and for that reason excavations for foundations and footings will need to be made to the Bearpaw shale, an average depth of approximately 15 feet. The shale will then need to be sealed off to prevent change in moisture content.

A preliminary estimate of the cost of excavation and sealing indicates that it would be approximately $2.00, in addition to the normal $1.00 per square foot of ground floor area.

Weather, insofar as it affects construction costs, would not seem to be a determining factor. Fort Peck has, on the average, a high percentage of extreme high and extreme low temperatures but not to the extent that would materially affect costs, particularly over a three-year program.

(b) Accessibility of Materials: In the case of most items of construction, the Fort Peck Site is relatively remote from the sources for these materials. Reference is made to the section of the report on "Availability of Materials" for more information on this subject.

(c) Accessibility of Labor: It is recognized that at either site the greater part of the construction force will need to be imported. This is particularly true of skilled labor. Published wage scales in both areas are approximately the same, but on a project of the size and scope of this one, increased efficiency of labor may be expected at the site nearer the larger sources of labor supply.

Of almost equal importance to supply of labor is the need for keeping workers satisfied and on the job, and minimizing labor turnover. Here again, reasonable proximity to the larger centers provides easier access to home for many and to recreational facilities off-site for all. In this respect Fort Peck is very poorly situated since the nearest large city is approximately 275 miles distant.

(d) Accessibility to Railroads and Highways: Both sites are located near existing railroads and highways. However, highways and railroads at the Fort Peck Site are in an east-west direction only. The center of the Fort Peck Site is approximately 23 airline miles from the nearest point on the railroad and 20 miles to the nearest point on the highway to Glasgow. For more information on railroads and highways, reference is made to the section on these subjects.

Following are some unit costs applicable to the Fort Peck Site, based on field information:

(a) Construction Camp: Housing facilities for construction workers and their families, together with other facilities such as light, power and water, markets, schools, recreation, etc., would be of a temporary nature. Insofar as possible, building construction would be largely of wood. Even so, these facilities will represent a cost of approximately $7,000,000.

(b) Railroads: While the exact location of the off-site (spur line) railroad is not yet established, the general character of the area indicates a cost of approximately $95,000 per mile for off-site railroad and $85,000 to $95,000 for on-site tracks.

(c) Highways and Roads: Conditions affecting the cost of highways indicate an off-site cost of $55,000 per mile for 18-foot wide concrete roadway, and a cost of $43,000 to $45,000 for on-site roads. Area and patrol roads would average about $25,000 per mile for all-weather surfaces.

(d) Power Transmission Lines: For high voltage lines, $26,000 per mile is indicated, and for low voltage lines $12,000 per mile.

(e) Power Sub-Stations: The installed cost of sub-station equipment will vary from $25 per KVA for larger (4,000 KW and up) stations to $30 per KVA for smaller units.

(f) Diesel Generator Stations: Approximately $300 per KW is indicated, based on current jobs in this area.

(g) Power Distribution System: Dependent on the mileage involved the present costs are varying between $13,500 and $15,000 per mile.

(h) Telephone Lines: An average on overhead lines is $6,000 per mile. Underground installations are approximately $15,000 per mile.

(i) Telephone Distribution System: Assuming a ratio of one residential phone to one business or industrial phone, an average unit cost of $260 per phone should cover the cost of a complete telephone system, except telephone lines.

(j) Water System: The cost of the water system for the construction camp and residential areas is discussed in "Water Supply System" (III F.).

(k) Steam Generating Station: The cost of a steam generating station, including boilers, generators, and related equipment, will be approximately $300 per kilowatt of capacity. On the basis of a 20,000 KW unit, the cost would be approximately $6,000,000.

(l) Security Fence: Assuming an installation similar to the one at the Fort Peck Dam, the cost would be about $13,000 per mile for single-line fence, and 4 such lines would cost $52,000 per mile. This does not include electrical lighting or control. Fence lighting would add approximately $10,000 per mile of fence.

(m) Permanent Buildings: Comparative costs of materials and labor indicate that reinforced concrete construction is the logical type for buildings at the Fort Peck Site. Brick masonry is expensive, due to both relatively high freight charges on material and present low productivity on the part of labor.

Following are some average unit cost figures which are based on information from contractors who have done or are doing work in the general area.

TYPE OF BUILDING	AVERAGE COST PER SQUARE FOOT
* Administration - Office, 2 story	$20.00
Warehouse - 1 story	8.00
Garage, 1 story, standard equipment	13.00
Machine shops, 1 story, no equipment	12.00
Service and First Aid - 1 story	18.00
Shops, Markets, 1 story, no fixtures	16.00
Schools, 1 and 2 story	20.00

* Does not include laboratory or hospital facilities.

Operational Costs:

The estimated costs for the supplying of steam, water, and electric power for this project are as follows:

Steam	$1,680,000 per year
Water	$ 161,000 per year
Electric Power	$2,200,000 per year

Included in the cost of water is a charge of $0.01 per thousand gallons for water from the Fort Peck Reservoir. The figure is a preliminary one and in the final determination may vary up to $ 0.15 per thousand gallons.

The cost of steam is based on two times the cost of coal, with coal estimated at $2,800 per day. See the discussion on fuel (IV H.) for more detailed information on cost of coal.

3. THE POCATELLO SITE

Construction Costs:

(a) General Field Conditions: The soil at the proposed site at this location consists of an overburden varying from 1 foot to 8 feet in depth, underlying which is lava. In local areas the depth of topsoil may exceed this figure.

As reported elsewhere, this lava has good bearing qualities and will not retain water. Excavation would be required for utility lines to an average depth of 10 feet for protection against freezing. This would be the equivalent of rock excavation and the cost would be relatively high.

There would also be an increase in the cost of setting poles for overhead power lines, telephone lines, security fences, etc.

Steam distribution lines would be installed overhead on wood pole structures, thus avoiding a considerable amount of rock trenching.

(b) Accessibility of Materials: In general, most materials are available within a radius of 150 miles of Pocatello. Concrete aggregates are obtainable on the site. For more information on material supply, reference is made to the section on "Availability of Materials".

(c) Accessibility of Labor: Reference is made to the section on "Availability of Manpower".

(d) Accessibility to Railroads and Highways: The center of the Pocatello Site is approximately 14 miles from the railroad and highway.

Following are some unit costs applicable to the Pocatello Site, based on field information.

(e) Construction Camp: In this connection, it should be noted that there is located near Pocatello a considerable amount of temporary housing and other structures, and that a considerable saving might be effected if these could be obtained. These structures, located at the Pocatello Army Air Base, have been declared surplus and turned over to the City of Pocatello. It is possible that all or part of these facilities could be obtained and transported to the Pocatello Site and used as a construction camp.

These buildings include barracks for 7,000 persons, mess halls, recreation buildings, administration and storage buildings, hangars, lavatories, theatre, Post Office, etc. Most are of wood construction. Hangars are steel frame with corrugated iron roofs and siding.

There is also available at Midway a former C.C.C. Camp including housing and other facilities for 120 men. This location is very close to the proposed site. These facilities are privately owned at present, but could be purchased as part of the site. With some rehabilitation this could serve as a preliminary headquarters.

(b) Railroads: No off-site railroad will be required. On-site reailroad is estimated at $90,000 per mile.

(c) Highways and Roads: An allowance of $50,000 per mile for on-site highways and $25,000 per mile for area and patrol roads is indicated. No off-site highway will be required.

(d) Power Transmission Lines: Setting an average of 7 pole-line structures per mile in rock will add $1,000 per mile over normal, depending on the amount of lava encountered. A cost of $27,000 per mile for high voltage lines is indicated. Setting 18 structures per mile for on-site low voltage lines will add $1,700 per mile over normal. Costs are estimated at $13,500 per mile for on-site low voltage lines, carrying both power and telephone.

(e) Power Sub-Stations: Some saving in the cost of substructures can be effected, but not enough to reflect in the over-all cost. The cost is estimated at $25 per KVA, the same as Fort Peck.

(f) Diesel Generator Stations: The cost here is the same as at Fort Peck, $300 per KW.

(g) Power Distribution System: Costs are estimated at $13,500 per mile plus $1,500 per mile for rock excavation, or an average of $15,000 per mile.

(h) Telephone Lines: The estimate is $6,000 per mile plus $1,500 per mile for rock excavation, or $7,500 per mile for overhead lines.

(i) Telephone Distribution: Costs are the same as at Fort Peck, assuming the same requirements, or $260 per telephone.

(j) Water System: The cost of water system is set up in the discussion of that subject (III F.).

(k) Steam Generating Station: The cost of this facility at Fort Peck was estimated to be $6,000,000. Of that amount, approximately $4,500,000 would be mechanical work and equipment, and $1,500,000 would be building work.

It is estimated that the structure could be built in the Pocatello area for $150,000 less than at Fort Peck, due principally to difference in soil conditions and labor efficiency.

A cost differential of 5% in favor of Pocatello can be anticipated on mechanical and equipment installation, in this case due to increased labor efficiency and freight rate differential.

A conservative estimate of over-all saving in cost would be between $240,000 and $300,000 for the steam generating plant.

(l) Security Fence: For setting posts in rock, the estimated cost is $15,000 per mile for single line fence or $60,000 per mile for 4 lines.

(m) Excavating in Lava for Underground Utilities: In order to obtain some idea of the extra cost of excavating for underground utilities at the Pocatello Site, the quantity of on-site sewer and water lines was assumed as being 25 miles. Off-site water lines were not included as the report on water supply includes an allowance for rock excavation.

Two cubic yards of excavation (5' x 10' x 1') were assumed for one linear foot of trench.

The result is 264,000 cubic yards of excavation and backfill at an estimated cost of $3.50 to $7.00 per cubic yard over and above normal $0.55 per cubic yard costs, or $1,000,000 to $2,000,000 more than the probable cost at Fort Peck.

Operational Costs:

The estimated costs for the supplying of steam, water, and electric power for this project are as follows:

*Steam	$1,460,000 per year
Water	$ 73,500 per year
Electric Power	$1,200,000 per year

* (The cost of steam is based on two times the cost of coal, with coal estimated at $2,000 per day. See the discussion on fuel for more detailed information on cost of coal).

IV E. CONSTRUCTION AND OPERATIONAL COSTS (Cont'd.)

4. SUMMARY

The principal factors influencing cost which favor the Pocatello Site are:

1. The recruiting of labor is more favorable, which means a more plentiful supply and implies a wider choice of construction personnel and increased efficiency. It naturally follows that there would be less turnover of labor, which definitely makes for lower costs.

2. The location also favors the obtaining of a great part of the construction materials which will be required at a cost equal to or below the cost of similar materials at Fort Peck.

3. Less excavation will be required for foundations and footings, and no special precautions need be taken to prevent gain or loss of moisture by the lava.

4. The site is located nearer to existing railroads and highways.

5. There is a possibility that certain temporary structures located nearby can be transported to the site and utilized as a construction camp.

6. The general character of the site is such that it will involve less expenditure for site clearance and drainage.

As opposed to the items listed above, there is one major item which favors the Fort Peck Site from the standpoint of construction costs. That is:

7. The added expense for excavating in lava for underground utilities, poles, and fences is not required at Fort Peck.

These factors are evaluated as follows, using Fort Peck conditions as a basis for comparison:

	Pocatello Cost
Item #1	5.0% less
Item #2	4.0% less
Item #3	2.0% less
Item #4	1.0% less
Item #5	Not evaluated
Item #6	1.0% less
Item #7	3.5% more
Estimated saving in project cost at Pocatello	9.5%

IV E. CONSTRUCTION AND OPERATIONAL COSTS (Cont'd.)

Operating costs insofar as utilities are concerned will be appreciably less at the Pocatello Site than at Fort Peck. On the basis of available information, the direct charges all favor Pocatello by the following percentages as based on Fort Peck costs:

Steam	33.5%
Water	55.0%
Electric Power	30.0%

It should be noted that the costs which have been presented are preliminary only. The difference in water costs, for example, is accounted for by assuming a charge for water at Fort Peck of $0.01 per thousand gallons. At $0.15 per thousand gallons the charge for water favors Pocatello by 92%.

At the Pocatello Site the Naval Proving Ground includes some services which are already developed, such as railroad track and siding, wells, power, roads, building, equipment, etc. Were this area included in the plant site, such equipment and services would be of considerable value in getting the new project underway.

IV F. TRANSPORTATION

1. THE FORT PECK SITE

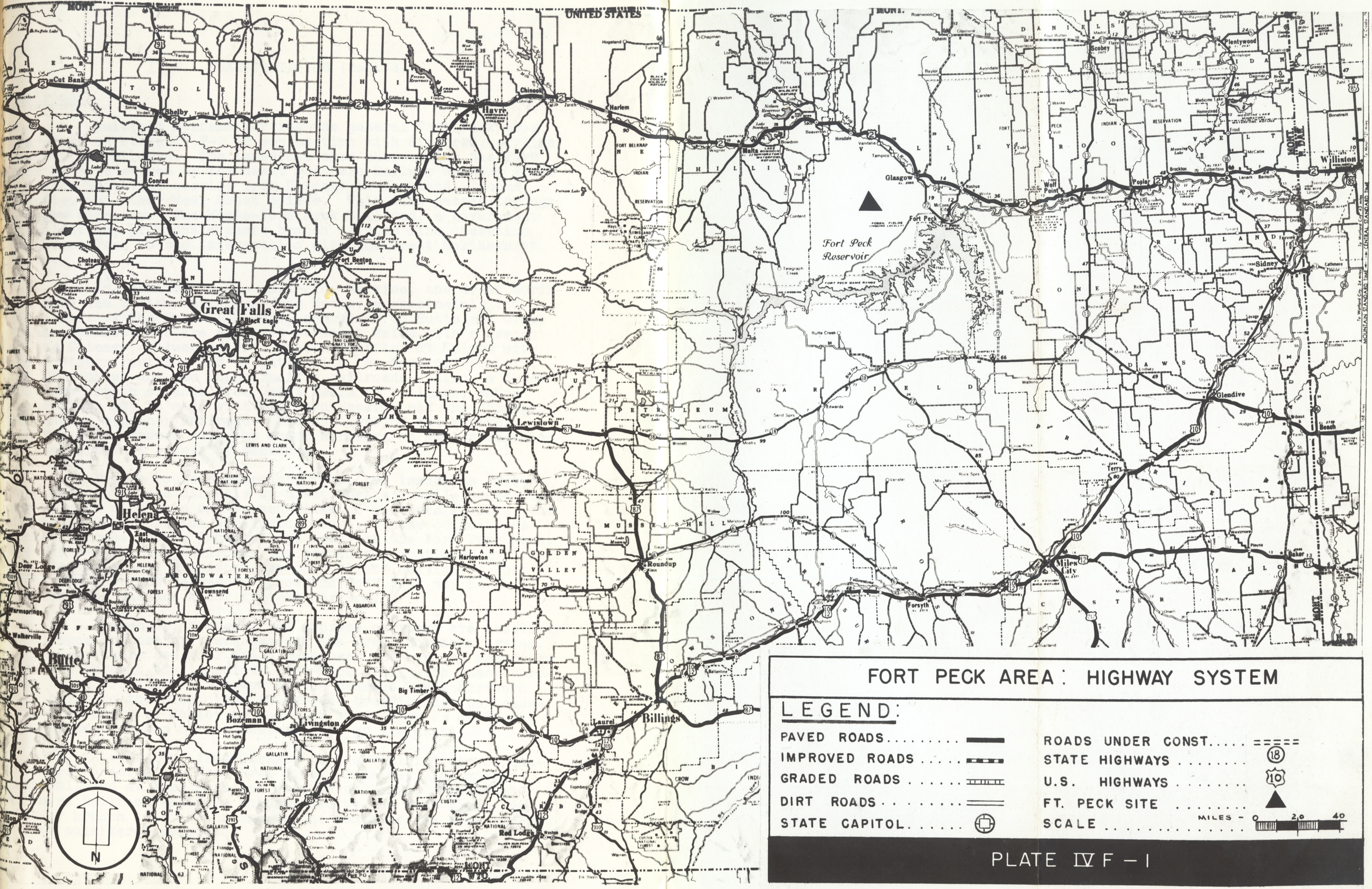
Highways:

The highway system serving the Fort Peck Site and the general area around it is shown on Plate IV F-1. U.S. Highway No. 2 (paved) extends across the northern part of Montana, passing through Nashua, Glasgow, and Hinsdale while State Highway No. 22 (also paved) extends from Glasgow to Fort Peck. An extension of this paved road from Fort Peck southward to intersect State Highway No. 18 between Van Norman and Brockway is proposed If this highway is constructed it will provide access southward to Miles City and other points and will eliminate the necessity of going east to Wolf Point before traveling south.

There is a paved county road between Nashua and Fort Peck and a dirt road crosses the site area from Fort Peck to the southwest. The only other roads of consequence in the immediate area are graded county roads. Secondary systems are sparsely scattered and consist mainly of graveled or graded roads. Such systems are widely spread over the general Fort Peck area and do not provide for all-weather travel.

Major intercity motor carriers which operate through points near the Fort Peck Site are the Intermountain Transportation Company, which transports passengers, and the United Transfer and Storage Company, a freight carrier. Intermountain has an extensive route system throughout Montana. Its route which affects the Fort Peck area directly extends from Bainsville, on the eastern edge of the State, to Great Falls via Wolf Point, Glasgow, and Havre on U.S. Highway No. 2. There are currently two schedules each way daily on this route. United Transfer and Storage is authorized to carry freight between Glasgow, Havre, and Great Falls, plus intermediate points. It also serves other points on routes which do not enter the Fort Peck area.

Transport of passengers and freight by these two carriers is on an east-west basis, with services to the south via distant points to the east or west as indicated by the highway system.



FORT PECK AREA: HIGHWAY SYSTEM

PLATE IV F-1

Railroads:

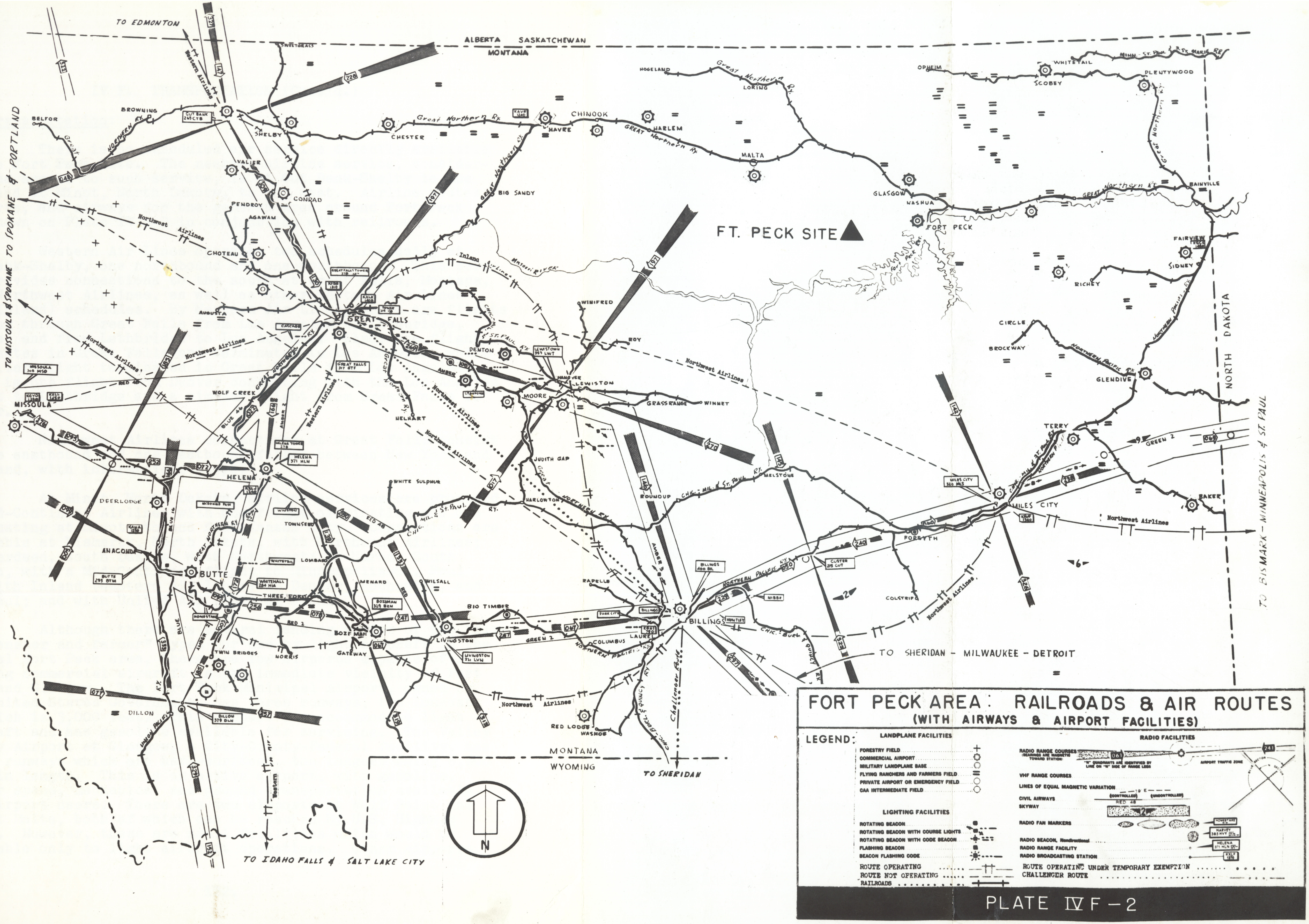
Railroad systems serving the general Fort Peck area are shown on Plate IV F-2 in conjunction with airports, airline routes, and airways. The immediate area surrounding the Fort Peck Site is served by the Great Northern Railway system, which provides main line service from Chicago to Portland, Tacoma, Seattle, and other West Coast points. This line passes through Glasgow directly. The Wiota-Fort Peck Railroad, a government installation, provides a short branch or spur line operation from Fort Peck to the intersection with the Great Northern at Wiota.

In addition to the main line service, the Great Northern also has a line extending from Havre, approximately 150 miles west of the Fort Peck Site, southward to Butte via Great Falls. Connections are afforded at Great Falls with a branch of the Chicago, Milwaukee, St. Paul & Pacific; at Helena with the Northern Pacific; and at Butte with the Northern Pacific, the Milwaukee, and the Union Pacific railroads. Also, a Great Northern branch extends from Great Falls to Billings, where connections may be made with Northern Pacific and the Chicago, Burlington & Quincy Railroad. Branch lines of the Northern Pacific also connect with the Great Northern at Newlon Junction in the northeast corner of Montana.

From a route standpoint, then, the immediate Fort Peck area is served directly by Great Northern while connections may be made with main and branch lines of Northern Pacific, the Milwaukee Road, and the Burlington Route. These connections cannot be made in the immediate vicinity of the Fort Peck Site. The Wiota-Fort Peck Railroad, the previously mentioned government installation, furnishes the only direct service to Fort Peck. Connections between Glasgow and Fort Peck may be made by passenger bus and motor freight carrier.

Passenger, freight, and express services are available at Glasgow and nearby towns through the Great Northern system. At present there are four daily passenger and express schedules each way through the immediate Fort Peck area, with these services being provided at Glasgow as the nearest Great Northern rail point to the site. Any southbound traffic must be transferred at Havre or Shelby to the west of Glasgow or at Sydney and Newlon Junction on the eastern edge of the State.

A spur line from Glasgow or its vicinity can be constructed to serve the Fort Peck Site. Possibly, the government railroad at Fort Peck can also be utilized. The Great Northern Railroad would be intercepted by the spur line. Any spur or branch line extensions to the south of the site could not be considered feasible.



FORT PECK AREA: RAILROADS & AIR ROUTES
(WITH AIRWAYS & AIRPORT FACILITIES)

PLATE IV F-2

IV F. TRANSPORTATION (Cont'd.)

Air Transportation:

There is no scheduled air service directly available to the Fort Peck Site. The nearest airline service, considering the access to such service, is at Cut Bank-Shelby to the west and at Minot, North Dakota, to the east. Airline routes, airports, and airways for the general area around Fort Peck are shown on Plate IV F-2 in conjunction with railroads.

Western Air Lines operates two schedules daily at Cut Bank-Shelby, one northbound and one southbound. This service provides connections to the south at Great Falls, Montana, with Northwest Airlines, as well as other Western Air Lines (and Inland) schedules. By Western Air Lines, there are flights passing through Great Falls from Los Angeles to Lethbridge, Canada, and from Lethbridge to Los Angeles. Also, one flight originates in Great Falls and terminates in Los Angeles, while a similar flight terminates in Great Falls from Los Angeles. There is one flight from Denver connecting with the Los Angeles flight to Lethbridge and a similar flight from Great Falls to Denver.

Northwest Airlines connections at Great Falls consist of one eastbound and one westbound flight between New York and Portland, with intermediate stops.

At Minot, North Dakota, airline services are provided by Mid-Continent Airlines with one flight originating and one terminating at Minot, to and from Kansas City. Connections are available at Bismarck, North Dakota, with Northwest Airlines; at Aberdeen, South Dakota, with Northwest; at Huron, South Dakota, with a Mid-Continent flight to Minneapolis-St. Paul and with Inland (Western Air Lines) to Denver, Rochester, and St. Paul; and with United Air Lines at Omaha.

Although there are several landing strips of the "flying rancher and farmer" types for use by light aircraft in the general Fort Peck area, there are few airports capable of receiving commercial aircraft in the immediate vicinity of Fort Peck and Glasgow. The Fort Peck Municipal Airport, owned by the United States Government, has three runways, the longest of which is 3,000 feet. This airport can accommodate light aircraft and has gasoline available for servicing. The Valley County Airport at Glasgow, a City-County-Federal facility, has three runways which are hard-surfaced, the longest being 8,800 feet in length. This is an active airport, with gasoline, hangar space, mechanics, and ground transportation available for airport users. There are two airports at Wolf Point and one at Malta, both of which can be reached by U.S. Highway No. 2. However, these are small facilities which would be adaptable only to light aircraft operations. Other airports in the general Fort Peck area are too far away to be of use to the Fort Peck Site.

There are no air navigation aids located in or near the Fort Peck Site. However, a U.S. civil airway crosses the southern part of Montana and there are radio range stations at Miles City, Custer, Billings, Lewiston, Great Falls, and Cut Bank. Other ranges and airways are located in the western part of Montana.

IV F. TRANSPORTATION (Cont'd.)

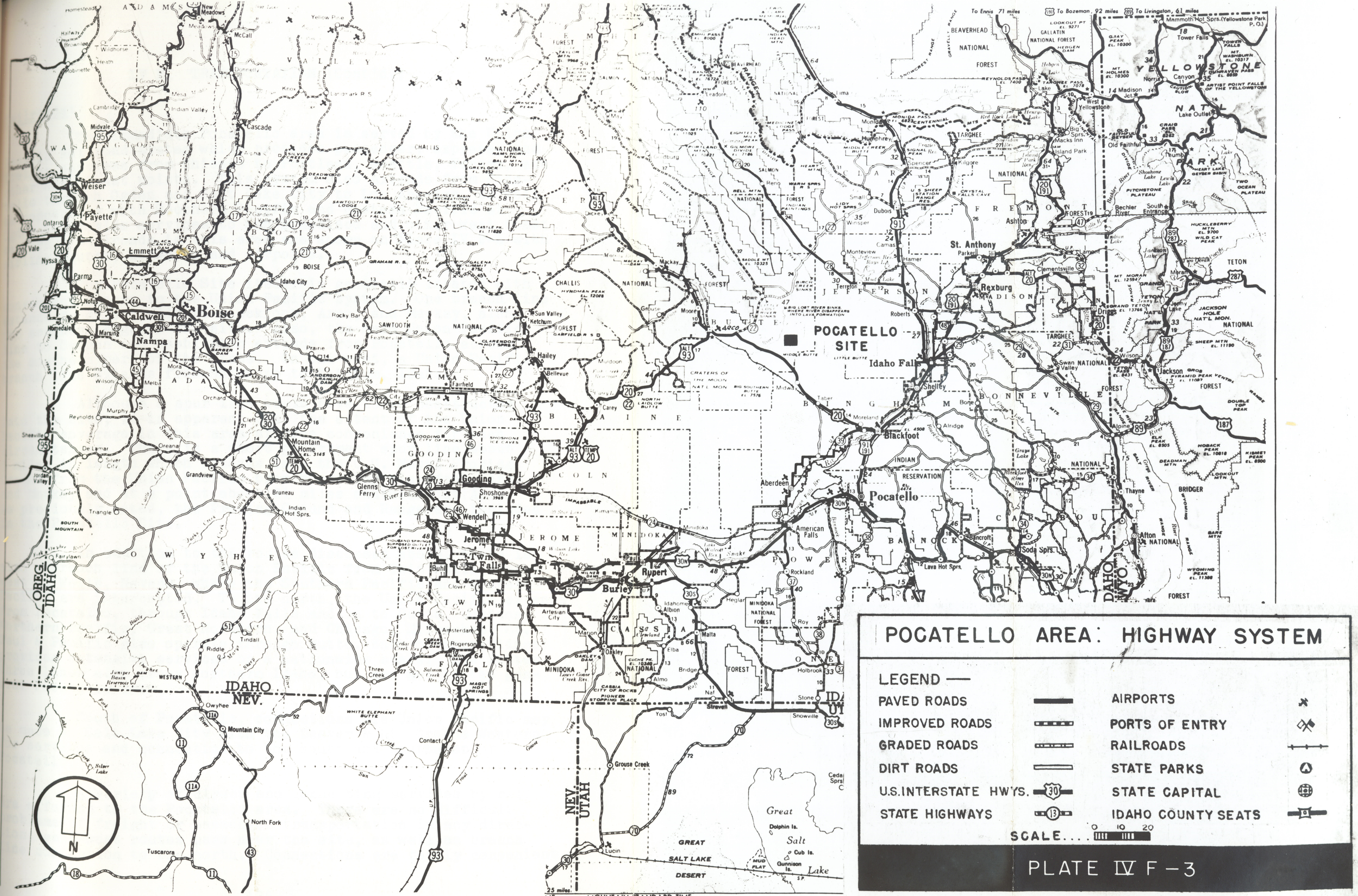
2. THE POCATELLO SITE

Highways:

The Pocatello Site is accessible by all-weather, paved U.S. and State highways. The highway system for this area is shown on Plate IV F-3. The most convenient all-weather routes are U.S. 20, adjacent to the site, U.S. alternate 93 (and State 22), and U.S. temporary 20, which extend in part from Blackfoot to Arco, then down to Gooding and Bliss, and on west through Boise. This system runs, generally, near to the Pocatello Site. At the southern end of the U.S. Naval Proving Ground a short section of U.S. Highway 20 has been relocated slightly to the south, and there is an access road from the highway to the Navy area. Within the Proving Ground, roads extend around the building area and out into the Proving Range, passing through that area proposed for the reactor array. From Pocatello, paved U.S. 30-N and State 25 proceed west to intercept U.S. 30 at Bliss. This system is to the south of the Pocatello Site. Also State Highway 39, which is paved, extends from American Falls to Blackfoot, being southeast of the site. In general, the entire Pocatello area is fairly well served by paved highways which provide access to the Pocatello Site.

Paved State and U.S. highways which serve this immediate site also run directly, or connect with similar highways, into Washington and Oregon to the west, to Montana on the north, Wyoming on the east, and to Utah and Nevada on the south.

There are approximately 41 motor freight and passenger carriers which are certificated to operate to and through cities in the vicinity of the Pocatello Site. Eleven of these are primarily passenger carriers, while the remainder are mainly motor freight operators. Ten motor freight companies operate to and within Butte County, near the site, or carry freight between Arco and Blackfoot, Pocatello, and other nearby points. Two carriers are certificated to carry passengers through Arco, with one line extending down to Pocatello and the other to Twin Falls, as well as points to the north. There are five major bus passenger carriers operating through Pocatello; six through Idaho Falls; and three through Blackfoot. Also, there are approximately twenty-one motor freight carriers serving these cities and other communities in their vicinity. From this system of highway transportation services available in the nearby population centers, it is apparent that further extensions of these certificated routes to include the Pocatello Site can be instituted upon demand by sufficient numbers of users.



POCATELLO AREA: HIGHWAY SYSTEM

PLATE IV F-3

Railroads:

The immediate Pocatello area is served by the Union Pacific Railroad system which provides passenger, express, and freight services from Chicago to Portland, Seattle, Tacoma, and other West Coast points. This system also extends from Pocatello through Ogden and Salt Lake City to Los Angeles, as well as connecting with Southern Pacific and Western Pacific at Ogden to provide services to San Francisco and other West Coast centers. Railroads in this area are shown on Plate IV F-4 with airline routes, airways, and airports.

The Pocatello Site itself is generally located with convenient access to the Union Pacific system. One branch line extends from Pocatello to Blackfoot, Arco, and Mackay, along the southern edge of the site. Also, the main Union Pacific line to Oregon and Washington extends from Pocatello across the southern part of the State. On the west, a Union Pacific branch line extends from Shoshone to Ketchum, Idaho.

Although a spur line would have to be constructed into the site, it is apparent that the extent of the Union Pacific coverage in this area affords convenience for such circumstances. There is a short government spur line about 5 miles in length which extends into the U.S. Naval Proving Ground from the Union Pacific branch serving Blackfoot, Arco, and Mackay and at a point about 21 miles southeast of Arco. As previously noted, the Proving Ground and Range are included in the Pocatello Site.

In addition to the routes discussed above, there is also a branch line of the Union Pacific from Twin Falls southwest to Wells, Nevada, where the Southern Pacific and Western Pacific are intercepted. To the north, the Union Pacific extends from Pocatello, through Idaho Falls and on to Butte, Montana. Northern Pacific, Great Northern, and Chicago, Milwaukee, St. Paul & Pacific also operate through Butte. Each of these lines provides extensive services on a nationwide scale. The latter three lines also cross northern Idaho, but are not in the general Pocatello area.

South of Pocatello, connections via Union Pacific may be made at Salt Lake City with the Denver & Rio Grande Western for services and connection to the south and southwest of Pocatello.

A variety of direct and connecting services by rail are afforded to the Pocatello area. There are no difficult problems of freight or passenger transportation in any direction; east-west routes pass near the site, as well as branch line connection to the north. Connections are fairly convenient


POCATELLO AREA: RAILROADS & AIR ROUTES
(WITH AIRWAYS & AIRPORT FACILITIES)
MAP SYMBOLS
LANDPLANE FACILITIES
COMMERCIAL OR MUNICIPAL AIRPORT REGULAR SERVICES
CAA OR STATE INTERMEDIATE FIELDS
FLIGHT STRIPS—MAY BE SUB-STANDARD
COMMERCIAL OR MUNICIPAL AIRPORT IRREGULAR SERVICES
MILITARY FIELD
FORESTRY FIELD
LINES OF EQUAL MAGNETIC VARIATION
CIVIL AIRWAYS
LIMITED PERIOD ROUTE
ROUTE OPERATING
SEAPLANE FACILITIES
SEAPLANE BASE OR ANCHORAGE
LIGHTING FACILITIES
ROTATING BEACON AND ELEVATION
ROTATING BEACON WITH COURSE LIGHTS
ROTATING BEACON WITH CODE BEACON
FLASHING BEACON
BEACON FLASHING CODE
RAILROADS
RADIO FACILITIES
RADIO RANGE COURSES
RADIO FAN MARKER
RADIO BEACON, NON-DIRECTIONAL
RADIO RANGE FACILITY
FACILITIES AVAILABLE AT FIELD
RADIO BROADCASTING STATION
RADIO DIRECTION FINDING STATION
RADIO COMMUNICATION STATION
TO BUTTE & GREAT FALLS
TO BOISE & SEATTLE
TO ROCK SPRINGS - CHEYENNE & DENVER
TO SAN FRANCISCO
TO LOS ANGELES
DANGER AREA
POCATELLO SITE
MONTANA
IDAHO
WYOMING
NEVADA
UTAH
YELLOWSTONE NATIONAL PARK
Yellowstone Lake
American Falls Reservoir
Western Airlines
United Airlines
Empire Airlines
Union Pacific R.R.
Southern Pacific R.R.
Western Pacific R.R.
Snake R.
GREAT SALT
State 5
State 6
State 7
Pocatello
Idaho Falls
Gooding
Strevell
Malad City
Ogden (Mun) Tower
Salt Lake City
Wendover
Wendover AFB Tower
Elko
POCATELLO
AMERICAN FALLS
IDAHO FALLS
ARCO
KETCHUM
SALMON
MACKAY
DIVIDE
LAURIN
LEADORE
ASHTON
WEST YELLOWSTONE
JACKSON
EICHFIELD
HILL CITY
MOUNTAIN HOME
BLISS
SHOSHONE
TWIN FALLS
BURLEY
OAKLEY
BANCROFT
CONDA
COKEVILLE
LOGAN
HYRUM
BRIGHAM
OGDEN
EVANSTON
PARK CITY
KELTON
LUCIN
WELLS
COBRE
TOBAR
SHAFTER
WESTON
MC CAMMON
HORSESHOE BEND
NEW MEADOWS
077°
257°
329°
185°
073°
253°
102°
192°
332°
176°
012°
282°
236°
206°
290°
093°
186°
056°
271°
092°
326°
147°
330°
006°
269°

PLATE IV F-4

for travel or freight movement to the southwest, south, and southeast at Ogden and Salt Lake City.

Air Transportation:

Scheduled air service for the Pocatello area is furnished at five points within approximately 50 to 100 miles of the site. Airline routes, airports, and airways for the Pocatello area are shown on Plate IV F-4, in conjunction with the railroad systems.

Pocatello has direct service by Western Air Lines and Empire Air Lines. Western Air Lines furnishes scheduled service on Route 19 (permanently certificated) which extends from Great Falls, Montana, to Salt Lake City. Idaho Falls is also served by this route. Empire Air Lines operates over a limited-period (feeder airline) route, No. 78, from Idaho Falls through Pocatello, Burley, Twin Falls, Gooding, Boise, and on to Pendleton, Oregon, and Spokane, Washington. Western currently has two northbound and two southbound schedules daily through Pocatello and Idaho Falls. Empire also has two daily schedules each way on the stops listed above.

Connecting routes with the Western and Empire airlines are available at Boise, Ogden, Salt Lake City, and Butte. At Boise, United Air Lines provides services to Seattle, Portland, and other West Coast points, as well as schedules to Salt Lake City. At Ogden and Salt Lake City, United provides extensive coast-to-coast schedules and connections with many of the other major airlines to principal cities. Western also has a route extending from Salt Lake City to Los Angeles and other coastal cities.

Airport facilities are more or less in a 60-mile arc swinging from east to the west of the Pocatello Site, following generally the Snake River from Idaho Falls to Twin Falls and to the north along the Union Pacific Railroad branch to Ketchum. The Arco Airport is adjacent to the site and is a commercial-type facility with irregular services (referring to maintenance, servicing, etc.). At Mackay, there is another commercial-type airport with regular services, and there is a landing strip at nearby Midway. Following generally the Snake River, commercial-type airports with regular services and airline schedules are located at Idaho Falls, Pocatello, Burley, and Twin Falls. Another commercial airport with regular service features is located at American Falls. Airports with irregular services are found at Blackfoot, Pingree, Pocatello (2), Aberdeen (2), Jerome, Shoshone (2), and Richfield (2). Flight strips are located at Rupert, Eden, Hazeton, and Cary. Also, there is a military field at Pocatello.

Air navigation facilities are available in this area with both U.S. civil and State airways surrounding the site on all sides. U.S. Amber No. 2 runs from north to south through Idaho Falls and Pocatello, and U.S. Red No. 1 crosses from east to west through Burley. State airways also pass through Arco in a general west to east direction, as well as through Twin Falls, Burley, and Pocatello. Radio ranges are located at Idaho Falls, Pocatello, and Burley. Lighting facilities are located on the U.S. civil airways.

3. SUMMARY

Highways:

All-weather paved highways in the Fort Peck area exist only in an east-west direction, passing through Glasgow. Dependable facilities to the south or north can be reached only by going from Glasgow to Havre on the west or to Wolf Point on the east. County roads in the immediate vicinity of Fort Peck and Glasgow are of a graded or graveled nature and are not dependable in inclement weather conditions. Access roads could be constructed from Glasgow and Fort Peck to the site.

The Pocatello Site is served by a more complete road system, with all-weather paved highways providing dependable transportation in all directions. County roads are mostly on the same basis as at Fort Peck, but the paved system is much more comprehensive. Access roads could be constructed from U.S. No. 20 to the site. The highway bridge system crossing the Snake River and other streams should be noted in considering general access to the Pocatello Site. There are highway bridges across the river at American Falls, Blackfoot, and Idaho Falls. Between Idaho Falls and Blackfoot, there is another bridge across the Snake River on a segment of the highway which is located west of the river. It is believed that transportation across the bridge system to the Pocatello Site will not be seriously hampered at any time by weather conditions.

Passenger bus and motor freight service is more favorable for the Pocatello Site than for the one at Fort Peck. One major passenger route passes through Glasgow, near the Fort Peck Site, and connections with other lines or with other route segments of Intermountain Transportation Company are available at considerable distances from Glasgow. The Pocatello Site is more favorably located in this respect; although only one passenger carrier route currently passes near the proposed site, service can be increased to provide good connections and frequency of schedules to Pocatello, Idaho Falls, and other points. Service in all directions is available at these cities. The motor freight situation is also more favorable at the Pocatello Site, with a total of thirty freight carriers operating near the site or within approximately 50-60 miles at the aforementioned cities.

Railroads:

Although the Fort Peck Site and Glasgow are served directly by the Great Northern Railway, it is apparent that while east-west travel can be effected by this system, north-south service is available only through connections with other systems at distant points or by use of the Great Northern branch from Havre to Butte.

Rail services to the Pocatello Site can be more easily effected to provide movement in all directions than to the Fort Peck area. Not only does the Union Pacific provide main and branch line service through the Pocatello area, but also convenient connections are available at Ogden and Salt Lake City for passage to the west, east, and south. Connections to the north can be effected by use of the Union Pacific branch to Butte.

Spur lines to both of the sites would be necessary. In regard to the Fort Peck Site, it has been previously noted that such a spur could connect with the Great Northern line in the vicinity of Glasgow. The Pocatello Site could be served by spurs from the Union Pacific branch between Blackfoot and Mackay or the branch of the same system which extends from Pocatello through Blackfoot and Idaho Falls to Butte. It has been noted that a spur line extends from the Mackay-Blackfoot branch of the Union Pacific into the Naval Proving Ground.

There are no difficult situations in regard to railway line clearances in the case of either site, although the railroad systems serving the Pocatello area generally have higher maximums as to lengths and widths of loads.

Air Transportation:

Scheduled air service is available to the Fort Peck Site at distances exceeding 250 miles to the west and east. Airport facilities are fairly adequate and chartered or non-scheduled services could be provided by using the Valley County Airport at Glasgow. This facility could also be used by government commercial-type aircraft. Air navigation facilities are not too extensive in the vicinity of Fort Peck and Glasgow, although there are several radio ranges to the south.

The Pocatello Site does not receive scheduled air transportation at a close-by location, but as mentioned there are five points in the general Pocatello area which do have scheduled air service. Pocatello and Idaho Falls would be most convenient, being within about 40 to 50 miles of the site. Airport facilities for commercial and light aircraft are fairly well dispersed in the general area with the Blackfoot and Arco fields being nearest to the site. Air navigation facilities are provided rather extensively in this area, with U.S. civil and State airways in the immediate site vicinity and with lighting facilities along the civil airways.

For purposes of comparison, Table IV F-1 has been prepared to show the relative distances to the Pocatello and Fort Peck sites from various cities throughout the country. Also, the time element is introduced by showing the travel time by air and rail from each of these cities to the sites. The domestic airline route system of the United States is shown on Plate IV F-5, illustrating the accessibility of the sites by air transportation.

TABLE IV F-1

SAMPLE COMPARATIVE TRAVEL TIMES AND DISTANCES
FORT PECK AND POCATELLO SITES

	FORT PECK SITE *1			POCATELLO SITE *1		
	Air *2 Hours	Train Hours	Train Miles To Glasgow	Air Hours	Train Hours	Train Miles To Pocatel
Chicago	18-20'	21-55'	1,198	14-35'	27-15'	1,546
*3 Kansas City	18-35'	25-55'	1,264	14-40'	28-30'	1,297
*3 St. Louis	20-58'	35-25'	1,356	17-20'	45-00'	1,713
Washington, D.C.	27-25'	42-15'	1,965	19-05'	46-16'	2,313
Knoxville	35-52'	44-50'	1,804	24-23'	60-55'	2,325
Sante Fe	29-12'	53-00'	1,984	10-32'	30-00'	1,275
Los Angeles	23-55'	39-15'	1,664	8-35'	29-45'	955
San Francisco	28-05'	52-50'	1,628	12-50'	33-00'	991
*3 Minneapolis	16-00'	14-25'	752	16-05'	40-20'	1,573
Denver	19-25'	42-25'	1,504	8-00'	17-00'	795
Salt Lake City	18-00'	29-45'	879	2-50'	6-45'	170
New Orleans	31-45'	38-25'	2,119	23-35'	51-15'	2,170
*4 Richland, Wash.	24-45'	24-30'	882	8-45'	20-15'	768
New York City	20-10'	40-10'	2,184	20-05'	45-30'	2,532
Portland	19-32'	16-05'	1,062	11-20'	26-20'	1,043

Notes:

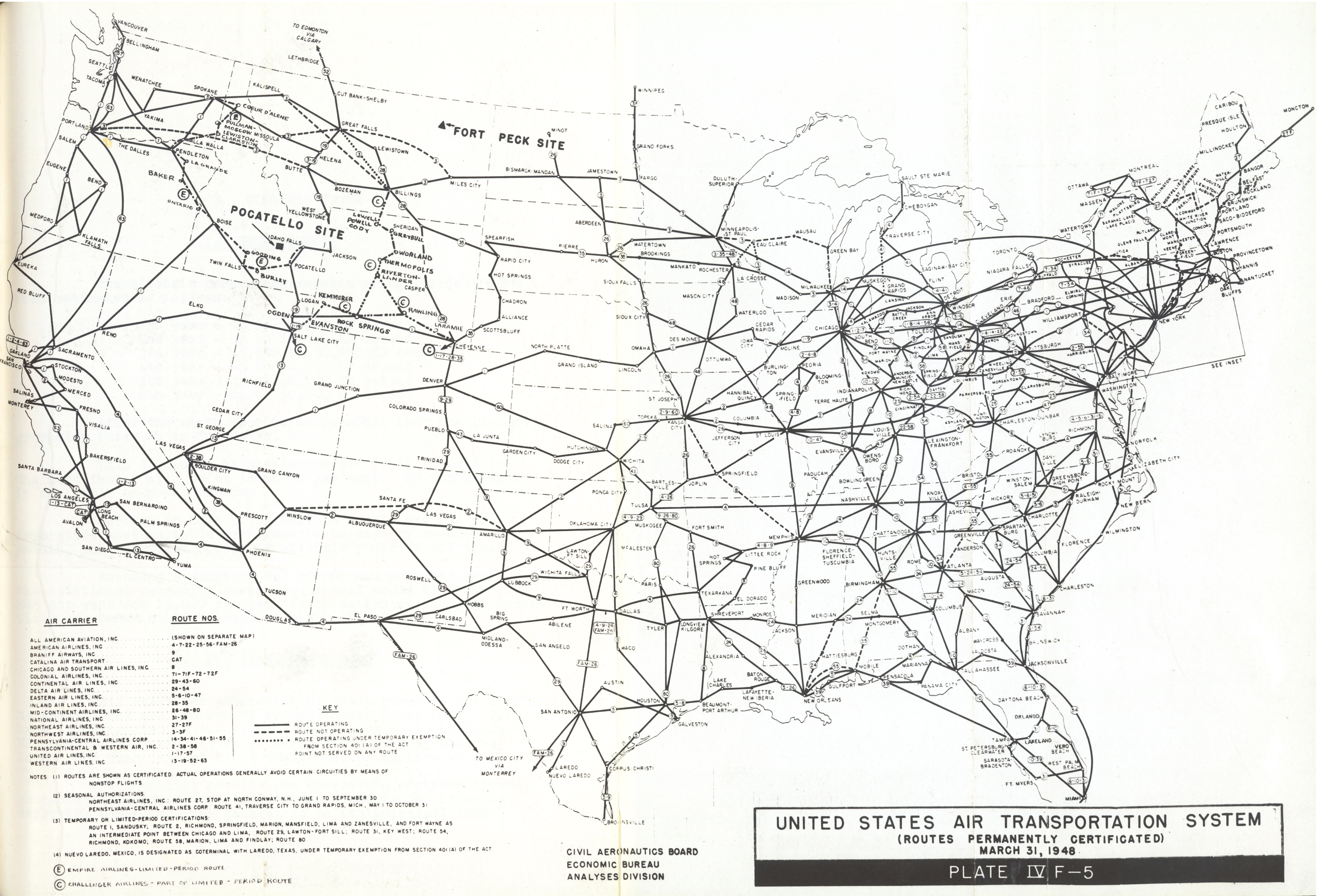
*1 Travel times to the two sites are total elapsed times including "lay-overs" for both air and train travel, as well as an allowance of 1 3/4 hours (approximately 70 miles) driving time from Pocatello, Idaho, to the Pocatello Site and 3/4 of an hour (approximately 35 miles) from Glasgow, Montana, to the Fort Peck Site.

*2 "Air hours" for the Fort Peck Site include rail time from the last point of air service to Glasgow, which is not on an airline route.

*3 In some instances, "air hours" to Pocatello include rail travel from Salt Lake City to Pocatello because of schedule difficulties.

*4 "Air hours" to the Pocatello Site include driving time between Richland and Walla Walla.

Source: Rail schedules for October-December, 1948; Air Traffic Guide for February, 1949.


UNITED STATES AIR TRANSPORTATION SYSTEM
(ROUTES PERMANENTLY CERTIFICATED)
MARCH 31, 1948
PLATE IV F-5
CIVIL AERONAUTICS BOARD
ECONOMIC BUREAU
ANALYSES DIVISION
FORT PECK SITE
POCATELLO SITE
AIR CARRIER
ROUTE NOS.
ALL AMERICAN AVIATION, INC. (SHOWN ON SEPARATE MAP)
AMERICAN AIRLINES, INC. 4-7-22-25-56-FAM-26
BRANIFF AIRWAYS, INC. 9
CATALINA AIR TRANSPORT CAT
CHICAGO AND SOUTHERN AIR LINES, INC. 8
COLONIAL AIRLINES, INC. 71-71F-72-72F
CONTINENTAL AIR LINES, INC. 29-43-60
DELTA AIR LINES, INC. 24-54
EASTERN AIR LINES, INC. 5-6-10-47
INLAND AIR LINES, INC. 28-35
MID-CONTINENT AIRLINES, INC. 26-48-80
NATIONAL AIRLINES, INC. 31-39
NORTHEAST AIRLINES, INC. 27-27F
NORTHWEST AIRLINES, INC. 3-3F
PENNSYLVANIA-CENTRAL AIRLINES CORP. 14-34-41-46-51-55
TRANSCONTINENTAL & WESTERN AIR, INC. 2-38-58
UNITED AIR LINES, INC. 1-17-57
WESTERN AIR LINES, INC. 13-19-52-63
KEY
ROUTE OPERATING
ROUTE NOT OPERATING
ROUTE OPERATING UNDER TEMPORARY EXEMPTION FROM SECTION 401 (A) OF THE ACT
POINT NOT SERVED ON ANY ROUTE
NOTES: (1) ROUTES ARE SHOWN AS CERTIFICATED. ACTUAL OPERATIONS GENERALLY AVOID CERTAIN CIRCUITIES BY MEANS OF NONSTOP FLIGHTS.
(2) SEASONAL AUTHORIZATIONS:
NORTHEAST AIRLINES, INC.: ROUTE 27, STOP AT NORTH CONWAY, N.H., JUNE 1 TO SEPTEMBER 30
PENNSYLVANIA-CENTRAL AIRLINES CORP.: ROUTE 41, TRAVERSE CITY TO GRAND RAPIDS, MICH., MAY 1 TO OCTOBER 31
(3) TEMPORARY OR LIMITED-PERIOD CERTIFICATIONS:
ROUTE 1, SANDUSKY; ROUTE 2, RICHMOND, SPRINGFIELD, MARION, MANSFIELD, LIMA AND ZANESVILLE, AND FORT WAYNE AS AN INTERMEDIATE POINT BETWEEN CHICAGO AND LIMA; ROUTE 29, LAWTON-FORT SILL; ROUTE 31, KEY WEST; ROUTE 54, RICHMOND, KOKOMO; ROUTE 58, MARION, LIMA AND FINDLAY; ROUTE 80
(4) NUEVO LAREDO, MEXICO, IS DESIGNATED AS COTERMINAL WITH LAREDO, TEXAS, UNDER TEMPORARY EXEMPTION FROM SECTION 401 (A) OF THE ACT
E EMPIRE AIRLINES - LIMITED - PERIOD ROUTE
C CHALLENGER AIRLINES - PART OF LIMITED - PERIOD ROUTE
TO EDMONTON VIA CALGARY
TO MEXICO CITY VIA MONTERREY
SEE INSET

IV G. ELECTRIC POWER

1. REQUIREMENTS

The electric power requirements of the project have been estimated as follows:

1st year - up to 5,000 KW demand
2nd year - up to 10,000 KW demand
3rd year - 15,000 to 20,000 KW demand
4th year - up to 30,000 KW demand
5th year - up to 40,000 KW demand
6th year - up to 50,000 KW demend

After the sixth year it is possible that the load may gradually build up to 70,000 KW.

This load will be continuous and it is assumed that the load factor will be at least 90 per cent. No information is available on power factor.

Service to this plant must be continuous and it is imperative that suitable arrangements be made to assure a smooth, uninterrupted supply of electric power at all times.

Assuming a domestic use of 800 KWH per year per person, the additional community power requirement would be 20,000,000 KWH per year for 25,000 people. It is estimated that the domestic power demand would be approximately 10,000 KW.

2. NORTHWEST POWER POOL

All utilities generating electric power in the Pacific Northwest area are members of the Northwest Power Pool. This area is designated by the Federal Power Commission as Region VII and includes the States of Washington, Oregon, Montana, Idaho, and Utah (except for a small part of eastern Montana).

Each utility has its own generating stations interconnected by a system of high-voltage transmission lines to carry the power from the generators to the principal load centers and to permit power to be fed from one part of the system to another when required.

The various utilities are further interconnected by a system of high-voltage transmission or tie lines to permit them to feed power back and forth or share loads. The utilities having a surplus of power are able to help those with a shortage of power to carry the loads imposed on them. As long as the demand on the group as a whole does not exceed the total generating capacity of the group no power shortages will occur in the area.

Region VII should be divided into two parts for further consideration in this report.

Region VII (a):

The states of Washington and Oregon and the utilities operating therein, including both private utilities and the Federal Generation Program at Bonneville and Grand Coulee, will be referred to as Region VII (a).

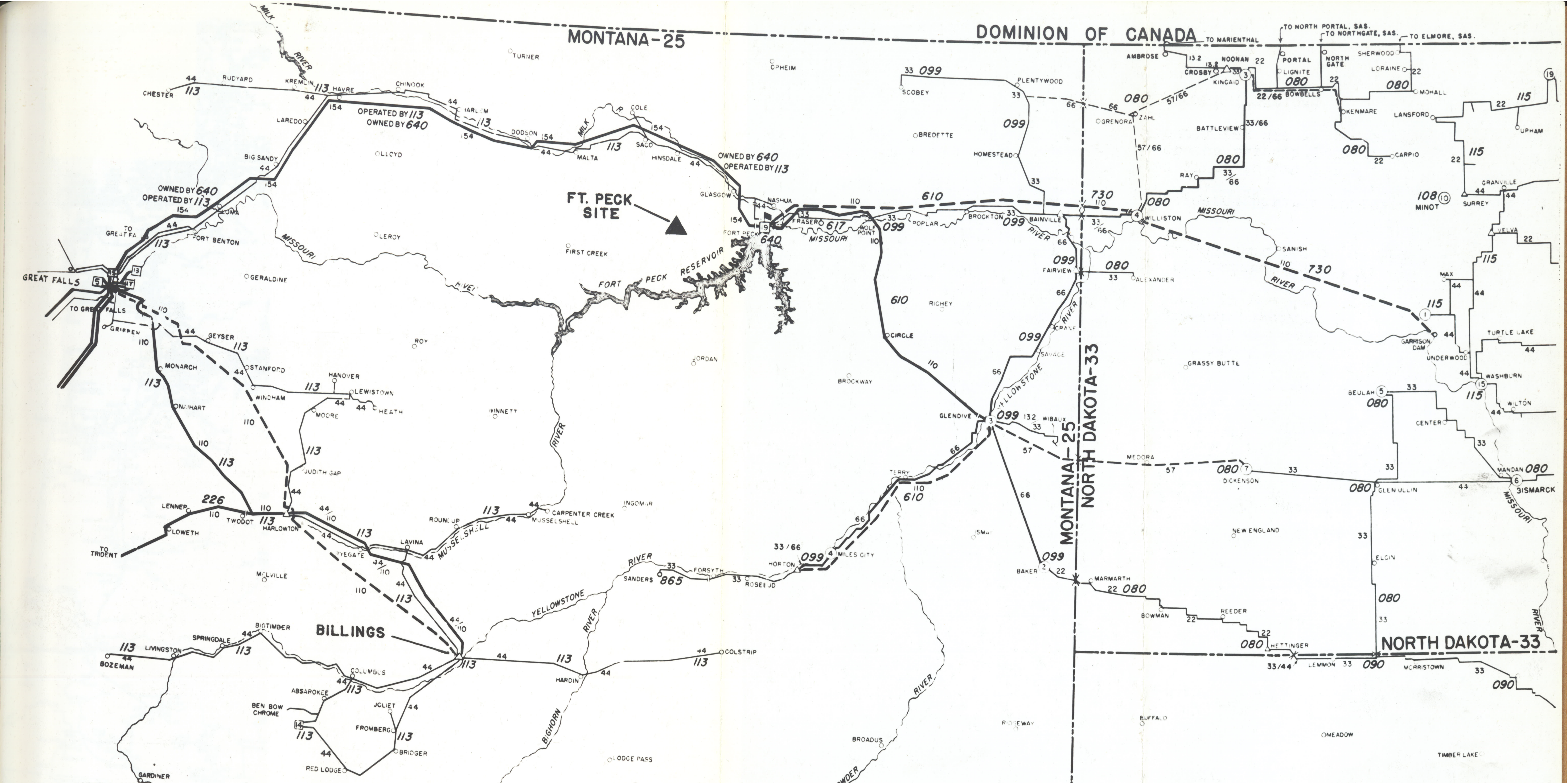
The power industry in Region VII (a) has not kept pace with the region's growth, hence this area is now in the midst of an acute power shortage. Everything possible is being done to reduce the peak loads.

Two 110 KV tie lines run between Spokane and Thompson Falls, Montana, one owned by the Washington Water Power Company and the other by the Montana Power Company. In December, 1948, over 120,000 KW of power was sent into Region VII (a) over these tie lines to help carry the peak load in that area. The Bonneville Power Administration estimates that this critical situation will continue in Region VII (a) for several years.

Region VII (a) does have considerable construction now in progress to alleviate its power shortage. Grand Coulee will have nine more generators added between April, 1949, and October, 1951, which will increase its generating capacity by 1,080,000 KW. The energy it can develop will then be determined by the available water. McNary Dam, now under construction, will contribute 96,000 KW in 1953, 333,000 KW in 1954, 495,000 KW in 1956, and 574,000 KW by 1957. Additional transmission lines to carry the Grand Coulee power are now under construction.

Region VII (b):

The states of Montana, Idaho, and Utah and the utilities operating therein, including the private utilities and the Federal Generating Program at Fort Peck, will be referred to as Region VII (b).



PRINCIPAL ELECTRIC UTILITY GENERATING STATIONS & TRANSMISSION LINES: NORTHWEST CENTRAL REGION (FORT PECK SITE)

LEGEND

SLANT NUMBERS AT LINES OR STATIONS IDENTIFY OWNERSHIP. SEE ACCOMPANYING INDEX

OWNERSHIP IS IDENTIFIED BY FIVE DIGIT NUMBERS, THE FIRST TWO DIGITS OF WHICH IDENTIFY THE STATE AND ARE SHOWN ADJACENT TO STATE NAMES.

GENERATING STATIONS

OWNERSHIP
- 1 PUBLICLY OWNED (NON-FEDERAL)
- 2 PUBLICLY OWNED (FEDERAL)
- 3 PRIVATELY OWNED

HYDRO FUEL
- 1 UNDER CONSTRUCTION
- 2 EXISTING

TRANSMISSION SUBSTATIONS

△ TRANSMISSION SUBSTATION WHERE CHANGES OF VOLTAGES ARE SHOWN.
NOTE – STEP UP SUBSTATIONS AT GENERATING PLANTS NOT INDICATED BY SEPARATE SYMBOL

COMMUNITIES

- 25,000 POPULATION AND OVER
- 10,000 TO 25,000 POPULATION
- LESS THAN 10,000 POPULATION

SCALE IN MILES

10 0 10 20 30 40 50 60 70 80 90 100

TRANSMISSION LINES

WHERE TWO NUMBERS OCCUR (VIZ-44/110) THE FIRST NUMBER INDICATES OPERATING VOLTAGE AND THE SECOND NUMBER INDICATES INSULATED OR DESIGN VOLTAGE

LINES LESS THAN 22KV INDICATED IN SPECIAL CASES ONLY
NOMINAL OPERATING VOLTAGES INDICATED IN THOUSANDS OF VOLTS

33 EXISTING — 33 UNDER CONSTRUCTION

110 100,000 TO 165,000 VOLT CIRCUIT

66 57,000 TO 88,000 VOLT CIRCUIT

22 22,000 TO 55,000 VOLT CIRCUIT

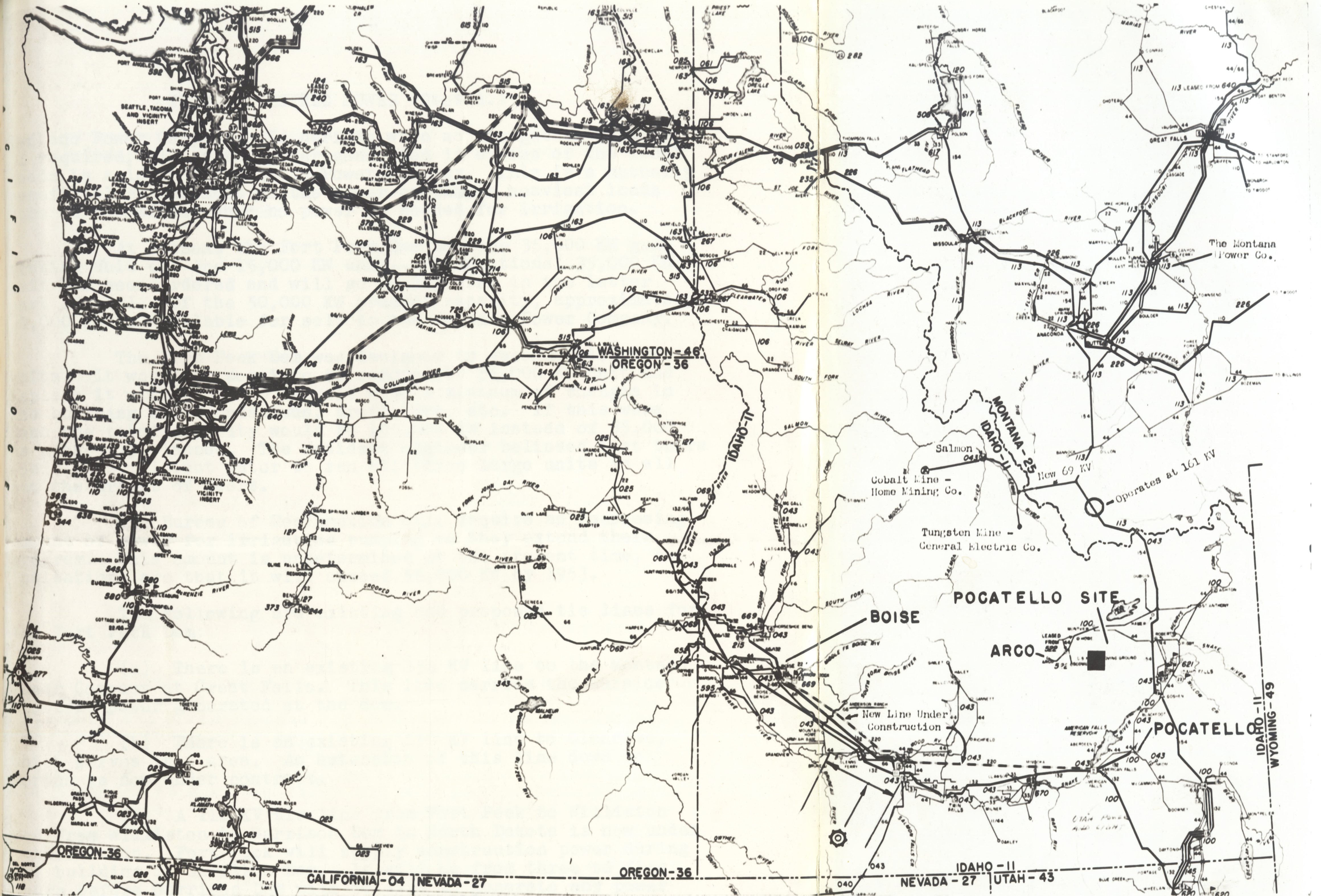
33C CIRCUITS OTHER THAN 60 CYCLE FREQUENCY INDICATED

INTERCONNECTION BETWEEN AFFILIATED COMPANIES

INTERCONNECTION BETWEEN NON-AFFILIATED COMPANIES

TRANSMISSION LINE OF ONE COMPANY CROSSING STATE BOUNDARY (SEPARATE OWNERSHIP NUMBERS REFER TO EACH STATE)

PLATE IV G-1



PRINCIPAL ELECTRIC UTILITY GENERATING STATIONS & TRANSMISSION LINES: PACIFIC NORTHWEST REGION (POCATELLO SITE)

LEGEND

SLANT NUMBERS AT LINES OR STATIONS IDENTIFY OWNERSHIP, SEE ACCOMPANYING INDEX. NUMBERS IN STATION SYMBOLS REFER TO ACCOMPANYING TABULATED LIST. OWNERSHIP IS IDENTIFIED BY FIVE DIGIT NUMBERS, THE FIRST TWO DIGITS OF WHICH IDENTIFY THE STATE AND ARE SHOWN ADJACENT TO STATE NAMES.

TRANSMISSION LINES

WHERE TWO NUMBERS OCCUR (VIZ: 44/110) THE FIRST NUMBER INDICATES OPERATING VOLTAGE AND THE SECOND NUMBER INDICATES INSULATED OR DESIGN VOLTAGE.

LINES LESS THAN 22KV INDICATED IN SPECIAL CASES ONLY. NOMINAL OPERATING VOLTAGES INDICATED IN THOUSANDS OF VOLTS.

11 EXISTING — 11 UNDER CONSTRUCTION

- 189,000 VOLT CIRCUIT AND OVER
- 80,000 TO 188,000 VOLT CIRCUIT
- 56,000 TO 79,000 VOLT CIRCUIT
- 22,000 TO 55,000 VOLT CIRCUIT
- CIRCUITS OTHER THAN 60 CYCLE FREQUENCY INDICATED
- INTERCONNECTION BETWEEN AFFILIATED COMPANIES
- INTERCONNECTION BETWEEN NON-AFFILIATED COMPANIES
- TRANSMISSION LINE OF ONE COMPANY CROSSING STATE BOUNDARY (SEPARATE OWNERSHIP NUMBERS REFER TO EACH STATE)

GENERATING STATIONS

OWNERSHIP
- PUBLICLY OWNED (NON-FEDERAL)
- PUBLICLY OWNED (FEDERAL)
- PRIVATELY OWNED

HYDRO / FUEL
- UNDER CONSTRUCTION
- EXISTING

TRANSMISSION SUBSTATIONS

△ TRANSMISSION SUBSTATION WHERE CHANGES OF VOLTAGES ARE INDICATED. NOTE - STEP UP SUBSTATIONS AT GENERATING PLANTS NOT INDICATED BY SEPARATE SYMBOL

COMMUNITIES

- 25,000 POPULATION AND OVER
- 10,000 TO 25,000 POPULATION
- LESS THAN 10,000 POPULATION

(4 SITES BEING INVESTIGATED ARE ON THIS PORTION OF THE SNAKE RIVER)

SCALE IN MILES
10 0 10 20 30 40 50 60 70 80 90 100

PLATE IV G-2

Montana Power Company. In periods when no irrigation pumping is required, all of the power generated in excess of the local needs is sold to the Montana Power Company. This is a mutually beneficial arrangement as the power company's heaviest loads come in the winter when no power is needed for irrigation.

At present the Fort Peck Dam has one 35,000 KW generating unit and one 15,000 KW unit. An additional 35,000 KW unit has been ordered and will go on the line in the latter part of 1951. Of the 50,000 KW present capacity, approximately 40,000 KW is available for sale to the Montana Power Company.

The Fort Peck Dam was designed to accommodate three units. It would be possible to remove the 15,000 KW unit and replace it with a 35,000 KW unit with a minimum of changes in the building and foundations, draft tube, etc. If this were done the total capacity would be 105,000 KW instead of 85,000 as presently planned. The resident engineer believed that there would be sufficient water to run all three large units in all but the driest of years.

The Bureau of Reclamation will require an increasing amount of power for irrigation pumping as they extend their program. This amount is undetermined at the present time, but indications are that it will exceed 55,000 KW by 1953.

The following are existing and proposed tie lines for the Fort Peck Dam:

(a) There is an existing 154 KV line to the Montana Power Company at Great Falls. This line carries the surplus electric power generated at the dam.

(b) There is an existing 110 KV line to Glendive, which serves that area. An extension of this line down to Horton is now under contract.

(c) A 110 KV tie line from Fort Peck to Williston and from Williston to Garrison Dam in North Dakota is now under construction. Fort Peck will supply construction power during the building of Garrison Dam. It will be from three to five years before Garrison Dam will be able to generate any power of its own. After the construction period this dam will have electric power available over and above its own needs, including the provision of power for irrigation pumping. Initially, it will have a capacity of 128,000 KW and ultimately a capacity of 320,000 KW.

The line now under construction to Fort Peck has a capacity of 30,000 to 50,000 KW. It is to be increased in carrying capacity or additional lines will be built as Garrison

Dam increases in size. The complete program of development and distribution from Garrison Dam has not been worked out as yet.

The Montana Power Company:

At present the Montana Power Company's principal source of electrical energy is derived from the following hydro generating plants:

Station	KW Capacity
Black Eagle	18,000
Canyon Terry	7,500
Flint Creek	1,100
Hauser Lake	18,000
Holter	50,000
Kerr	56,000
Madison	9,000
Milltown	3,400
Morony	45,000
Mystic Lake	11,500
Rainbow	35,000
Thompson Falls	35,000
Ryan	60,000
Present Total	349,500

Presently, the Montana Power Company is purchasing up to 40,000 KW from the Bureau of Reclamation.

This company does not have any steam generating plants on their system at present. However, one is being designed for 66,000 KW and it is planned for construction in the Billings area, to be ready about September, 1951.

An additional hydro generating plant is now under construction at Kerr, Montana, and will have a capacity of 56,000 KW. The total capacity of this system will be 405,500 KW by April, 1949.

A comparison of peak loads and probable purchasable power in the future is as follows:

Year	Peak Load	Purchasable Power
1947	329,000 KW	389,500 KW
1948	354,000 KW	389,500 KW
1949	--	445,500 KW
1950	--	445,500 KW
1951	--	511,500 KW

This indicates purchasable power to spare at the present time. This surplus power is that which the Montana Power Company is sending to Idaho, Utah, and Region VII (a) to help meet their peak demands.

The Montana Power Company serves the Anaconda Copper Company, which had a peak of 170,000 KW, and the Milwaukee Railroad, which had a peak load of 40,000 KW in December, 1948. As increases in the requirements of these major users were planned the utility company was informed, and it in turn was able to include sufficient additional generating capacity in its expansion program to meet the requirements. The Montana Power Company has indicated its willingness to do this for any other large user.

The following are tie lines for this area:

(a) There is one 161 KV line to Utah Power and Light Company. This will be described further in this discussion.

(b) There are two 110 KV lines between Thompson Falls, Montana, and Spokane, Washington; one is owned by the Montana Power Company and the other by the Washington Water Power Company. In December, 1948, over 120,000 KW was sent into Region VII (a) over these tie lines to help meet its demand.

The Bureau of Reclamation Plant and associated generating facilities now under construction at Hungry Horse will contribute to the available supply of electric power in this region, but no method of distribution has yet been determined. This plant will develop 64,000 KW in 1952, 118,000 KW in 1953, and 185,000 KW in 1955.

<u>The Idaho Power Company</u>:

At present the Idaho Power Company's principal source of electrical energy is derived from the following hydro generating plants.

Station	KW Capacity
American Falls	27,000
Twin Falls	9,500
Shoshone Falls	12,000
Upper Salmon	35,500
Clear Lakes	2,200
Thousand Springs	7,300
Upper Malad	7,200
Lower Malad	13,500
Swan Falls	11,500

Station	KW Capacity
Horse Shoe Falls	1,500
Cascade & Bellview	300
Present Total	128,000

The Idaho Power Company has been purchasing surplus power from the Bureau of Reclamation to the extent of 7,000 KW at Black Canyon and 5,500 KW at Minidoka. The Bureau of Reclamation has a new Reservoir Plant at Anderson Ranch now under construction which will be ready about July, 1950. In the event they market this power in a similar manner it will add 22,000 KW to the purchasable power available after July, 1950. This is included in the totals tabulated.

Another similar plant called the Palisades Development (Bureau of Reclamation) has been authorized by Congress. It is hoped that this project will be completed in about 5 years time. It will have a capacity of 30,000 KW, but is not included in the totals tabulated.

The Idaho Power Company has no steam generating stations on its main network at the present time. There is one very small isolated station at Salmon which is mentioned here for purposes of record.

Additional units are being installed at Lower Salmon and Bliss Stations. At the end of 1949 these stations will supply 106,000 KW to the system and by the end of 1950 an additional unit will increase this figure to 129,000 KW.

Several sites for future dams are now being investigated by diamond drilling for foundation data. Design and construction will then be authorized to proceed on as many developments as the growth of load warrants. Idaho Power Company engineers say that present plants of this type are being designed, constructed, equipment secured and installed, and necessary transmission lines built in 2 to 2-1/2 years time. Future growth is coordinated closely with estimates on the future needs to maintain a suitable economical balance.

Sites having a potential capacity of 240,000 KW are now being investigated on the Snake River in the Lower Salmon and Glenn Falls area. There are many other additional sites in this territory which could be developed as required.

The Snake River is a very dependable source of hydro power. Due to the fact that this river has a high watershed, a large percentage of water comes from melting snow which contributes to a sustained summer flow. Also, large quantities of underground water inflow from springs, keeping the temperature of the river high enough in winter to eliminate icing troubles. The river is further controlled for irrigation which smooths out the rate of flow over a longer period.

A comparison of measured or probable peak loads and purchasable power in the future is as follows:

Year	Peak Load	Purchasable Power
1948	185,000 KW	140,000 KW *
1949	220,000 KW (Est.)	246,500 KW
1950	250,000 KW	293,000 KW
1951	285,000 KW	293,000 KW

*: The 1948 peak was met by purchasing power from the Montana Power Company and Utah Power & Light Company. From now on, the Idaho Power Company can carry their own peaks as shown.

Tie lines to other utilities will be discussed under Utah Power and Light Company.

New transmission line facilities in this area are as follows:

(a) A new 230 KV transmission line 190 miles long is now under construction from Boise to Lower Salmon and to American Falls. This will increase the load carrying capacity of the main backbone of the system.

(b) A new 69 KV transmission line 60 miles long is under construction from the 161 KV Montana, Idaho, and Utah tie line over to Salmon to connect to that plant. It will be extended west to a cobalt mine now being developed by the Home Sound Mining Company and this load will be approximately 2,500 KW. It will also be extended south to a tunsten mine owned by the General Electric Company and being operated on lease by a western firm. The present 600 KW (diesel generated) load will be picked up and the mine expects to increase the demand to 1,000 KW.

There are large deposits of phosphate extending from a point southeast of Pocatello, well into Montana. The Westvaco Chlorine Products Company, Pocatello branch, has a plant under construction which will make elemental phosphorus. Large electric furnaces of 17,000 KW each are used in this process. Two furnaces are scheduled to go on the line in the Westvaco plant, the first in April, 1949, and the second in January, 1950. Two more are to go in at a later and as yet unscheduled date. The first two furnaces are included in the tabulated loads and will be supplied by the Idaho Power Company as will future furnaces when they are installed, as indicated by plant requirements.

Utah Power & Light Company:

The Utah Power and Light Company's source of electrical energy is grouped under three classifications:

(a) Steam generated power in its company-owned plants.
(b) Hydro generated power in its company-owned plants.
(c) Surplus power purchased from local plants.

There are two steam generating plants in this system: Jordan Station, having a capacity of 43,000 KW, and Orem Station, having a capacity of 18,000 KW. A new 63,000 KW unit is being added at Jordan and a 43,000 unit at Orem. Some plans have also been made for a second additional 63,000 KW unit at Jordan, possibly by the end of 1953.

Five hydro plants on the Bear River have a total capacity of 124,000 KW and several small plants have a capacity of 25,000 KW. These latter are run-of-the stream plants and their output is not too reliable.

The Utah Power and Light Company has had a working agreement since 1944 with two large local industrial plants to purchase the surplus power which is produced in their operations. The Geneva Steel Corporation and the Kennecott Copper Company each supplies 25,000 KW to the utility system. However, plans being made by these companies may limit their combined surplus to 25,000 KW after 1950.

A comparison of measured or probable peak loads and purchasable power in the future is as follows:

Year	Peak Load	Purchasable Power
1948	245,000 KW	260,000 KW
1949	265,000 KW (Est.)	260,000 KW *
1950	290,000 KW (Est.)	303,000 KW *
1951 (Sept.)	----	341,000
1953 (End)	----	404,000

*: The Utah Power and Light Company intends to purchase 40,000 KW from the Montana Power Company to increase the margin during these years.

These data indicate that the Utah Power and Light Company will be able to carry the peak loads expected to be imposed on it in the foreseeable future. Should a new load of increasing size be brought into the company's territory, necessary steps would be taken to provide for it.

The following two tie lines are in operation in this area:

(a) One 134 KV line extends from the Wheelan Station to the Idaho Power Company American Falls plant. This line carries 60,000 KW in a satisfactory manner and is very dependable in operating characteristics.

(b) There is one 161 KV line from the Grace Station to the Montana Power Company Anaconda Station near Anaconda, Montana. The Grace to Goshen portion is owned by the Utah Power and Light Company, Goshen to Montana State line by the Idaho Power Company, and the portion north of the Montana State line by the Montana Power Company. This line carries 45,000 KW nicely and has been operated at 50,000 KW for some time on several occasions.

4. COSTS

The Department of the Interior is proposing a uniform rate for power sold in the Missouri Valley. Under these conditions the power for this project works out to be about 5.5 mills per K.W.H. at Fort Peck. In the upper Snake River Valley power generation plants are larger and less costly, transmission lines are shorter, and load centers are more definitely defined. As a result of these conditions, power costs at the Pocatello Site will be less than at Fort Peck. Indications are that power at the Idaho site will be about 3.5 mills per K.W.H.

5. SUMMARY

Sufficient power is not now available at either site to meet the anticipated total requirements of the new project, and such power would have to come from generating plants some distance away and which are now either being constructed or are still in the planning stage. It is apparent, however, that within the time available, adequate power could be made available at either site.

If the project were located at Fort Peck, the dam there would appear to be the logical source of electrical energy. However, commitments for power for present and future irrigation programs limit the quantity which would be available to about 17,000 KW. The balance of the requirements, over 40,000 KW, would have to come from the Montana Power Company and from Garrison Dam in North Dakota, which is now under construction. Power from the Garrison Dam, however, will not be available until about 1953. The distance from Fort Peck Dam to the plant site is about 27 miles. Transmission lines for construction and operation will have to be built for either site.

The utilities companies serving the Pocatello area do not have sufficient capacity at the present time to meet the full requirements of the project. It should be noted, however, that these companies will have sufficient combined capacity beginning in 1950 to carry their own loads as well as the initial requirements of the Reactor Testing Station without assistance from other private utilities. The experience of these companies has been that given sufficient advance notice they are able to develop new generating facilities to keep pace with the increasing load. Power for construction could be made available, although a transmission line approximately 25 miles in length would have to be constructed to serve the site.

The annual power requirement for the plant operation in the year 1955 is calculated as follows:

$$24 \times 50{,}000 \times 365 \times 0.90 = 394{,}000{,}000 \text{ K.W.H./yr.}$$

Assuming consumption of 400,000,000 K.W.H. per year of purchased power, the total yearly cost would be $2,200,000 at Fort Peck and $1,400,000 at Pocatello.

The influx of new people associated with this project would be more easily established in the Pocatello area than at Fort Peck. Cities in the former area are larger and better developed and electrical service could be had with much less new construction and cost than would be the case at Fort Peck.

IV H. FUEL AVAILABILITY AND COSTS

1. REQUIREMENTS

The quantity of fuel required for the operation of the plant is based on a total steam requirement of 200,000 pounds per hour. It is assumed that this will be a continuous load except for space heating, which will require approximately 50,000 pounds of steam per hour and will be seasonal. In addition, some fuel may be required from time to time for the operation of the standby electric power generating facilities. No allowance is made for this latter item in estimating the fuel requirements for the plant.

The increased population in the vicinity of the site will also require some additional fuel for heating of homes. The quantity of fuel required for these purposes is difficult to estimate but on the very generous basis of four tons per person the quantity needed becomes approximately 100,000 tons per year. For cooking purposes coal, butane gas, or electricity could be used at either site. Probably electricity would be the most popular and these requirements have been discussed in the section of this report relating to Electric Power.

The quantity of coal required for the production of 200,000 pounds of steam per hour will depend on the type of coal used. The heating value of the several grades of coals available varies greatly, ranging from approximately 6,500 BTU per pound for North Dakota lignite to approximately 14,000 BTU for eastern U.S. coal. In Table IV H-1 is presented detailed information on the coals considered for each of the several sites, as well as the quantity of each kind of coal which would be required for plant purposes and the cost per ton at the mine and at the plant site. The coal requirements per day are calculated in accordance with the following:

$$\text{Tons Per Day} = \frac{200{,}000 \times 24 \times 970.2 \times 1.06}{2000 \times \text{BTU of Coal} \times 0.75}$$

For this calculation a factor of evaporation of 1.06 and an over-all efficiency of 75 per cent are assumed.

Should it be desired to use fuel oil for the generation

TABLE IV H - 1
EVALUATION OF COAL SOURCES AND REQUIREMENTS
FORT PECK AND POCATELLO SITES

Source Fort Peck Site	Type	Heating Value BTU/lb.	ANALYSIS Vol. Matter %	Fixed Carbon %	Ash %	Mois-ture %	Sulfur %	Ash Fusion of	Price - Per Ton At Source or Mine	Delivered at Site Pocatello	Delivered at Site Fort Peck	Daily Requirement Tons/Day	Daily Cost $/Day
Kinkaid, N. D.	Lignite	6,500 to 7,300	26 to 29	26 to 31	8 to 12	28 to 35	Less Than 1.0	---	2.35 to 2.60		6.25	506	3,160
Williston, N. D.	Lignite	6,500 to 7,300	26 to 29	26 to 31	8 to 12	28 to 35	Less Than 1.0	---	2.35 to 2.60		6.10	506	3,090
Eastern U. S. Coal at Duluth, Minn.	Bitum.	14,000	---	---	---	---	---	---	10.15 to 12.00		17.85	235	4,200
Colstrip, Mont.			---	---	---	---	---	---	---		---	---	---
Carbon County, Montana	Sub-Bitum.	11,000	---	---	---	---	---	---			9.35	299	2,800
Roundup, Mont.	Lignite	8,500	---	---	8 to 12	25 to 30	Less Than 1.0	---	---		11.66	388	4,500
Sheridan, Wyoming	Lignite	8,500	---	---	8 to 12	25 to 30	Less Than 1.0	---	---			388	
Pocatello Site:													
Carbon County, Utah *1	Bitum.	13,500	45.35	---	7.5	6.0	0.79	2285	4.60	8.20		244	2,000
Kemmerer, Wyo. *2	Sub-Bitum.	10,450	35.06	40.7	3.8	19.9	---	2300	3.25	6.55		315	2,060
Rock Springs, Wyoming *3	Sub-Bitum.	12,500	38.7	50.1	4.7	6.4	---	2350	4.90	8.20		263	2,155

NOTE: In addition to the coals listed in the above table, some coal is also produced at Great Falls, Montana. While this coal has a relatively high heat value, it is quite dirty and difficult to burn. Local industry prefers to use other coals which are of a better quality.

*1 - Supplier--U. S. Fuel Co.
*2 - Supplier--Kemmerer Coal Co.
*3 - Supplier--U. S. Fuel Co.

of steam in the plant, the quantity required would be:

$$\frac{200,000 \times 24 \times 970.2 \times 1.06}{3.25 \times 18,000 \times 0.78} = 42,600 \text{ gal/day.}$$

It is assumed that no natural gas will be required for plant operations. However, gas can be made available by opening up new wells and running a new line from the gas field to the plant site. The daily gas requirement would be:

$$\frac{200,000 \times 24 \times 970.2 \times 1.06}{1,000 \times 0.78} = 6,320,000 \text{ cubic feet.}$$

IV H. FUEL AVAILABILITY AND COSTS (Cont'd.)

2. THE FORT PECK SITE

Coal:

Coal deposits of varying qualities are geographically located so as to be within reasonable distance of the Fort Peck Site. In general, there are large deposits of lignite and semi-bituminous coal in Montana and parts of North and South Dakota. These fields are well known and are presently being worked at a number of locations. Reserves of these lower-grade fuels are very great. The sources, types, heating values, analyses, requirements, costs, and other information on coal for this area are shown in Table IV H-1.

These points of supply are:

Kinkaid, N. D.	Carbon County, Mont.
Williston, N. D.	Roundup, Mont.
Duluth, Minn.	Sheridan, Wyoming
Colstrip, Mont.	

Reference is made to Plate IV H-1, which shows the location of fuels and principal shipping points for both the Fort Peck and Pocatello Sites.

The daily cost of supplying coal in the quantity required at the Fort Peck Site is tabulated below:

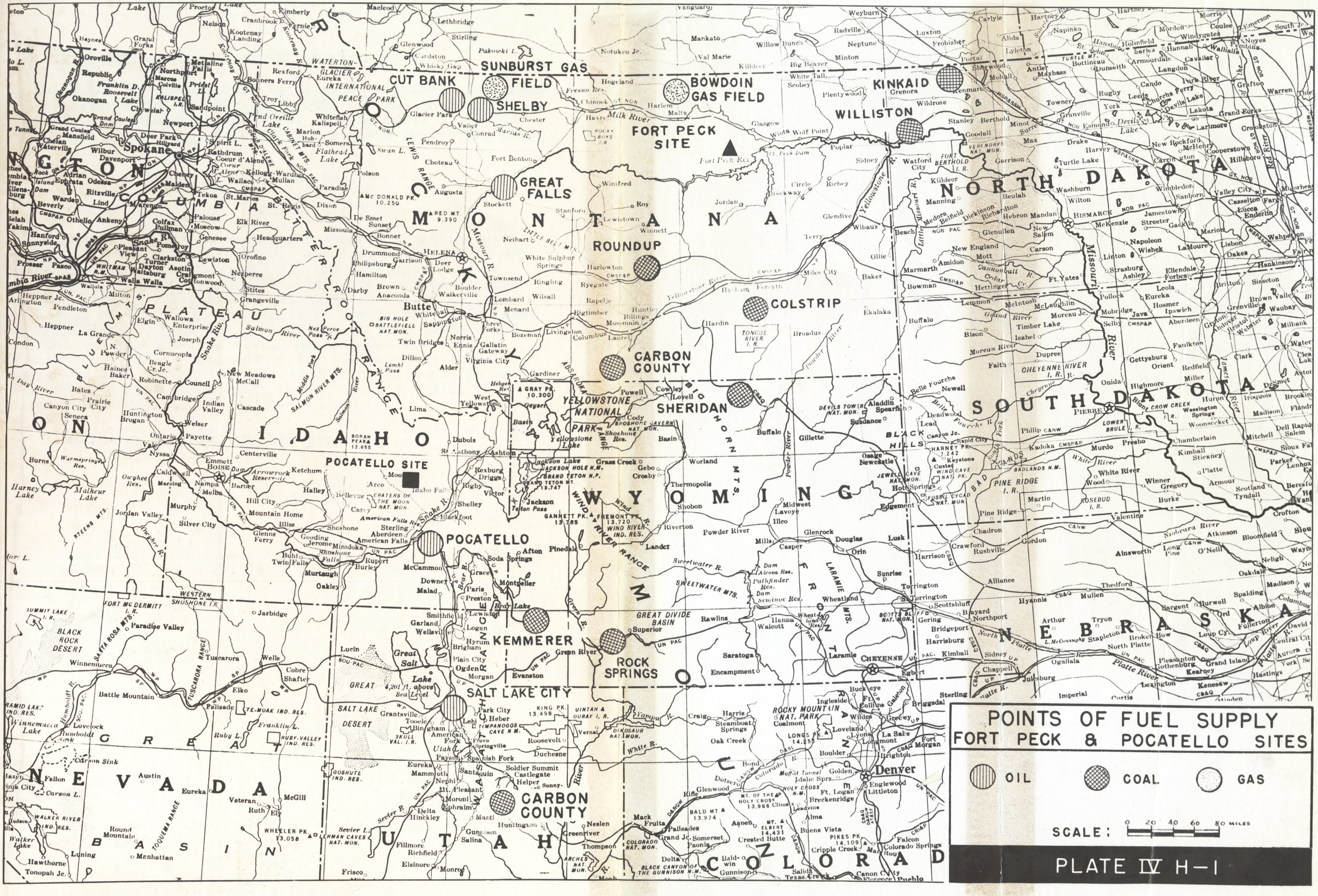
Kinkaid, N. D.	$3,160.00	per day
Williston, N. D.	3,090.00	" "
Eastern	4,200.00	" "
Colstrip, Mont.		
Carbon County, Mont.	3,800.00	" "
Roundup, Mont.	4,500.00	" "
Sheridan, Wyoming		

These figures are based on mine prices and freight rates to Glasgow, Montana.

Oil:

Fuel oil for the Fort Peck Site can be obtained from Shelby or Cut Bank, Montana. There is a relatively small demand for No. 6 fuel oil in this area, and the price fluctuates widely. Refineries are located in both the Shelby and Cut Bank areas and the supply is reported as plentiful. Plate IV H-1 also shows sources of fuel oil for both sites.

The cost of fuel oil for the Fort Peck Site ranges from $1.85 to $2.35 per barrel. Freight costs are $1.44 from



POINTS OF FUEL SUPPLY
FORT PECK & POCATELLO SITES

PLATE IV H-1

Shelby and \$1.4976 from Cut Bank to Glasgow, Montana. Delivered prices, therefore, are \$0.0783 to \$0.0902 per gallon from Shelby and \$0.0797 to \$0.0916 from Cut Bank. On the basis of \$0.085 per gallon the daily cost of fuel oil for steam production would be:

$$42,600 \times \$0.085 = \$3,620 \text{ per day.}$$

<u>Gas</u>:

Natural gas for industrial purposes is not now available for use at the Fort Peck Site. An eight-inch natural gas pipe line runs from the Bowdoin Field and Sunburst Field in Montana to Williston, North Dakota. This line serves Glasgow and is now operated at capacity. It could not serve an additional demand at Glasgow. The supply of gas in the fields mentioned is plentiful, however, and additional pipe lines could be extended to the Fort Peck area. Natural gas sources are shown on Plate IV H-1. The cost of gas delivered to the site, including the cost of the new pipe line and equipment, is estimated at \$0.50 per thousand cubic feet. On this basis, fuel costs for steam generation would be:

$$\frac{6,320,000 \times \$0.50}{1,000} = \$3,160 \text{ per day.}$$

IV H. FUEL AVAILABILITY AND COSTS (Cont'd.)

3. THE POCATELLO SITE

Coal:

As in the case of the Fort Peck Site, coal deposits of varying qualities are also geographically located so as to be within reasonable distance of the Pocatello Site. Semi-bituminous coal deposits are found and are being exploited at Carbon County, Utah; Kemmerer, Wyoming; and Rock Springs, Wyoming. Plate IV H-1 shows the location of these coal mines and the principal shipping points, in addition to information on other fuels for this site and the one at Fort Peck.

The reserves at the three sources which would serve the Pocatello Site have been estimated to be as follows:

	Proven Tons	Partly Proven
Rock Springs, Wyoming	471,307,000	969,107,000
Kemmerer, Wyoming	165,293,000	500,000,000
Carbon County, Utah	300,000,000	

Costs of supplying coal at Pocatello, Idaho from the several sources suitable for the Pocatello Site are:

Carbon County, Utah	$2,000.00	per day
Kemmerer, Wyoming	2,060.00	" "
Rock Springs, Wyoming	2,155.00	" "

These figures are based on mine prices and freight rates to Pocatello, Idaho. The requirements are shown in Table IV H-1 according to heating value of coals from each of the sources of this fuel. The reserves at these points are large and there is no concern on this point. The capacity of production at Rock Springs is 6,500,000 tons per year while present production is 3,000,000 tons per year. The Kemmerer mine at Kemmerer, Wyoming, is equipped to supply with present equipment an additional 1,000 tons per day, and the U.S. Fuel Company has ample capacity at Carbon County, Utah.

Oil:

Fuel oil for the Pocatello Site could be obtained from a refinery of the Phillips Petroleum Company at Pocatello or from the Salt Lake City Oil Company. Officials of the Phillips refinery at Pocatello have stated that they could supply a new customer with fuel oil up to a volume of 25,000 gallons per day. Transportation of fuel oil from the Salt Lake City refinery presents no difficult problems. The location of these refineries in relation to the Pocatello Site may be noted on Plate IV H-1.

The delivered price of fuel oil would be \$0.0861 per gallon from the Phillips refinery at Pocatello and \$0.084435 from the Salt Lake City source.

On the basis of the cheaper of these sources the daily cost of fuel oil for generating the required quantity of steam per day would be:

42,600 x \$0.084435 = \$3,590 per day.

<u>Gas</u>:

For the Pocatello Site the nearest supply of natural gas is a pipe line from the Hugeton Field in Kansas, to Denver, Colorado, and Cheyenne, Wyoming. This source is considered to be of no immediate value for the Pocatello Site.

IV H. FUEL AVAILABILITY AND COSTS (Cont'd.)

4. SUMMARY

Suitable fuel for the generation of steam is available for either site. Based on the production of 200,000 pounds of steam per hour, the most economical sources of fuel for each site give daily fuel costs as follows:

Fort Peck	$2,800
Pocatello	2,000

This is for coal from Carbon County, Montana, to Fort Peck and for coal from Carbon County, Utah, to Pocatello.

The use of fuel oil or gas for either site would result in the following daily costs:

	Fuel Oil	Gas
Fort Peck	$3,620	$3,160
Pocatello	$3,590	not available

APPENDIX

Biographical Notes on Consultants

Consultants Reports

Alvord, Burdick & Howson

Harold T. Stearns

George Summerfield

J. Stewart Williams

BIOGRAPHICAL NOTES ON CONSULTANTS

The following are biographical notes on the consultants employed in the preparation of this report.

Louis Richard Howson is a partner in the firm of Alvord, Burdick & Howson, Consulting Engineers, Chicago, Illinois. He was educated at the University of Wisconsin, receiving the degree of Bachelor of Science in Civil Engineering in 1908 and the degree of Civil Engineer in 1912.

Mr. Howson entered the employ of the firm then known as Alvord and Burdick in 1908. Since 1915, he has been continuously associated with the firm as assistant engineer, principal assistant engineer, and partner. The firm name was changed to Alvord, Burdick & Howson in 1922. Mr. Howson has been in responsible charge of water supply, sewerage, sewage disposal, flood relief, and public utility valuations in projects throughout the United States.

Projects under Mr. Howson's charge on water works investigation, reports and/or plans and specifications, and supervision of construction include those for such cities as: Chicago, Peoria, Pekin, and LaGrange, Illinois; Milwaukee, Racine, Kenosha, Fond du Lac, and Oshkosh, Wisconsin; Louisville, Lexington, Paducah, and Ashland, Kentucky; Cleveland, Dayton, and Springfield, Ohio; Miami and Orlando, Florida; Houston and Laredo, Texas; Roanoke, Virginia; Aberdeen, South Dakota; Denver, Colorado; Springfield and St. Louis County, Missouri; Des Moines, Iowa; Saginaw, Michigan; and others.

Sewerage and sewage disposal projects which were the responsibility of Mr. Howson include those for such cities as Winnipeg, Manitoba; Green Bay, La Crosse, Fond du Lac, Racine, and Kenosha, Wisconsin; Davenport, Iowa; Aurora and Galesburg, Illinois; Canton, Ohio; and Moose Jaw, Saskatchewan; plus other cities. He has been a consultant to the Secretary of War of the United States in regard to the Sanitary District of Chicago and has testified in four cases before the United States Supreme Court regarding sanitation at Chicago and diversion from Lake Michigan in the employ of the States of Minnesota, Wisconsin, Michigan, Ohio, Pennsylvania, and New York.

His services as Consulting Engineer on flood work have been utilized in such localities as Decorah and Cedar Rapids, Iowa; Lincoln, Nebraska; and Galesburg, Illinois.

Mr. Howson has appraised over 100 public utility properties serving both public and private interests. These appraisals include those for Louisville, Lexington, and Paducah, Kentucky; Cleveland and Bowling Green, Ohio; Spokane, Washington; and Elizabeth, New Jersey.

He is a registered professional engineer in the States of Iowa, Colorado, Texas, South Dakota, Minnesota, Kentucky, Indiana, Wisconsin, Michigan, Ohio, Illinois, Washington, Florida, Nebraska, Virginia, Pennsylvania, Alabama, Idaho, and Oklahoma. Publications credited to him include numerous technical papers on water supply, sewage treatment, and public utility valuation.

Mr. Howson is a member of the Illinois State Board of Conservation and National Resources, American Society of Civil Engineers, American Society of Mechanical Engineers, Western Society of Engineers (ex-president), American Water Works Association (ex-president), Illinois Society of Engineers, and the American Institute of Consulting Engineers.

Donald H. Maxwell is a member of the firm of Alvord, Burdick & Howson, Consulting Engineers, Chicago, Illinois. He was educated at the Massachusetts Institute of Technology, receiving his degree in Sanitary Engineering in 1908.

Mr. Maxwell entered the employ of the firm of Alvord and Burdick in 1909 with the position of Assistant Engineer. Since 1915, he has been a member of the firm, which has continued since 1922 as Alvord, Burdick & Howson.

As the Assistant Engineer, Mr. Maxwell was engaged in the inspection of construction of reinforced concrete towers, was resident engineer on the construction of concrete reservoirs, made investigations of water supply, made reports for improvements, did field work and design for septic tank and slow sand filter sewage treatment plant, and did field work on projects investigating ground water supply on various projects.

Since 1915, he has been engaged continuously in various capacities in field investigations, reports, and plans, concerning all branches of water works, flood relief, sewerage, and sewage treatment.

These projects include field investigation for Oklahoma City Water Works Report; Columbus, Ohio; Franklin County, Ohio, Flood Reports and others. Water purification plant designs in which he participated include those for Louisville, Kentucky; Cedar Rapids, Iowa; and Milwaukee, Wisconsin, plus others. Water works valuations include, among others, those for Kokomo, Indiana; Washington Court House, Ohio; and Louisville, Kentucky. Mr. Howson was engaged in sewage treatment plant design for Aurora, Illinois; Green Bay and LaCrosse, Wisconsin; and others. Among the water works reports in which he participated were those for Aberdeen, South Dakota; Springfield, Missouri; and Springfield, Ohio.

Some of the more important recent projects in which Mr. Maxwell has been engaged include the following:

Investigation and report on water supply for Houston, Texas, outlining for comparison seven projects, cost varying from $8,869,000 to $19,972,000.

Report on water rates for Kansas City, Missouri, including study of operating economies and adoption of water softening.

Resident partner (for the Architect-Engineer) on construction of Ft. Leonard Wood, Missouri, cost approximately $36,000,000.

In charge of field work and preparation of part of the plans for the $2,500,000 15 MGD well and 20-mile pipe line, Mill Creek Valley Water Supply. Project to serve Wright Aeronautical Corporation, Lockland, near Cincinnati, Ohio.

Report to the Federal Works Agency on water requirements and water resources of defense industries in the Lockland area.

Investigation and report on storm water drainage for Gary, Indiana. Improvements estimated at $5,167,000.

Report on softening of the Louisville, Kentucky water supply and cost of plant additions involved, estimated at $669,000. Now engaged on plans for this improvement.

Reports on Plant Improvements, Evanston, Illinois, Water Works.

Plans and general supervision of construction of Evanston, Illinois, Water Works Improvements including 24 MGD filter plant addition, new pumping station, service building, etc., total cost $2,800,000.

Report on Collecting Sewers and Sewage Treatment for the Birmingham Metropolitan Area, Jefferson County, Alabama, estimated cost of improvements $16,000,000.

Mr. Maxwell has a Certificate of Qualification (in Subsection "A") in the National Bureau of Engineering Registration. He is a registered professional engineer in the States of Illinois, Michigan, Texas, and Wisconsin. Publications credited to him include various papers in engineering periodicals and the Journal of the American Water Works Association.

He is a member of the American Society of Civil Engineers, Illinois Society of Engineers, Western Society of Engineers, American Water Works Association, and the Chicago Engineers Club.

Harold T. Stearns is a practicing Consulting Geologist, with an office in Hope, Idaho. He received the degree of Bachelor of Science from Wesleyan University in 1921 and the degree of Doctor of Philosophy from George Washington University in 1926.

In 1921 and 1922 Dr. Stearns was Mineral Examiner for the United States General Land Office.

He was with the United States Geological Survey from 1922 to 1946, being District Geologist for the Hawaiian Islands at the time of his resignation. Also during the period from 1941 to 1945 he was Geologist-in-charge of Pacific Investigations for the United States Geological Survey and served as consultant for the Armed Forces in the Pacific Theater.

Since 1946, Dr. Stearns has been a consulting geologist for public and private interests.

Publications by Dr. Stearns include twenty geologic books, government bulletins, and numerous scientific and economic articles on geology, volcanism, ground water, dam sites, quarry sites, and similar subjects.

In the course of his work with the U. S. Geological Survey, Dr. Stearns spent much time studying the ground water resources of the Snake River Lava Plain. He is co-author of Water Supply Paper #774 and #775 of the U.S.G.S., and his knowledge of the conditions in the lava plain is very extensive.

He is a member of the West Coast Advisory Service, National Research Council, Phi Beta Kappa, and is a Life Fellow, Geological Society of America. Dr. Stearns was awarded a Presidential citation and Medal for Merit for professional services during World War II.

George Summerfield, Public Relation Counsel, Detroit, Michigan, received his academic training at Michigan State College, Wayne University, and the University of Michigan. For the past sixteen years he has operated his own firm serving business and industrial organizations.

Mr. Summerfield's activities include research and counseling on sales and advertising, market and economic surveys, and analyses and similar services for public agencies, labor organizations, sales organizations, manufacturers, and engineering consultants.

The following are typical of the clients served by Mr. Summerfield:

Gray Marine Motors
Hartung Aircraft Corporation
Methods Engineering Institute
Puffer & Darling
Smith, Hinchman & Grylls, Inc.
Peninsular Metal Products
Foreman's Association of America

Representative of the projects for which Mr. Summerfield conducted market and economic surveys and analyses are: Study of Aviation Facilities for the State of Illinois, which consisted of comprehensive studies of 170 airports; City of Detroit Airport Survey; and the Port of Monroe, Michigan, Survey.

J. Stewart Williams is Professor of Geology and head of that department at the Utah State Agricultural College. He received the degree of Bachelor or Science from Brigham Young University in 1923, the degree of Master of Arts from Columbia University in 1927, and the degree of Doctor of Philosophy from George Washington University in 1932. He was at Yale University in 1934-35, and since that time has been in his present position.

In addition to his duties as Professor and head of the Department of Geology at Utah State Agricultural College, Dr. Williams has participated professionally as follows:

Collaborator in seismology for Utah, U. S. Coast and Geodetic Survey, 1942 to date.

Collaborator, U. S. Soil Conversation Service, and U.S. Department of Agriculture, Logan, Utah, 1945-1946.

Collaborator, Intermountain Forest and Range Experiment Station, U. S. Department of Agriculture, Ogden, Utah, 1943-date.

Geologist (WAE), U. S. Geological Survey, 1946-date.

Member, Committee on Geophysical Effects of Detonation, National Research Council, James B. Macelwane, Chairman, 1945-1946.

Consultant to various companies and organizations including two major oil companies, a major phosphate company, Utah State Road Commission, irrigation companies, and private individuals, 1935-date.

Dr. Williams is the author of the following publications:

Tully Formation of New York (with G. Arthur Cooper). Bull. Geol. Soc. Am., vol. 46, pp. 781-868, 1935.

"Park City" Beds on Southwest Flank Uinta Mountains, Utah. Bull. Am. Assn. Petrol. Geologists, vol. 23, pp. 82-100, 1939.

Phosphate in Utah. Utah Agric. Experiment Station, Bull. 290. 1939.

The Oldham Seismograph Station at Utah State Agricultural College, Logan, Utah. Bull. Seismological Soc. Am. Vol. 32, pp. 49-59, 1942.

The Cambrian Section in the Logan Quadrangle, Utah (with G.B.Maxey). Am. Jour. Science, vol. 239, pp. 276-285, 1942.

The Phosphate Reserves of Utah (with A.M.Hansen). Utah Agric. Experiment Station, Bull. 304, 1942.

Carboniferous Formations of the Uinta and Wasatch Mountains, Utah. Bull. Geol. Soc. Am., vol. 54, pp. 591-624 1943.

Nomenclature of Triassic Rocks in Northwestern Utah. Am. Jour. Science, vol. 243, pp. 473-479, 1945.

Brazer (Mississippian) and Lower Wells (Pennsylvanian) Section at Dry Lake, Logan Quadrangle, Utah. Bull. Am. Assoc. Petroleum Geologists, vol. 29, pp. 1143-1155, 1945.

Geological Studies in Utah. Seventh Annual Faculty Research Lecture, Utah State Agric. College, Logan, Utah, 1948.

Geology of the Paleozoic Rocks, Logan Quadrangle, Utah. Bull. Geol. Soc. Am., vol. 59, pp. 1121-1164, 1948.

Dr. Williams is a member of the American Association of Petroleum Geologists, American Geophysical Union, Seismological Society of America, Phi Kappa Phi, and Sigma Xi. He is a Fellow, Geological Society of America, and Fellow, the Paleontological Society.

REPORT ON

WATER SUPPLY

FT. PECK AND SNAKE RIVER PLAIN SITES

JANUARY, 1949

Alvord, Burdick & Howson
Engineers Chicago

WATER SUPPLY

By

Alvord, Burdick & Howson

This report deals with the availability, quality and cost of developing the water supply for a project at the tentative site either on the north side of Fort Peck reservoir, Montana, or on the Snake River plain west of Idaho Falls, Idaho.

QUANTITY OF WATER REQUIRED

The basis of development as given to us and used in this study is an ultimate plant water supply of 23 MGD of which approximately 14 MGD would be cooling water, and a resident personnel domestic supply of 6 MGD, the latter preferably provided by enlargement of some existing community supply.

The plant water supply requirement for the first year is stated to be only 1.5 MGD, increasing rather uniformly to 15 MGD in 1955 and thereafter to the ultimate amount of 23 MGD.

The stated domestic water supply requirement, including that for the construction camp, totals only 0.17 MGD in 1949, increasing to a maximum of 8.2 MGD in 1954, and dropping to 7.95 MGD in 1955.

SUMMARY AND CONCLUSIONS

For convenience the results of our investigation and study are summarized herewith and on Table 1, which shows estimated construction costs based on present prices.

TABLE 1
SUMMARY OF WATER SUPPLY CONSTRUCTION COSTS

	FT. PECK RESERVOIR SUPPLY			SNAKE RIVER PLAIN SUPPLY	
	A Intake in Res. 450' head	B Penstock Supply 250' head	C Tailrace Intake 450' head	A Well Supply 600' head	B River Supply 400' head
Intake	110,000	25,000	50,000	-	50,000
Tunnels	775,000	-	-	-	-
Suction Wells	335,000	-	-	-	-
Pumping Station	710,000	300,000	300,000	-	300,000
Pumping Equipment	428,000	305,000	462,000	-	420,000
Aux. Power Station	200,000	-	-	-	-
Generating Equip.	300,000	-	-	-	-
Pipe Lines	3,900,000	7,000,000	7,000,000	3,490,000 (1)	15,060,000
Reservoirs	1,400,000	1,400,000	1,400,000	1,520,000	1,520,000
	360,000	360,000	360,000	-	-
Wells	-	-	-	2,400,000	-
Well pumps	-	-	-	600,000	-
Gas Engine Reserve	-	-	-	150,000	-
Power lines	200,000	25,000	55,000	230,000	50,000
Special .7 MGD Treatment Plant	350,000	350,000	350,000	350,000	350,000
Total	$ 9,068,000	$ 9,765,000	$ 9,977,000	$8,740,000	$17,750,000
Eng. & Cont.	1,359,000	1,467,000	1,497,000	1,307,000	2,667,000
Total	$10,427,000	$11,232,000	$11,474,000	$10,047,000	$20,417,000
9 MGD Filter Plant, if required	900,000				900,000
Eng. & Cont.	130,000				130,000
Total	$ 1,030,000				$ 1,030,000

(1) If well supply lines are extended, the additional cost of two 36" lines in parallel is approx. $400,000 per mile and the add'l. annual cost of power for pumping 23 MGD would be approx. $400 per mile.

1. FT. PECK SITE - DOMESTIC WATER SUPPLY

The nearest conveniently located community on the Great Northern Railroad is the town of Glasgow, about 20 miles north-east from the indicated center of the site. The public water supply at Glasgow, population about 4,000, is from two shallow wells in the alluvium, located close to Milk River. This supply could be increased to produce the stated additional 6 MGD by adding wells at an estimated cost of approximately $65,000. The present water is yellowish in color and high in iron. A water treatment plant to produce a better quality potable supply would cost approximately $517,000, based on 6 MGD capacity.

Deep wells in the shale at Glasgow have negligible yields and would not be a suitable source for this large a community supply.

An alternative supply could probably be had from the Milk River. The cost, including water rights and a 6 MGD filter plant and pumping station, is estimated at $625,000. These estimates do not include any additions to the local distribution system which, based on a normal amount of 2 miles of mains per 1,000 population and an average cost of $3.00 per foot, would cost $380,000 for the stated plant resident population of 12,000 in 1955.

2. FT. PECK SITE - PLANT WATER SUPPLY

The plant supply would be taken directly from Ft. Peck reservoir at the nearest practicable location from the plant center. Water would be taken through a submerged intake below minimum reservoir water level, that is, at a depth of 130 ft.

below spillway level. It would be pumped through duplicate 30" pipe lines to the top of the divide (about one-third of the distance to the plant center) where a 5 million gallon line reservoir would be located, and would flow thence by gravity through duplicate 30" pipe lines to two 11.5 MG reservoirs at the center of distribution. The cost of this development, referred to as Plan A and including a 0.7 MGD plant for treated process water, is estimated at $10,427,000.

The construction of shaft, tunnel and submerged intake could be avoided by taking water from the power plant penstock pipe below the dam. This would also eliminate pumping over the ridge but would involve 10 miles additional length of duplicate force mains. This alternative development, referred to as Plan B, is estimated to cost approximately $11,232,000. The construction cost of Plan C, taking water from the tailrace, would be approximately $11,474,000 and the head pumped against would be about 200 ft. more than in Plan B.

The annual power cost of pumping in Plan A, with submerged intake, is estimated at $72,000; in Plan B, taking water from the penstock pipe below the dam, approximately $39,000; and in Plan C, taking water from the tailrace, approximately $72,000, based on delivering 23 MGD continuously and 0.43¢ per kilowatt hour.

3. FT. PECK SITE - TEMPERATURE OF WATER

The water temperature, with water taken at a suitable depth, or from the penstock, or tailrace, would range from a maximum of about 54° in the fall to 35° in winter.

4. FT. PECK SITE - QUALITY OF WATER

The Ft. Peck reservoir water is relatively clear, has a hardness varying from about 150 to 200 p.p.m., chloride content of about 4 p.p.m., and boron content of 0.10 p.p.m.

5. SNAKE RIVER SITE - DOMESTIC WATER SUPPLY

The nearest town from this site by present branch railroad and highway is Blackfoot about 40 miles away and located on the east bank of Snake River and on a main branch line of the Union Pacific Railroad. This city has a present population of about 4,000 and is supplied by well water of good quality. The city is adapted to the necessary expansion to take care of the permanent plant population. The cost of the necessary additional wells and equipment to develop 6 MGD is estimated at approximately $131,000 and of the necessary distribution system to serve 12,000 additional population, approximately $380,000. No water treatment would be required although the soap hardness is 314 p.p.m.

6. SNAKE RIVER SITE - PLANT WATER SUPPLY

The plant water supply of 23 MGD would be obtained by deep wells in the lava. The lack of any considerable well development in the proposed location makes it necessary to provide liberally for the possible contingency of running into dry holes and wells of lower specific capacity than that of the two wells at the Navy range site. For estimating purposes we have assumed that 23 operating wells would be required based on an average of 1 MGD per well, plus a reserve of 7 stand-by wells, or a total of 30 equipped wells, and that to get those wells a total of 60 holes would have to be drilled. We have assumed further that the wells would be 800 ft. deep and spaced 4,000 ft. apart in each of two rows, the latter being 1,000 ft. apart, and would extend a total distance of approximately 12 miles in a southeasterly direction from the plant site. Water would be delivered through a duplicate pipe line of 24", 30" and 36" size, to two 11.5 MG reservoirs at the plant center. A 0.7 MGD plant for treated process water is included. The estimated cost of this development is approximately $10,047,000. The annual cost of power to lift the water an estimated average of 540 ft. to the ground surface and deliver it to the reservoirs would be approximately $73,500 based on 0.3¢ per K.W. hour and pumping 23 MGD continuously.

It may be that much more favorable conditions would develop than here assumed and that it would be possible to get along with a substantially smaller amount of well drilling and to save considerably on discharge pipe lines. However, the development of a major supply in this area is uncharted. There is believed to be ample water but the extent, location and cost of development are unknown and therefore have been estimated on what is believed to be a reasonably safe basis.

For comparison with the above well supply we have estimated the cost of delivering water from Snake River, assuming it to be available for this purpose. This would involve a pumping station near Idaho Falls, duplicate 36" pipe lines extending 41 miles west to two reservoirs at the plant center, and a 0.7 MGD plant for treated process water. The cost of development as above outlined would be $20,417,000, and the annual power cost of delivering 23 MGD would be approximately $41,700. A 9 MGD filter plant at the plant center, if required, would cost an additional $1,030,000.

7. SNAKE RIVER SITE - TEMPERATURE OF WATER

The Snake River plain well water temperature is about 54°.

8. SNAKE RIVER SITE - QUALITY OF WATER

The well water would have a chloride content of about 12 p.p.m. boron of about 0.02 p.p.m., pH 7.5 and total hardness of about 140 p.p.m.

The above water supplies are more fully discussed in the following pages.

WATER SUPPLY REQUIREMENTS

This report is based on developing a water supply in each locality to meet the stated requirements of 23 MGD for plant purposes and 6 MGD for domestic use by the resident or permanent population of the plant community. However, in considering the availability of water, we have had in mind the figure first given to us of 34 MGD for plant water supply as possibly being necessary, and we have considered the availability in each case of this quantity of water.

The stated construction camp and resident (permanent) populations and corresponding domestic water supply requirements and also the plant water supply requirements, during the construction period from 1949 to 1955, are shown on Table 2. It should be noted that the combined construction camp and resident water supply as estimated for the first year is only 0.17 MGD, and the plant water supply only 1.67 MGD. The corresponding figures for the second year are 1.41 and 4.41 MGD respectively, and for the third year 2.6 and 7.6 MGD respectively. The relatively small amounts required initially considerably simplify the problem of having water available in sufficient time.

It should also be noted that the total of camp and resident water supply requirements exceed 6 MGD by about 33% in 1954 and 1955. However, the per capita allowances seem extremely liberal for a normal community so that provision of 6 MGD should be more than enough to take care of the maximum day domestic demand of

TABLE 2

STATED POPULATION AND WATER SUPPLY REQUIREMENTS

Population	'49	'50	'51	'52	'53	'54	'55	Ult.
Construction (camp)	460	4,500	10,000	10,000	12,500	18,000	13,000	
Resident (permanent)	200	1,500	2,200	4,400	7,400	11,000	12,000	
Total	660	6,000	12,200	14,400	19,900	29,000	25,000	
Domestic Water Supply(MGD)*								
Const.camp @ 150 gal./cap.	0.07	0.66	1.5	1.5	1.87	2.7	1.95	
Resident @ 500 gal./cap.	0.10	0.75	1.1	2.2	3.8	5.5	6.0	6.0
Total	0.17	1.41	2.6	3.7	5.67	8.2	7.95	6.0
Plant Water Supply (MGD)*								
	1.5	3.0	5.0	7.0	10.0	12.0	15.00	23.0
Total Water Supply	1.67	4.41	7.6	10.7	15.67	20.2	22.95	29.0

* Million gallons per day

the combined resident and camp populations.

QUALITY

It is understood that 14 MGD of the 23 MGD ultimate total plant water supply will be used as cooling water. It is further understood that a maximum of 5% of the 14 MGD or 0.7 MGD will be subject to special treatment and should meet the following requirements:

Chemical or Condition	Water Plant Effluent Treated Process Water Requirements
Turbidity	0.0 ppm
Iron	0.0 - 0.03 ppm
Sulphates	No limit
Chlorides	Not to exceed 2.0 ppm
Soap hardness	Not to be greatly increased in process
Calcium	Not to be greatly increased in process
Magnesium	Not to be greatly increased in process
Methyl Orange Alkalinity	As determined by process
pH	7.5 - 7.8
Phenolphthalein Alkalinity	As determined by process
Free CO_2	No limit
SiO2	5 - 15 ppm

The estimates of cost given herein include the cost of a 0.7 MGD special water treatment plant which will be necessary at both sites in order to meet the above requirements.

It is our understanding that the remaining 9 MGD need only meet the requirements of a good potable water supply, such that filtration might be necessary in the case of a surface supply. The cost of such filter plant is shown as a separate item.

PLANT AND DOMESTIC WATER SUPPLIES SEPARATE

The estimate of cost of the plant water supply are shown separately from those of the corresponding domestic water supply, the two supplies in each case being separate and entirely independent of each other for purpose of this report.

It is understood that the plant operating personnel would preferably be accommodated at the nearest suitable existing town, which would presumably be Glasgow in the case of the Fort Peck project, and Blackfoot in the case of the Snake River project. The estimates of cost of the domestic supply include the necessary additional facilities to develop and deliver the required quantity to the distribution system, including cost of water treatment plant, where desirable, and the approximate cost of additions to the distribution system needed to serve the stated 12,000 additional resident population.

FORT PECK SITE

Estimates of cost of the plant water supply for the Fort Peck site are based on delivering the water at a point located about 24 miles west and 3 miles south from the Fort Peck dam power plant, and approximately 15 miles from deep water at the nearest point along the shoreline of Fort Peck reservoir, as shown on Fig. 1.

The cost of the supply for the permanent resident population and construction population, is estimated on the basis of the necessary increase in capacity of the municipal water supply of Glasgow.

DOMESTIC WATER SUPPLY

Glasgow being the nearest large town from the proposed site located on a main line railroad, is the logical place for accommodating the proposed resident population and probably also the construction camp population, except possibly in the early part of the work.

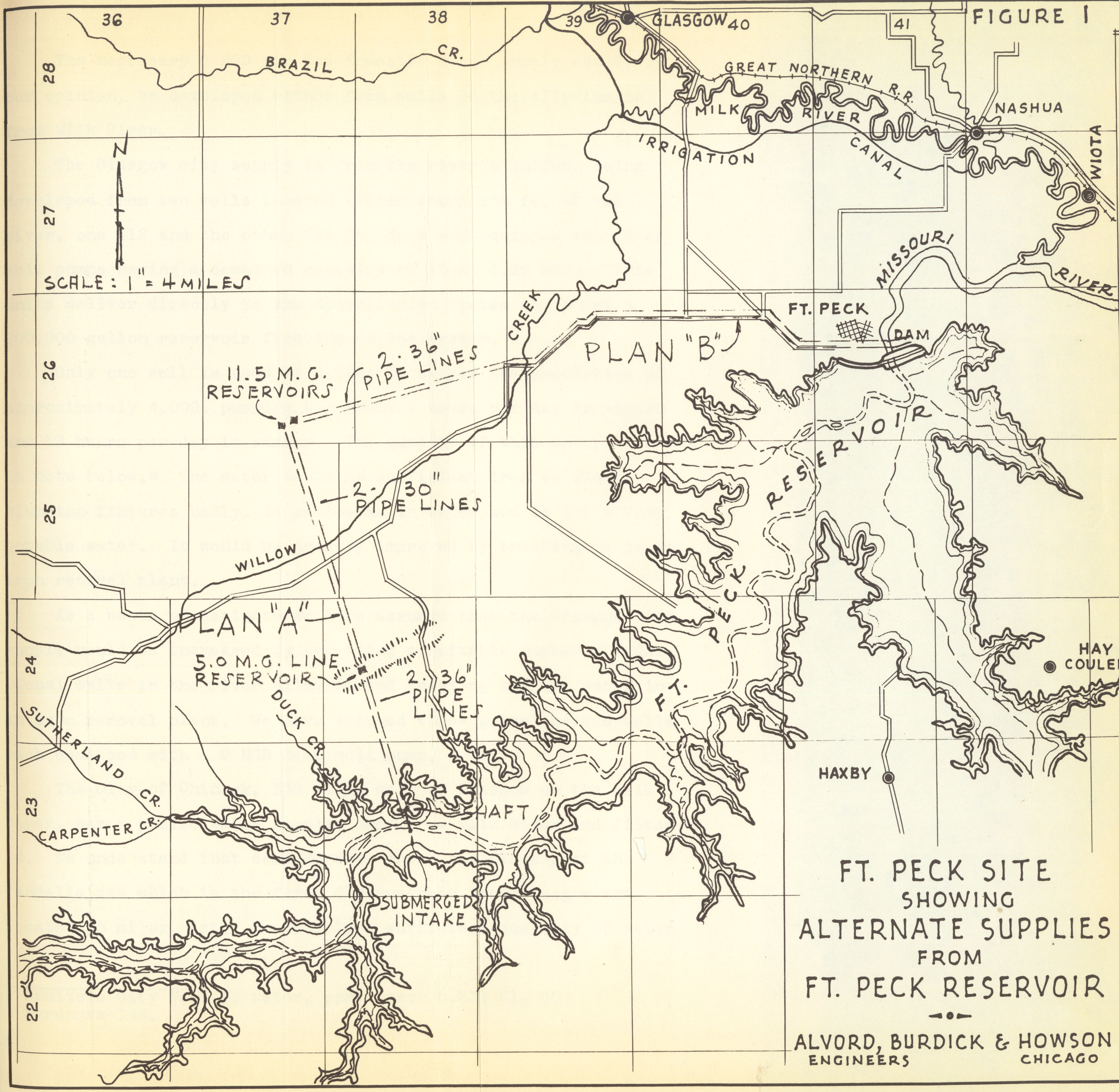
At Glasgow there are three sources of water supply, as follows:

(a) Deep wells in shale.

(b) Shallow wells in river alluvium.

(c) Milk River water, filtered.

The deep well source is a relatively soft water but too meager in quantity and too high in chlorides to be considered.



FT. PECK SITE
SHOWING
ALTERNATE SUPPLIES
FROM
FT. PECK RESERVOIR

ALVORD, BURDICK & HOWSON
ENGINEERS CHICAGO

The necessary 6 MGD for the domestic water supply could, in our opinion, be developed either from wells in the alluvium or from Milk River.

The Glasgow city supply is from the river alluvium, being developed from two wells located within about 250 ft. of the river, one 112 and the other 121 ft. deep and equipped with deep well pumps having a combined capacity of about 1.25 MGD. These units deliver directly to the distribution system which has a 200,000 gallon reservoir floating on the system.

Only one well is used at a time to supply the population of approximately 4,000, pumping for about 9 hours per day in winter and 18 hours per day in summer. The quality of this water is shown in note below.* The water contains sufficient iron to stain plumbing fixtures badly, is yellowish in color and is not a very potable water. It would be greatly improved by treating it in an iron removal plant.

As a basis of estimate we have assumed that the Glasgow city supply would be increased by providing a suitable number of additional wells in the river alluvium and treating all the water in an iron removal plant. We have assumed three gravel packed wells each equipped with a 2 MGD deep well pump.

The City of Chinook, 132 miles west of Glasgow on the Milk River, has a public water supply taken from Milk River and filtered. We understand that considerable water now flows past the Vandalia dam which is the first dam upstream from Glasgow and located 20 miles west. Presumably a sufficient quantity of water

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* Analysis City Well #2 water, ppm: Boron 0.33; Cl_2 60
Hardness 194.

would be available at Glasgow to provide a similar municipal water supply to that at Chinook. We have estimated the cost of such a supply filtered, as an alternate to the well water supply with iron removal. The cost of the water rights estimated at $20 per acre foot, would be $112,000 for 6 MGD. Based on a probable average use of 100 gallons per capita per day, it would be $26,800.

CONSTRUCTION COST OF DOMESTIC SUPPLY

We estimate the cost of a supply from the two alternative sources at Glasgow on the basis of a plant suitable for a maximum day pumpage of 6 MGD as follows:

(a)	Well supply only	$ 65,000
(b)	Well supply with iron removal	$582,000
(c)	Filtered river supply	$625,000

The stated additional resident population of 12,000 would necessitate the addition of approximately 24 miles of distribution system, the cost of which is estimated at approximately $380,000.

PLANT WATER SUPPLY

The only available source for the plant water supply is Fort Peck reservoir on the Missouri River. Fort Peck reservoir at the high water line extends about 180 miles by river above the dam and has a net storage capacity of about 19,000,000 acre feet.

The principal reservoir elevations which have a bearing on the proposed water supply are as follows:

	Elevation
Crest of dam	2280
Reservoir high water	2250
Spillway crest	2225
Minimum water level for power generation	2175
Minimum pool level	2095
Tailwater, approx.	2035

The above elevations, except tailwater, are shown graphically on Fig. 2 which gives the record of monthly maximum water surface elevations of Fort Peck reservoir from 1940 to date.

Prior to 1947 the reservoir was filling. Since then storage has been maintained above a level approximating spillway elevation 2225, and has reached a maximum of about 2245.

ALTERNATIVE PLANS

We have considered, for comparison, three different plans for developing a supply from the reservoir.

The first, referred to as Plan A, is based on taking water directly from the reservoir at the nearest suitable location where a submerged intake can be provided below minimum pool level, elevation 2095.

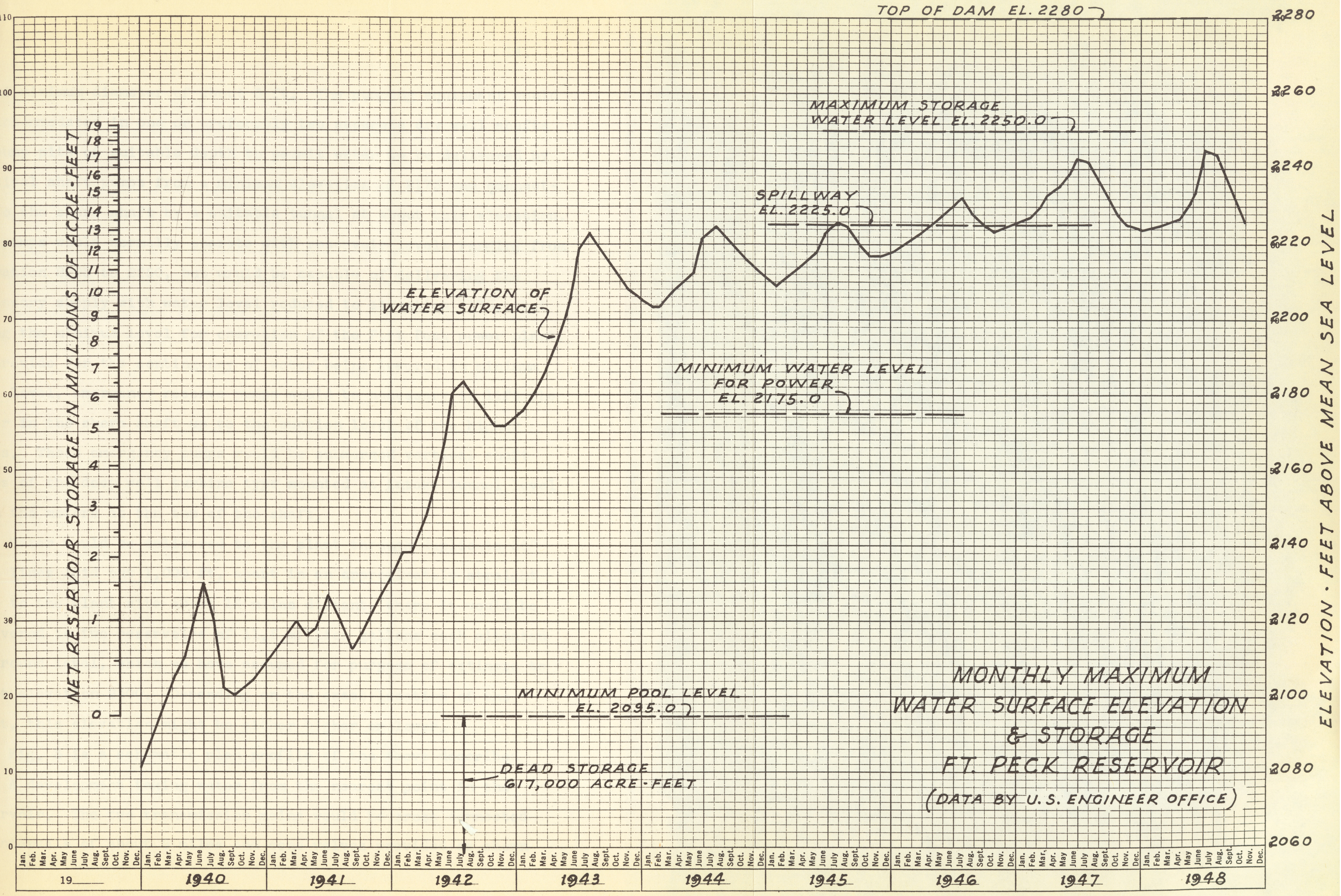
The second, Plan B, is based on taking water from a connection to be made to the penstock pipe between the dam and the power house, located about 25 miles northeast of the Plan A intake.

The third, Plan C, differs from Plan B only in that water would be taken from the tailrace, instead of from the penstock.

PLAN A

The slope of the river above the dam is only about 1.5 ft. per mile so that at the location opposite the proposed plant site a water supply intake could be provided below elevation 2095, by extending a tunnel close enough to the former river channel.

Allowing for a suitable shore shaft location protected against wave action at reservoir high water, the best available site will involve an intake tunnel about 2,500 ft. long. This tunnel would



TOP OF DAM EL. 2280
MAXIMUM STORAGE WATER LEVEL EL. 2250.0
SPILLWAY EL. 2225.0
ELEVATION OF WATER SURFACE
MINIMUM WATER LEVEL FOR POWER EL. 2175.0
MINIMUM POOL LEVEL EL. 2095.0
DEAD STORAGE 617,000 ACRE-FEET
NET RESERVOIR STORAGE IN MILLIONS OF ACRE-FEET
ELEVATION - FEET ABOVE MEAN SEA LEVEL
MONTHLY MAXIMUM WATER SURFACE ELEVATION & STORAGE FT. PECK RESERVOIR
(DATA BY U.S. ENGINEER OFFICE)
1940
1941
1942
1943
1944
1945
1946
1947
1948

be of minimum diameter of about 6 ft. The pumping equipment would be accommodated in one or preferably two separate dry well shafts or pump pits of suitable depth to permit water to be delivered by vertical shaft pumps from a minimum elevation of 2175 and connected to the shore shaft by a suitable tunnel at about this elevation. The pumps would normally operate with reservoir levels ranging from elevation 2225 to 2250, but would be capable of delivering the necessary supply with water level reduced to elevation 2175, that being the minimum level for operation of the Fort Peck power plant. To provide for the contingency of water being lowered to minimum pool level, emergency reserve pumps would be necessary to lift the water in the shore shaft up to the suction level of the higher pumps. These emergency pumps would be submerged vertical shaft pumps of the deep well turbine type mounted at intake tunnel level with the motors at the top of the shaft.

Water would be delivered to the plant through duplicate 36" pipe lines laid out 1,000 ft. apart in an approximately straight line to the plant site about 16 miles distant, where it would be delivered to two reservoirs of 11.5 million gallons each situated at ground level, which we have assumed for purpose of estimate to be at elevation 2400. Depending on the exact location of the plant, this elevation might be either higher or lower.

Fig. 3 is a schematic plan profile of the above described Plan A development taking water from the nearest point in the reservoir. The two transmission mains would be cross connected at intervals of about 5 miles and cone valves provided as shown so that not more than 5 miles of either transmission main would be put out of service by a single breakage.

The pipe sizes are based on a friction coefficient of C = 140 in the Hazen-Williams formula and the assumption of having to deliver all of the water through a single pipe line in one 5 mile stretch, both lines being assumed available for the rest of the distance. Normal operation would be with both lines in service for the entire length and power cost is estimated on this basis. Head capacity of pumps is based on the contingency of part of one line being out of service as above noted.

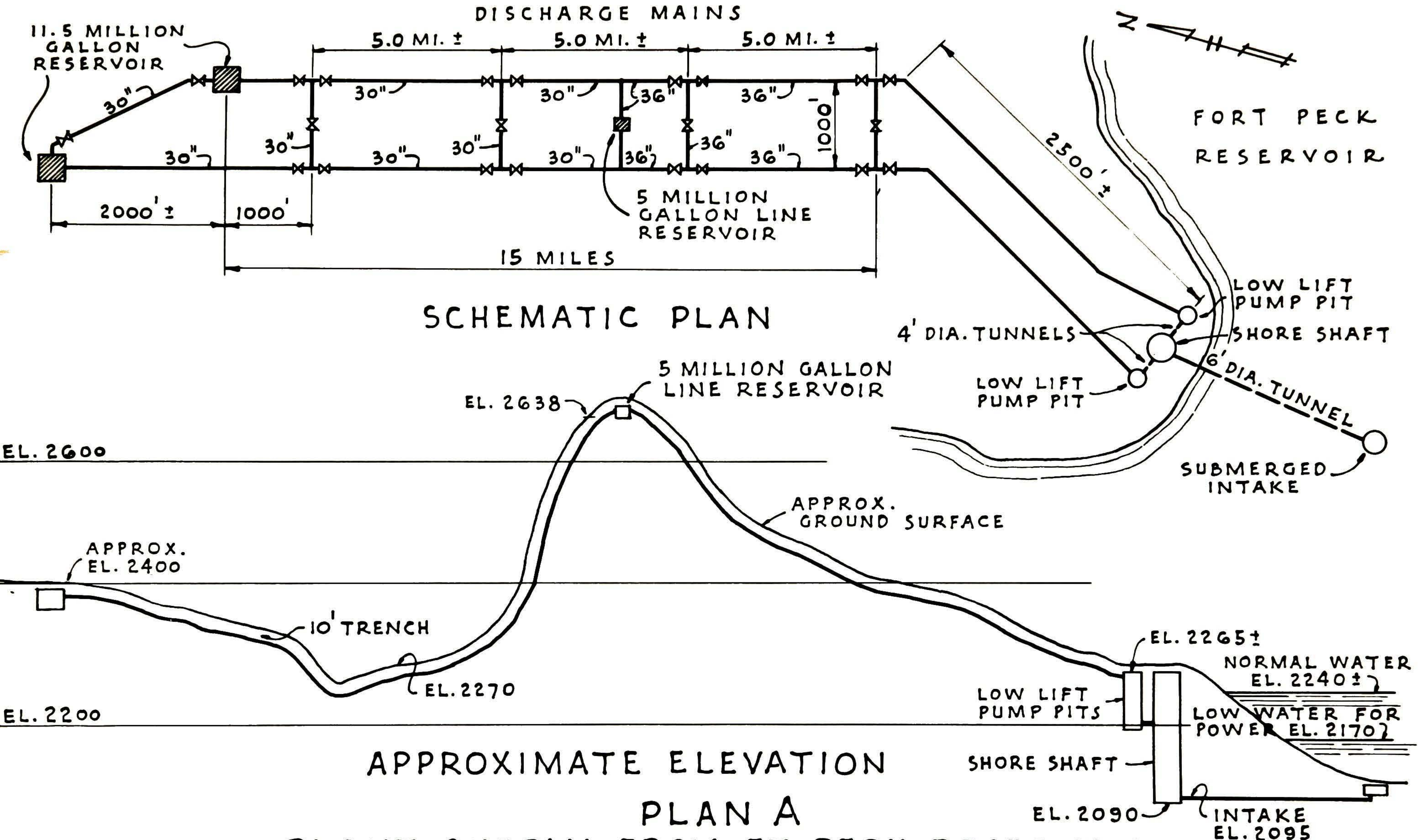
To provide for the contingency of interruption in electric power from outside source, a Diesel generator stand-by plant would be provided for at the pumping station to supply reserve power for the vertical shaft pumping equipment.

A minor disadvantage of Plan A is the fact that head would be wasted pumping over the high ridge between the reservoir and Willow Creek, as shown on the profile, Fig. 3.

SOIL CONDITIONS

The intake tunnel and shore shaft would be built in what is known locally as the Bearpaw shale in which excavation is not difficult. It is the same material in which the tunnels at Fort Peck dam were built.

The transmission mains would be laid either in shale or in alluvium. For purposes of security of supply and as protection against freezing, we have assumed 10 ft. trench depth.



PLAN A
PLANT SUPPLY FROM FT. PECK RESERVOIR
AT NEAREST SUITABLE LOCATION

FIGURE

PIPE MATERIAL

We understand that the soil is corrosive to iron pipe both at Glasgow and at Ft. Peck town. The transmission mains would be of reinforced concrete pipe.

ROADS

No allowance has been included for any improved roads that might be desirable for access to the pumping plant.

PLAN A - CONSTRUCTION COST

The construction cost of Plan A, as shown in detail on Table 3, is approximately $10,427,000. The estimated annual cost of power for pumping to deliver the rated capacity of 23 MGD, is approximately $72,000 based on 4.3 mills per kilowatt hour.

It should be practicable to complete the construction under Plan A in a 12 month period.

INITIAL SUPPLY

The requirements of 1.5 MGD plant supply in 1949 could not be met by the supply above outlined, particularly with reference to the submerged intake, tunnel and shore shaft. One of the pipe lines might be made available for service sufficiently soon but even this condition might not be practical to meet.

TEMPORARY SUPPLY

To meet the requirement of the plant supply in 1949, it is suggested that a temporary supply for use at least until winter would probably be necessary, this supply to consist of a 12" pipe line and temporary pumping installation with suitable boosters and provision for meeting the emergency of possible low levels in

TABLE 3
ESTIMATED COST
FT. PECK RESERVOIR SUPPLY

PLAN A

Intake in upper reservoir (12' diam. x 200' deep)		$ 110,000
Intake tunnel 2500 ft. - 6' diam. tunnel		625,000
Side tunnels 1000 ft. - 4' diam. tunnel		150,000
Shore shaft 30 ft. diam. x 175 ft. deep		335,000
2nd Stage shafts 2- 40 ft. diam. x 105 ft. deep		710,000
Pumping Equipment		
1st stage 4 - 8 MGD vert. shaft units 100' head	$ 60,000	
2nd stage 10 - 5 MGD vert. shaft units 450' head	250,000	
Electrical equipment & piping	118,000	
		428,000
Auxiliary Power Station		
Building 125,000 c.f.	$ 200,000	
Diesel generating equipment 2000 H.P.	300,000	
		500,000
Pipe Lines		
36" line - 61,000 ft.	$1,460,000	
30" line - 111,000 ft.	2,220,000	
Cone valves 10 - 30"	60,000	
Cone valves 12 - 24"	60,000	
Misc. appurtenances	100,000	
		3,900,000
Reservoirs		
2 - 11.5 MG reservoirs	$1,400,000	
1 - 5.0 MG reservoir	360,000	
		1,760,000
Power Line 40 miles		200,000
Special .7 MGD treatment plant		350,000
		$9,068,000
Engineering & Contingencies		1,359,000
Total		$10,427,000
If filtration is needed for 9 MGD add		900,000
+ Eng. and Conting.		130,000
		$ 1,030,000

the reservoir by providing a low lift pump installation mounted on an incline at the shore line and arranged for lowering or raising as required.

We estimate the cost of this temporary water supply for use during the first year and possibly part of the second year, at approximately $725,000. This cost should be added to the project cost shown hereinabove, making the total $11,152,000.

PLAN B - PLANT WATER SUPPLY

For comparison with Plan A we have estimated the cost of taking water directly from the power house penstock pipe below Fort Peck dam. This would eliminate the necessity of building an independent submerged intake. Instead, it is proposed that the power house penstock be tapped at a suitable location to supply a pumping station located near the power plant. The transmission mains thence to the proposed plant site would extend a total distance of approximately 26 miles, or 10 miles more than in the case of Plan A.

The reserve pumping equipment in Plan B would consist of dual drive units, with gasoline engines, this being the most economical type of reserve.

In this plan there would be more friction loss to pump against than in the case of Plan A, but this would be offset by the fact that the line would not have to cross as high a divide between the Missouri River and Willow Creek as in the case of Plan A. An exact comparison cannot be made owing to lack of accurate information as to elevation of the determining point on each divide. However, the effect of this on cost comparisons is only nominal.

PLAN B - CONSTRUCTION COST

The construction cost of Plan B as shown on Table 4, is estimated at approximately $11,232,000, and the annual cost of power for pumping at $39,000.

PLAN C - PLANT WATER SUPPLY

Because of possible complications involved in connecting to the penstock line, we have estimated the cost of Plan C in which water would be pumped directly from the power plant tailrace at about elev. 2035. This plan would otherwise be similar to Plan B, except as to pumping equipment being for higher head.

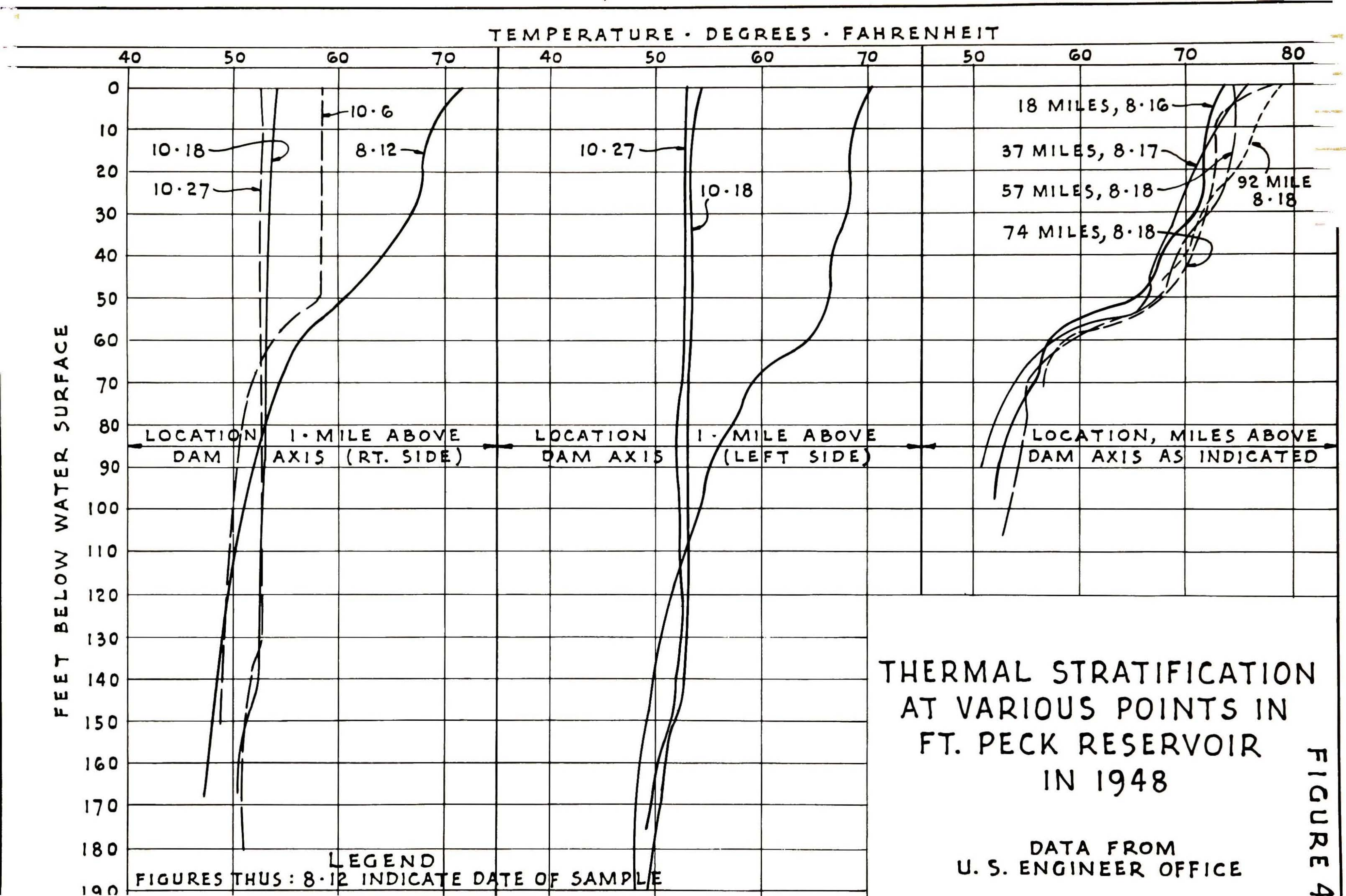
PLAN C - CONSTRUCTION COST

We estimate the construction cost of Plan C as shown on Table 5, at approximately $11,474,000, and the annual cost of power for pumping at $72,000.

TEMPERATURE OF WATER

Fig. 4 shows the thermal stratification of the reservoir water at various locations, as determined by observations made by the U. S. Engineer Office in 1948. It will be noted that during the summer the water reached a temperature at the surface of approximately 70° one mile above the dam and nearly 80° at a point 92 miles above the dam. The temperature was about 10° lower at 50 ft. depth in most cases and at 100 ft. depth was between 50° and 54°.

By mid-November the temperature near the dam was practically



THERMAL STRATIFICATION AT VARIOUS POINTS IN FT. PECK RESERVOIR IN 1948

DATA FROM U. S. ENGINEER OFFICE

FIGURE 4

TABLE 4
ESTIMATED COST
FT. PECK PENSTOCK SUPPLY

PLAN B

Connection to penstock		$ 25,000
Pumping Station Bldgs. - 2 stations		300,000
Pumping Equipment - 2 stations		
4 - 6 MGD units 250' head, electric drive	$ 50,000	
4 - 6 MGD units 250' head, dual drive	147,000	
Electrical equipment and piping	108,000	
		305,000
Pipe Lines		
36" Pipe - 280,000 ft.	$6,700,000	
Valves - 28 - 30" cone valves	170,000	
Misc. appurtenances	130,000	
		7,000,000
Reservoirs		
2 - 11.5 MG reservoirs	$1,400,000	
1 - 5.0 MG reservoir	360,000	
		1,760,000
Power Line		25,000
Special .7 MGD treatment plant		350,000
		9,765,000
Engineering & Contingencies		1,467,000
Total		$11,232,000

TABLE 5

ESTIMATED COST

FT. PECK TAIL RACE SUPPLY

PLAN C

Shore intake		$ 50,000
Pumping stations - 2		300,000
Pumping Equipment - 2 stations		
4 - 6 MGD units 450' head electric drive	$ 90,000	
4 - 6 MGD units 450' head dual drive	264,000	
Electrical equipment and piping	108,000	
		462,000
Pipe Lines		
36" pipe - 280,000 ft.	$6,700,000	
Valves - 28 - 30" cone valves	170,000	
Misc. appurtenances	130,000	
		7,000,000
Reservoirs		
2 - 11.5 MG reservoirs	$1,400,000	
1 - 5.0 MG reservoir	360,000	
		1,760,000
Power Line		55,000
Special .7 MGD treatment plant		350,000
		$ 9,977,000
Engineering		1,497,000
Total		$11,474,000

constant at all depths, ranging from 54° at the surface to a minimum of 49° at 175 ft. depth. Of course, at time of fall and spring turn-over the temperature would be equalized at about 39° Fahrenheit which would normally be the minimum bottom temperature except near the tunnel outlets at times of large discharge. The curves of thermal stratification show the advantage of taking water at 100 ft. depth or more rather than at the surface, for purpose of use as cooling water in summer.

If water were to be taken from a suitably designed submerged intake as in Plan A, greatest advantage would be taken of the low temperature near the bottom during the summer.

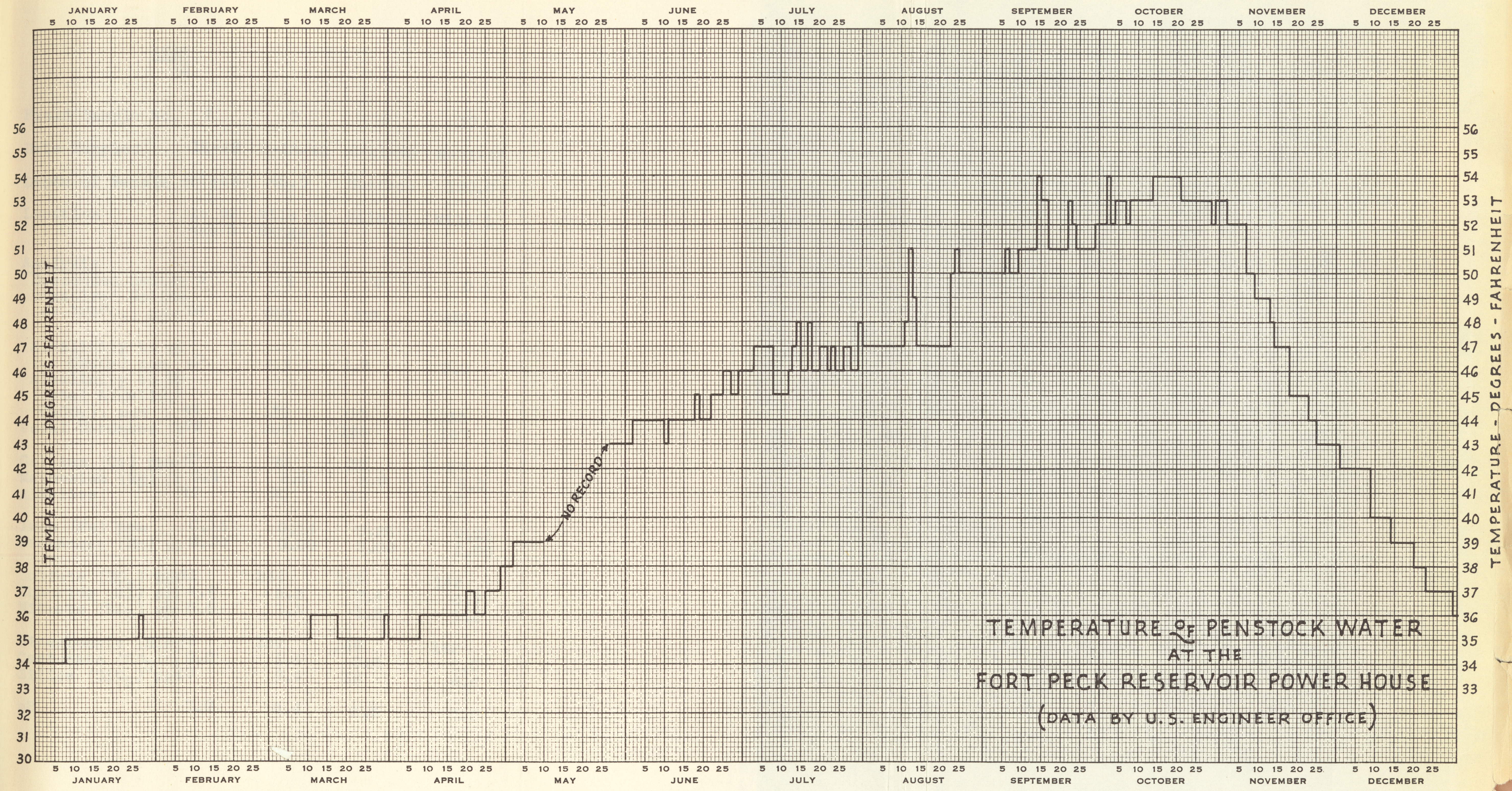
Fig. 5 shows the temperature of penstock water at the power house for 1947 as determined by the U. S. Engineer Office. It will be noted that the temperature varied from about 35° in winter and early spring to a maximum of 54° in late summer and early fall. The record for 1948 is substantially the same.

This curve represents the variation in temperature of the water in case the supply were taken from the penstock or from the tailrace, as in plans B and C.

QUALITY OF WATER

The quality of the Fort Peck water is summarized on Table 6. The hardness varies from approximately 130 to 200 parts per million and chlorides from 3.5 to 8.7 parts per million. Boron, as shown by a recent determination, is 0.10 parts per million.

The water is practically clear in the lower part of the reservoir.


JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
TEMPERATURE - DEGREES - FAHRENHEIT
30
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56
NO RECORD
TEMPERATURE OF PENSTOCK WATER
AT THE
FORT PECK RESERVOIR POWER HOUSE
(DATA BY U.S. ENGINEER OFFICE)

1947

TABLE 6
ANALYSES OF FT. PECK RESERVOIR WATER
(data by U. S. Engineer Office)

Field Sample No.	1	2	3	4	5	6	7	8	9	10
Date Sampled	8-16-48	8-16-48	8-17-48	8-17-48	8-18-48	8-18-48	8-18-48	8-18-48	8-21-48	8-21-48
Depth of Sample (feet)	Surface	90.0	Surface	90.0	Surface	70.0	Surface	45.0	Surface	190.0
Location	Mile 18 Range 1	Mile 18 Range 1	Mile 37 Range 2	Mile 37 Range 2	Mile 74 Range 26	Mile 74 Range 26	Mile 92 Range 3	Mile 92 Range 3	Mile 1	Mile 1
Analysis										
Suspended Solids, ppm	0	1	2	6	33	14	9	4	0	0
Dissolved Solids, Residue at 103°C.) ppm	379	448	363	436	377	397	398	553	395	461
Alkalinity to phenolphthalein (as $CaCO_3$) ppm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	1.3	0.0
Alkalinity to Methylorange (total Alkalinity as $CaCO_3$), ppm	123	131	119	136	130	134	144	135	123	133
Total Hardness (as $CaCO_3$) ppm	153	165	152	163	171	166	176	200	155	167
Calcium (Ca) ppm	51	56	51	55	58	56	60	70	52	57
Magnesium (Mg) ppm	6.1	6.1	6.0	6.2	6.3	6.3	6.4	6.2	6.0	6.0
Alkalies(	61	79	52	75	62	57	57	90	59	59
Iron (Fe) ppm	0.15	0.10	0.14	0.15	0.13	0.15	0.15	0.14	0.25	0.15
Manganese (Mn) ppm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sulfate (SO_4) ppm	143	164	132	170	160	138	141	244	143	142
Chloride (Cl) ppm	8.7	8.5	5.5	3.5	4.9	7.4	4.4	5.3	7.4	8.7
Nitrate (NO_3) ppm	0.7	1.9	1.0	2.2	0.8	2.5	5.2	1.3	1.2	1.2
Bicarbonate (HCO_3) ppm	150	130	145	166	159	163	176	159	148	162
Carbonate (CO_3) ppm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.8	0.0
Silica (SiO_2) ppm	12	11	11	12	11	16	10	9.4	19	6.6
pH	7.8	8.0	7.7	8.1	8.1	7.7	7.0	8.4	3.3	7.9

ADEQUACY OF SOURCE

The stated plant water supply of 23 MGD is very small relative to the Missouri River supply at Ft. Peck reservoir, where the use for power alone after installation of the third generator, will be about 6,000 c.f.s.

SNAKE RIVER PLAIN SITE

With the plant located in the area under consideration on the Snake River plain approximately 40 miles west of the city of Idaho Falls, the logical location of the resident plant population and perhaps also the construction camp population, would be the City of Blackfoot on the Snake River and reached from the site directly by highway and a branch line of the Union Pacific Railroad. Blackfoot is a town of about 4,000 population and is supplied with water from wells. The new pumping station has two wells, one 179 ft. deep and the other 182 ft. deep and equipped with 600 GPM and 800 GPM deep well turbine pumps respectively. Only one pump is used at a time, the smaller one being operated part of each day to furnish the ordinary supply, and the larger pump for fire protection and during hot summer days. In addition there is a reserve well equipped with a gasoline engine driven pump. Water temperature is about 52° F. Per capita consumption is about 150 gallons per day during August and averages much less for the year. The water has a soap hardness of 314 parts per million, total solids 396 parts per million, and turbidity 1 part per million as shown by the analysis on Table 7.

COMMUNITY WATER SUPPLY

The requirement of the stated community water supply of 6 MGD to take care of the resident population as an addition to the City of Blackfoot could be readily met by drilling 6 additional wells about 200 ft. deep, suitably located. The cost of developing this

TABLE 7

ANALYSIS OF BLACKFOOT, IDAHO CITY WATER SUPPLY
(BY IDAHO PUBLIC HEALTH DEPT.)
April 20, 1948

	Results in p.p.m.
Temperature 6.7° C = 44° F	
pH = 7.8	
Saturation index plus	0.2
Turbidity	1 p.p.m.
Total solids	396
Calcium (Ca)	83
Magnesium (Mg)	26
Iron (Fe)	0.02
Silica (SiO_2)	20
Aluminum (Al)	0
Alkalinity (as $CaCO_3$)	
Carbonate	0
Bicarbonate	290
Chlorides (Cl)	14
Sulfates (SO_4)	44
Fluoride (F)	0.2
Phosphorous (PO_4)	0
Hardness (soap)	314

supply including pumping equipment and pump houses is estimated at approximately $131,000. As stated in connection with the Glasgow development, discussed hereinabove, the cost of distribution system additions for an estimated population of 12,000 would be approximately $380,000.

The annual power cost of pumping 6 MGD from wells at Blackfoot is estimated at approximately $4,550.

PLANT WATER SUPPLY

It is proposed that the plant water supply be taken from deep wells in the basalt, or lava, which makes up the Snake River plain to a great depth, amounting to several thousand feet. Figs. 6 & 7.

Present well development in the near vicinity of the site, while giving favorable indications, is very meager. The two present Navy wells at the site are 685 ft. and 681 ft. deep respectively, static water level being at 464 ft. depth in the latter well. The larger pump has a rated capacity of 590 gallons per minute but pumping is not continuous. The recent test of the two Navy wells by Mr. R. L. Nace of the U. S. Geological Survey, Mr. H. T. Stearns, geologist, and Mr. A. Banta of Smith, Hinchman and Grylls, showed drawdown and specific capacity of the two wells as follows:

Well No.	Approximate Pumpage Rate	Measured Drawdown	Specific Capacity **
1	590 GPM	21 ft.*	28 GPM/ft.
2	150 GPM	10.1 ***	14.9GPM/ft.

* After 13 minutes operation.
** Gallons per minute per foot of drawdown.
*** After 6 minutes operation, then constant for an hour.

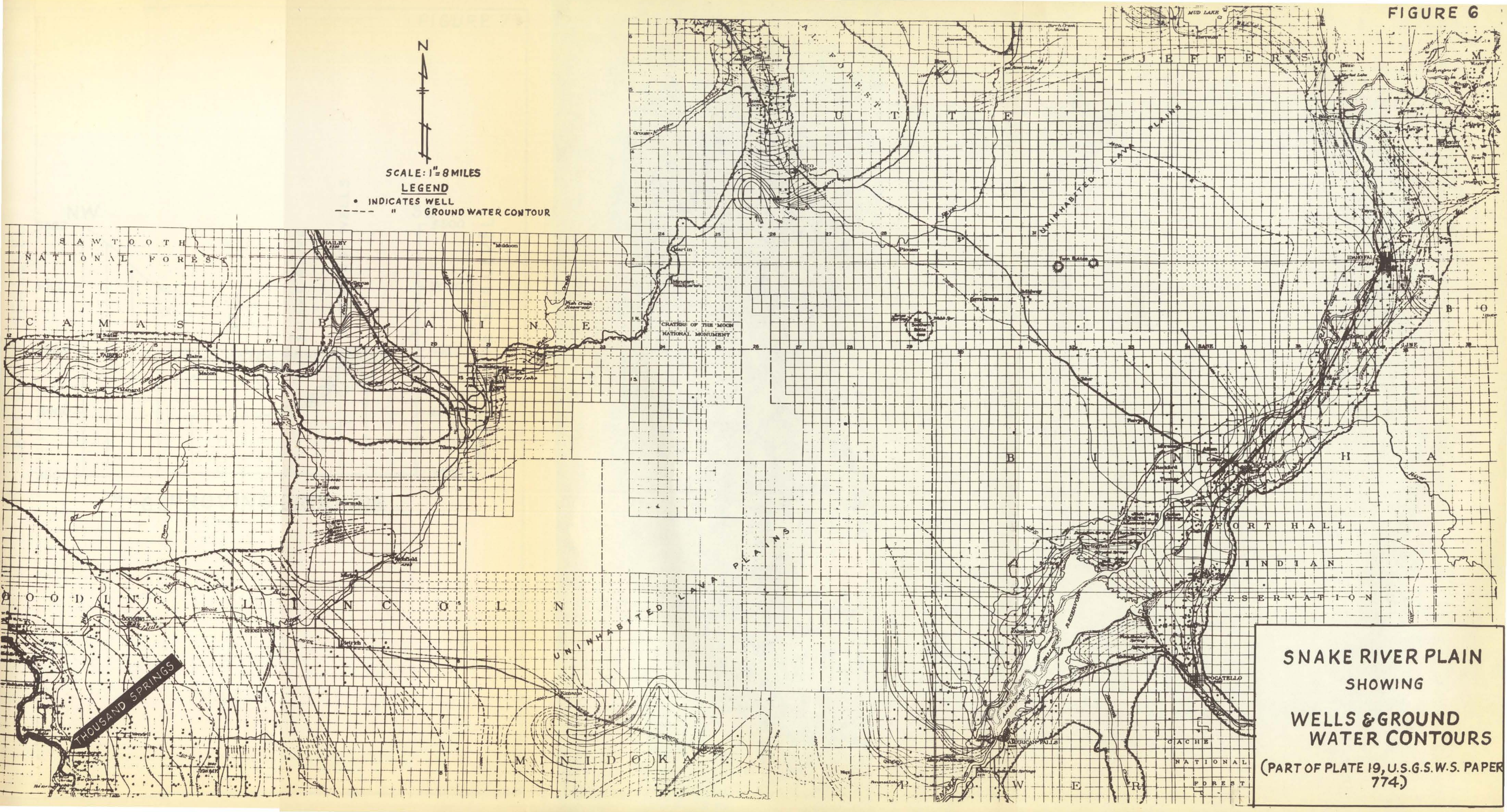
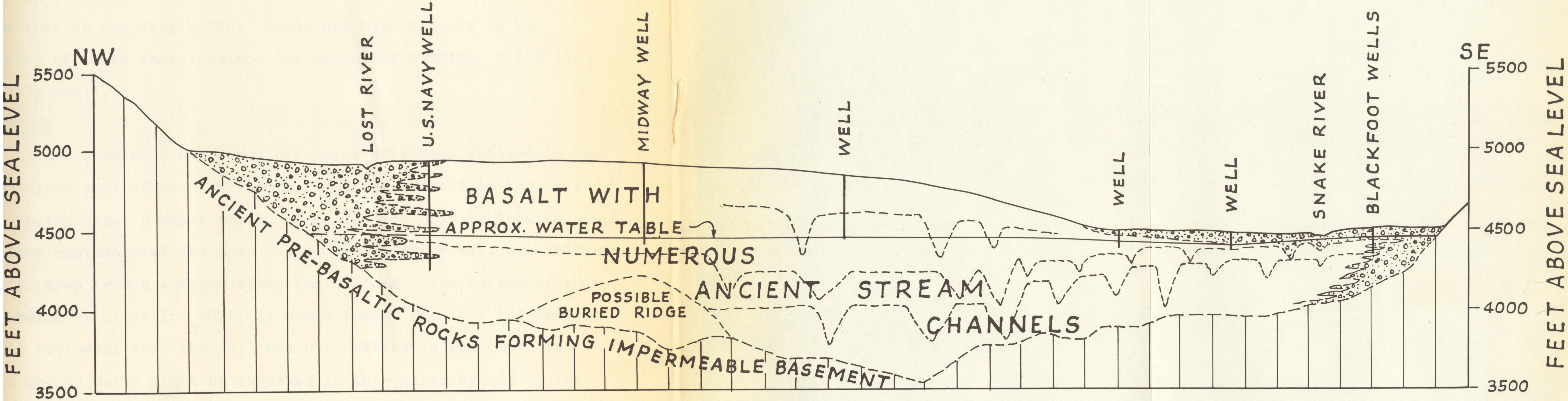


FIGURE 6

SNAKE RIVER PLAIN SHOWING WELLS & GROUND WATER CONTOURS

(PART OF PLATE 19, U.S.G.S. W.S. PAPER 774)

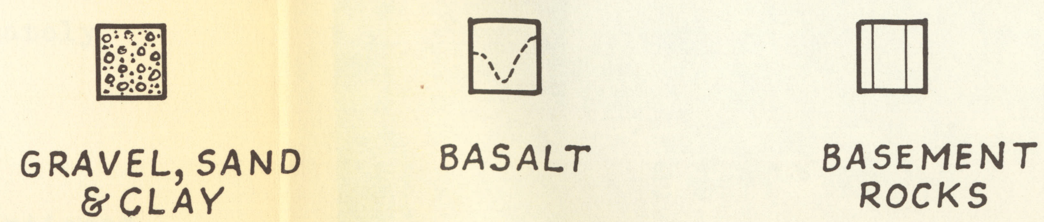


GENERALIZED GEOLOGIC SECTION FROM NW TO SE THRU U.S.N. PROVING GROUNDS
IDAHO

BY H.T. STEARNS, Geologist

SCALE: 1 INCH = 4 MILES

LEGEND



The next nearest wells are at Cerro Grande 7 miles south and at Midway 9 miles southeast, as shown on Fig. 8. The static water level in these two wells is about 28 ft. and 40 ft. respectively below that at the Navy wells. We do not have details as to capacity of these installations and amount of pumping, which is probably small.

DRY HOLES

As shown on Fig. 8 several dry holes have been drilled in the uninhabited part of the lava plain, the one nearest to the Navy wells being about 5 miles north. A second dry hole is located abou 25 miles southwest of the Navy wells. This latter well was drilled 525 ft. deep from a surface elevation of 5345. The bottom of this well being at elevation 4825, it would appear from the information to the northeast that the well was not drilled to the depth at which ground water might be expected in this vicinity and so its being a dry hole is inconclusive. The next well drilled to the southwest, at a distance of about 33 miles from the Navy wells, is 1107 ft. deep from a surface elevation of 5220 making the bottom of the hole elevation 4113. This well is just outside of the south boundary of the Craters of the Moon National Monument. Another dry hole occurs 12 miles further west, the well being drilled 325 ft. deep from the surface elevation of approximately 4,900, making the elevation of bottom about 4,575.

OTHER WELLS

About 1[illegible] miles south by east of the second dry hole mentioned above a well was drilled to a depth of 777 ft. from elevation 5000.

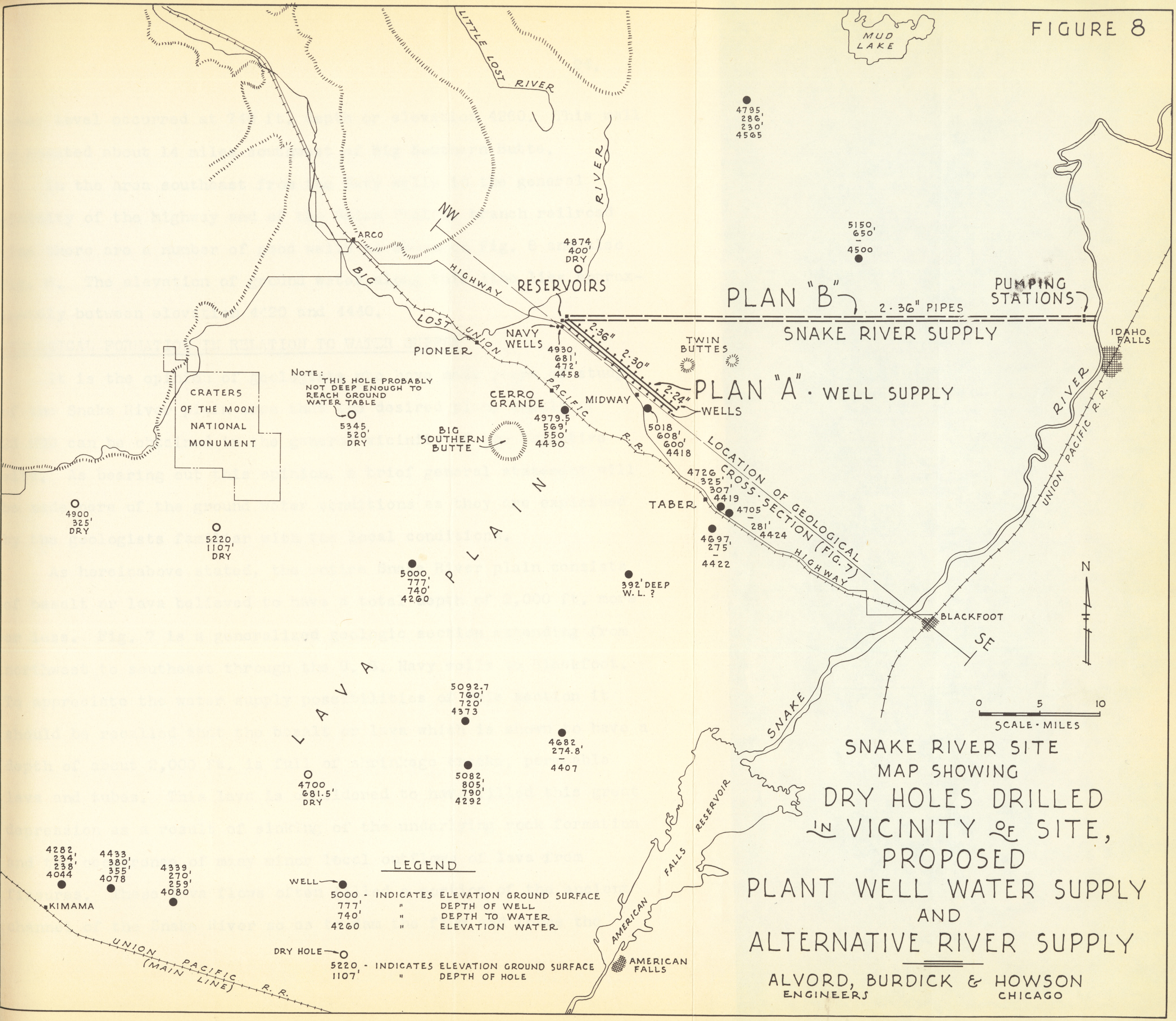


FIGURE 8
MUD LAKE
LITTLE LOST RIVER
RIVER
NW
ARCO
BIG LOST
HIGHWAY
UNION PACIFIC R.R.
RESERVOIRS
NAVY WELLS
PIONEER
CERRO GRANDE
MIDWAY
TABER
BLACKFOOT
IDAHO FALLS
TWIN BUTTES
BIG SOUTHERN BUTTE
CRATERS OF THE MOON NATIONAL MONUMENT
LAVA PLAIN
KIMAMA
AMERICAN FALLS
AMERICAN FALLS RESERVOIR
SNAKE RIVER
UNION PACIFIC (MAIN LINE) R.R.
SE
N
PLAN "B"
2 - 36" PIPES
PUMPING STATIONS
SNAKE RIVER SUPPLY
2-36"
2-30"
2-24"
PLAN "A" - WELL SUPPLY
WELLS
LOCATION OF GEOLOGICAL CROSS-SECTION (FIG. 7)
HIGHWAY
NOTE: THIS HOLE PROBABLY NOT DEEP ENOUGH TO REACH GROUND WATER TABLE
4795 286' 230' 4565
5150 650' – 4500
4874 400' DRY
4930 681' 472' 4458
4979.5 569' 550' 4430
5018 608' 600' 4418
4726 325' 307' 4419
4705 – 281' 4424
4697 275' – 4422
5345 520' DRY
4900 325' DRY
5220 1107' DRY
5000 777' 740' 4260
392' DEEP W.L. ?
5092.7 760' 720' 4373
4682 274.8' – 4407
5082 805' 790' 4292
4700 681.5' DRY
4282 234' 238' 4044
4433 380' 355' 4078
4339 270' 259' 4080
LEGEND
WELL
5000 - INDICATES ELEVATION GROUND SURFACE
777' " DEPTH OF WELL
740' " DEPTH TO WATER
4260 " ELEVATION WATER
DRY HOLE
5220 - INDICATES ELEVATION GROUND SURFACE
1107' " DEPTH OF HOLE
0 5 10
SCALE - MILES
SNAKE RIVER SITE
MAP SHOWING
DRY HOLES DRILLED
IN VICINITY OF SITE,
PROPOSED
PLANT WELL WATER SUPPLY
AND
ALTERNATIVE RIVER SUPPLY
ALVORD, BURDICK & HOWSON
ENGINEERS CHICAGO

Water level occurred at 740 ft. depth or elevation 4260. This well is located about 14 miles southwest of Big Southern Butte.

In the area southeast from the Navy wells in the general vicinity of the highway and of the Union Pacific branch railroad line there are a number of good wells as shown on Fig. 8 and also Fig. 6. The elevation of ground water along this line lies approximately between elevation 4420 and 4440.

GEOLOGICAL FORMATION IN RELATION TO WATER SUPPLY

It is the opinion of geologists who have made years of study of the Snake River plain area that the desired plant supply of 23 MGD can be obtained in the general vicinity of the tentative site. As bearing out this opinion, a brief general statement will be made here of the ground water conditions as they are explained by the geologists familiar with the local conditions.

As hereinabove stated, the entire Snake River plain consists of basalt or lava believed to have a total depth of 2,000 ft. more or less. Fig. 7 is a generalized geologic section extending from northwest to southeast through the U. S. Navy wells to Blackfoot. To appreciate the water supply possibilities of this section it should be recalled that the basalt or lava which is shown to have a depth of about 2,000 ft. is full of shrinkage cracks, permeable lava and tubes. This lava is considered to have filled this great depression as a result of sinking of the underlying rock formation and the occurrence of many minor local outflows of lava from fissures. These lava flows often filled a portion of the ancient channel of the Snake River so as to dam the flow and force the river to cut a new channel around the flow. This process is supposed to have gone on literally for millions of years, as a result of which there are innumerable ancient channels of the Snake River filled with lava or basalt. In cutting around these flows which often dammed the river from time to time, the river has finally been pushed to the extreme east and south edge of the Snake River lava plain.

There is no exact knowledge of these ancient river channels excepting as they appear along the present canyon walls of the Snake River and to some extent as shown by the deeper well borings.

The basalt is characterized by innumerable vertical shrinkage cracks, considerable amounts of porous or water permeable lava formations produced by expanding gas, and subterranean tubes or passageways left by the lava flows. The result is that ground water can flow readily through the typical formations.

The fact that the basalt is favorable to large ground water flows is evidenced by the numerous large springs in the north wall of the Snake River canyon at the southwest end of the plain. The direction from which this flow comes is indicated in a general way by the ground water contours on Fig. 6.

As shown on Fig. 6, which is reproduced from part of a map in U.S.G.S. water supply paper No. 774, the ground water contours are omitted in the central portion of the lava plain because of lack of wells in this central area about 35 miles wide by 80 miles long. Nevertheless, careful study has shown that the water which appears at Thousand Springs and at the other numerous springs in the Snake River canyon north wall to the southwest is contributed to the upper end of the lava plain by Big and Little Lost Rivers and from the Snake River above Idaho Falls. The flow from northeast to southwest underneath the lava plain is at right angles to the cross section shown on Fig. 6 and totals several thousand second feet. The only question, which cannot be answered explicitly, is as to the uniformity of distribution of this subsurface or ground water flow over the approximately 35 mile width of the lava plain. The presence of the three prominent buttes in the vicinity of Cerro Grand and Midway and the fact that a few dry holes have been drilled at points from 15 to 35 miles west of this area as above pointed out, makes it clear that the conditions are not uniform. On the other hand, some wells have very liberal yields.

<u>OPINION AS TO WATER SUPPLY POTENTIAL</u>

With reference to probable ground water supply conditions in the near vicinity of the proposed plant site, Mr. H. T. Stearns, who studied this area intensively for a number of years while with the U. S. Geological Survey, has expressed the following opinions:

(a) "It is estimated that about 175,000 acre feet annually (equivalent to 166 cu. ft, per sec.) is contributed by streams from the north to the water table under the (U.S. Navy) proving ground area, plus an unknown amount from irrigation losses on Egin Bench to the east of Mud Lake. Big Lost River contributes about 226,000 acre feet (about 202 c.f.s.) annually to the water table, but some of this may move southward a little west of the proving grounds. There is scarcely any withdrawal in this area by wells."

(b) "Because of the 'firm' underground flow is what counts in this case, a safe estimate would be about 100 second feet passing the north side of the Twin Buttes east of the mouth of Big Lost River. The direction of flow is apparently a little west of south based on the meager data available."

(c) "It is estimated that from 500 to 750 second feet flows southward underground in the first 10 miles southeast of the Twin Buttes, or about 50 to 70 second feet per mile of cross section. It can be tapped 3 to 5 miles southeast of the Buttes and perhaps closer."

CONSERVATIVE ESTIMATES DESIRABLE

In connection with a mjaor project, the lack of wells from which large quantities of water are pumped continuously in this area and knowledge of the few dry holes to the north, south and west, hereinabove referred to, in our opinion makes it desirable to take a very conservative view in estimating the average capacity and number and spacing of wells that would be necessary to produce the stated plant supply of 23 MGD.

WELL LAYOUT

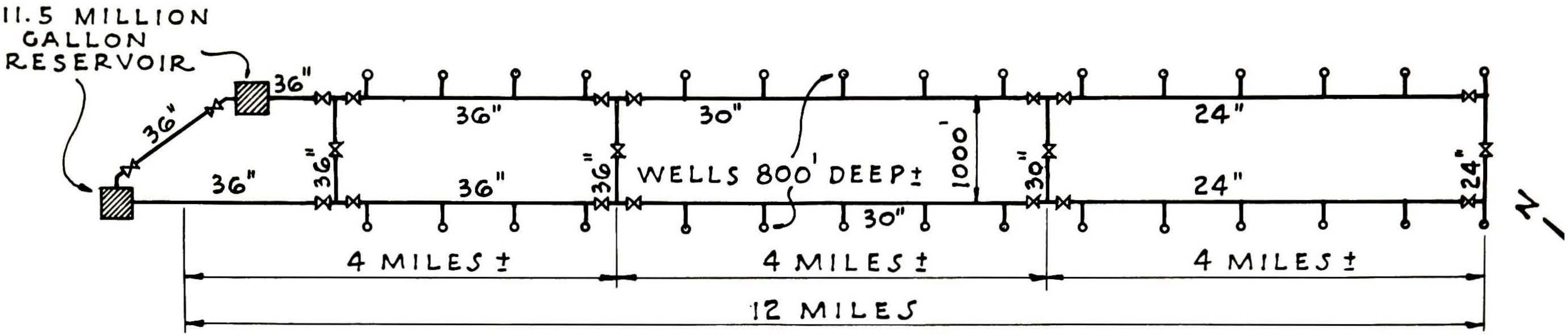
Considering all of the above, we have deemed it advisable, in order to be perfectly safe, to assume that half of the wells drilled will be dry holes or wells of too low specific capacity to be economical of development. We have assumed further that the yield per good well would average one million gallons per day and that to produce 23 MGD continuously there should be reserve or stand-by wells amounting to about one-third the number of wells actually being pumped, thus making a total of 30 wells equipped for pumping. Allowing for the dry holes or unsatisfactory wells on the above basis, a total of 60 wells are assumed necessary to be drilled.

As Mr. Stearns has pointed out, test holes and small diameter wells would be practically useless, it being better policy and more economical in the end to do the exploration with wells drilled large enough to insure a reasonably straight hole and one that can be used to advantage in case a good water supply happens to be tapped.

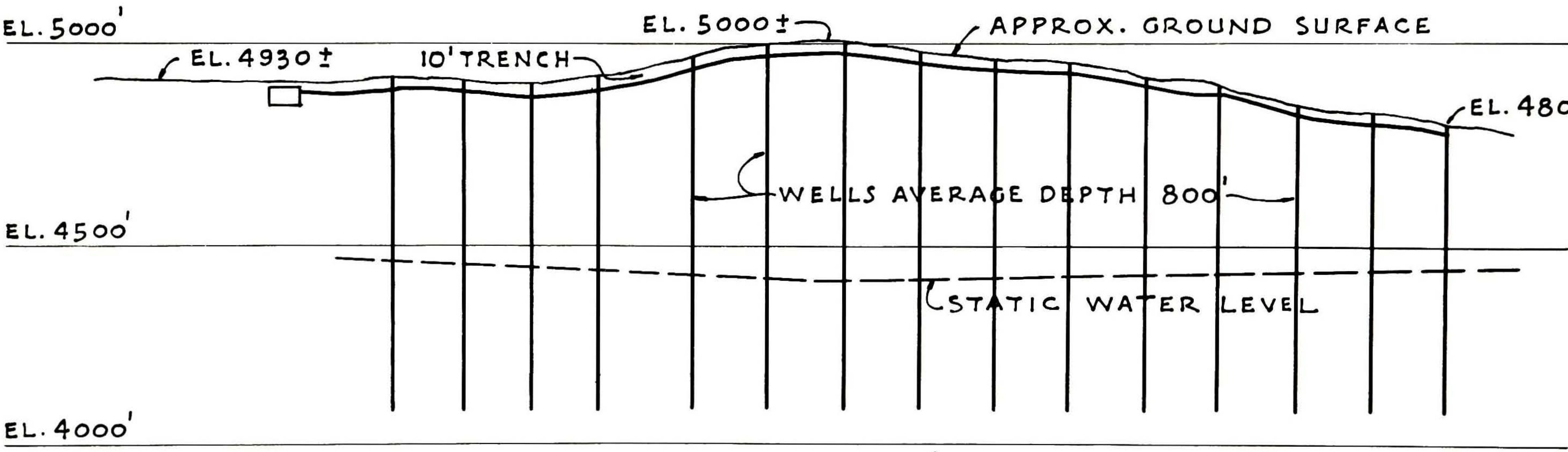
Allowing for lowering of the water table under continuous pumping of 23 MGD or approximately 35 cu. ft. per second, we have deemed it advisable to figure on 600 ft. depth of pump setting and wells drilled to 800 ft. average depth.

We have also based our estimate on the assumption that the wells equipped for service would be located along two parallel lines 1,000 ft. apart and extending in a southeasterly direction a total of 12 miles, the wells being spaced an average of 4,000 ft. in each line. Each row of wells would discharge into a separate transmission main 24" to 36" in size and extending to two $11\frac{1}{2}$ million gallon reservoirs at the plant site. The mains would be cross connected every four miles in the same way as with the surface water supply. The pumps would be designed so that the water could be delivered to the reservoirs with any one stretch of pipe line between cross connecting lines, out of service. The cost also assumes that the discharge mains would be laid in a trench 10 ft. deep in rock excavation. See Fig. 9.

No well houses are included in the estimate, it being considered satisfactory to use weatherproof motor control installations.



SCHEMATIC PLAN



APPROXIMATE ELEVATION

PLAN A
PLANT WELL WATER SUPPLY - SNAKE RIVER SITE

ALVORD, BURDICK & HOWSON

The pump motors, at least in part, would be of the submerged type which does away with long shafting, the motor being attached immediately to the pump 600 ft. down in the well. The pumps with gas engine stand-by drive would have to be of the vertical shaft type with motors at ground surface. The angle drives and gas engines would be designed suitably for outdoor installation, without a well house.

WELL PLAN ONLY TENTATIVE AND FOR ESTIMATE

It should be understood that the installation above described is intended primarily for the purpose of making a safely conservative estimate of the probable cost of developing the necessary quantity of water. A well supply is particularly adapted to gradual development over a period of 5 years or more as contemplated in the tabulation of water supply requirements from year to year (as shown on Table 1). As well drilling proceeds, along with continuous pumping of the supply, it will soon be evident as to whether substantial savings can be made in developing the ultimate supply. For instance, it may be found possible to develop a large part of the supply much closer to the plant site than we have assumed.

It may also develop that wells of much higher specific capacity are available. This would increase the amount of water that could be economically pumped from a single well and might greatly reduce the total number of wells required. This in turn would reduce the necessary length of discharge lines.

As suggested by Mr. H. T. Stearns, geologist, it may also be feasible and economical to develop the water supply by means of one or more shafts extending to below static water level and having horizontal tunnels at the bottom to tap the water supply.

In the present state of knowledge of the area, we do not consider it desirable to prepare estimates on the latter basis but it may be that experience gained by the drilling of several wells will indicate the desirability of considering such a development.

ROADS

The estimate does not include the cost of possibly necessary access roads to the wells. The layout being parallel to and not far removed from the present highway, access roads would probably be a relatively minor item.

ESTIMATED COST

We estimate the cost of the well and pumping installation as above outlined to develop 23 MGD, at approximately $10,047,000, as shown on Table 8. The annual power cost of pumping is estimated at $73,500 based on lifting the water approximately 600 ft., and a power cost of 3 mills per kilowatt hour.

TABLE 8
ESTIMATED COST
SNAKE RIVER PLAIN WELL SUPPLY

PLAN A

Wells - 60 wells 800' ave. depth*		$2,400,000
Electrical driven pumping equipment for 30 wells		600,000
Reserve gas engine drive for 15 wells		150,000
Power lines		230,000
Pipe Lines		
36" line 45,000 ft.	$1,350,000	
30" line 43,000 ft.	1,075,000	
24" line 43,000 ft.	860,000	
Cone valves 10 - 30"	60,000	
Cone valves 5 - 24"	25,000	
Cone valves 5 - 20"	20,000	
Misc. appurtenances	100,000	
		3,490,000
Reservoirs - 2 - 11.5 MG		1,520,000
Special .7 MGD treatment plant		350,000
		$8,740,000
Engineering & Contingencies		1,307,000
Total		$10,047,000

*30 assumed to turn out to be dry holes

SUPPLY FROM SNAKE RIVER

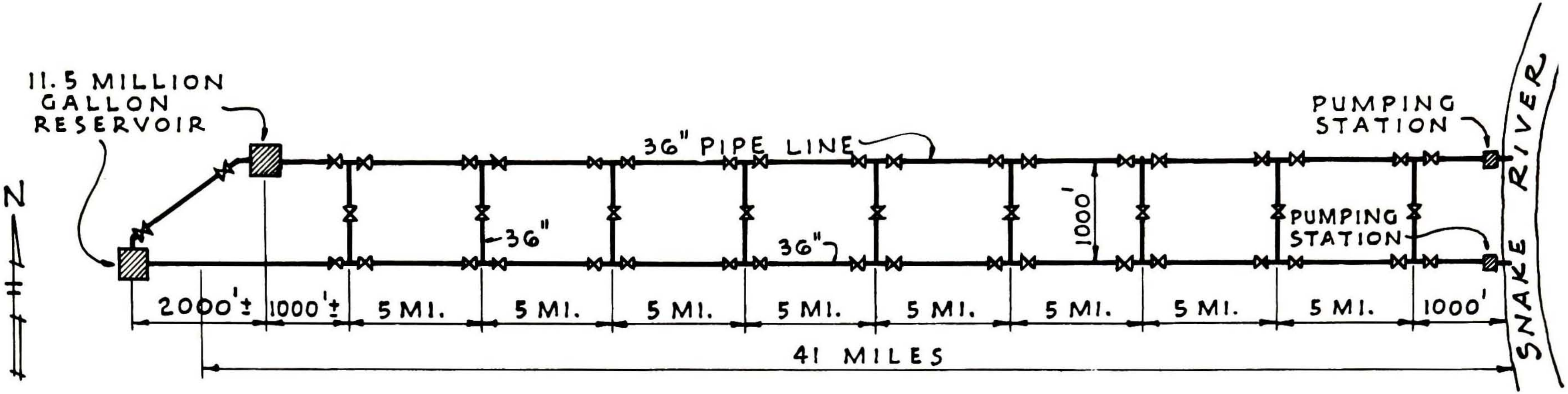
For comparison with the estimated cost of a well water supply as above estimated, we have estimated the cost of delivering water to the plant site from the nearest point on the Snake River, about 41 miles directly east. The installation would consist of duplicate pumping stations at the river bank near Idaho Falls and two 36" diameter discharge mains laid 1,000 ft. apart and cross connected at five mile intervals, as shown on Fig. 10. The cost including the two reservoirs at the plant site and a 0.7 MGD water treatment plant would be approximately $20,417,000, as shown on Table 9, and the corresponding annual power cost of pumping approximately $41,700.

TEMPERATURE OF WATER

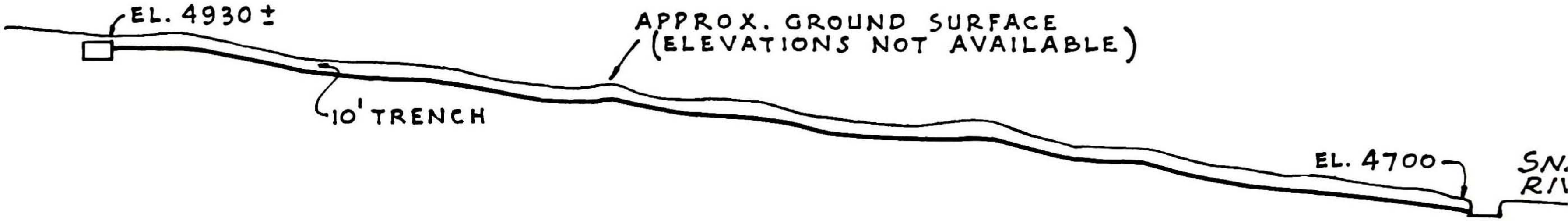
The Snake River well water has a temperature of about 54° F.

QUALITY OF WATER

The quality of the well water is shown by typical analyses on Table 10. For example: Boron 0.02 ppm, chlorides 12 ppm, iron 0.11 ppm, total hardness 146 ppm and pH 7.6. Analyses of Snake River water are also included on Table 10.



SCHEMATIC PLAN



APPROXIMATE ELEVATION

PLAN "B"
PLANT SUPPLY FROM SNAKE RIVER
(ASSUMING WATER AVAILABLE)

ALVORD, BURDICK & HOWSON
ENGINEERS CHICAGO

TABLE 9
ESTIMATED COST
SNAKE RIVER SUPPLY

PLAN B

River intake		$ 50,000
Pumping Station Buildings (2)		300,000
Pumping Equipment		
4 - 6 MGD electric driven units 400' head	$ 106,000	
4 - 6 MGD dual driven units 400' head	206,000	
Electrical equipment and piping	108,000	
		420,000
Pipe Lines		
36" pipe 486,000 ft.	$14,580,000	
Cone valves 47 - 30"	280,000	
Misc. appurtenances	200,000	
		15,060,000
Reservoirs 2 - 11.5 MG reservoirs		1,520,000
Power Line		50,000
Special .7 MGD treatment plant		350,000
		$17,750,000
Engineering & Contingencies		2,667,000
Total		$20,417,000

If filtration is needed for 9 MGD add	$ 900,000
+ Eng. & Conting.	130,000
	$ 1,030,000

TABLE 10
ANALYSES OF TYPICAL WATER SUPPLY SAMPLES
FROM THE SNAKE RIVER PLAIN AREA
COLLECTED BY R. L. NACE, U.S.G.S., JAN., 1949
ANALYSES BY U.S. GEOL. SURVEY - PARTS PER MILLION

Sample No.	2340	2341	2342	2344	2343	2345
Source	Arco Village No. 1 80 ft. Well	Arco Proving Ground Well #2	Midway 604 ft. Well (1)	Taber RR Well (2)	Snake River Below American Falls Dam	Snake R at Black above Reserv
Silica (SiO_2)	22	30	32	33	25	23
Iron in solution (Fe)	.02	.04	.02	.17	.13	.03
Total iron (Fe)	.02	.20	.06	1.1	-	-
Manganese (Mn)	0.0	0.0	0.0	0.0	0.0	0.0
Calcium (Ca)	67	39	28	37	56	46
Magnesium (Mg)	21	15	12	13	19	12
Sodium (Na)	11	7.9	15	16	25	19
Potassium (K)	2.4	3.5	3.5	4.2	4.8	3.7
Bicarbonate (HCO_3)	288	150	148	170	226	173
Sulphates (SO_4)	29	21	15	26	53	43
Chlorides (Cl)	8.0	24	12	12	24	14
Fluorides (F)	.2	.2	.5	.8	.9	1.1
Nitrates (NO_3)	2.6	1.9	1.4	1.7	1.8	1.0
Boron (B)	.01	.01	.01	.02	.01	.01
Total solids						
Sum	305	216	192	228	321	248
Hardness as $CaCO_3$						
Total	254	159	119	146	218	164
Noncarbonate	18	36	0	6	32	22
Specific conductance	506	346	288	347	504	387
pH	7.1	7.3	7.3	7.6	7.7	7.7
^{o}F	50	53.5	-	54	34	32

(1) T. 1 N., Rs. 30/31 E.
(2) T. 1 S., R. 32 E.

ACKNOWLEDGMENT

In conclusion we wish to take this occasion to acknowledge the helpful cooperation of Lt. Col. Gallaher, Executive Officer, Mr. H. H. Dunham, Chief Engr. Div., and of Mr. J. B. Van Fassen, U. S. Engineer Office, Fort Peck, Mont.; also of Dr. A. W. Piper, Mr. R. L. Nace, and Mr. Lynn Crandall of the U. S. Geological Survey, and of Dr. H. T. Stearns of Hope, Idaho, and formerly with the U. S. G. S., and of Mr. A. Banta of Smith, Hinchman & Grylls, Inc. and of Mr. Mark Fred of the Argonne National Laboratory, Chicago, Ill.

Respectfully submitted,

ALVORD, BURDICK & HOWSON,

By Donald H. Maxwell

L. R. Howson

January 25, 1949

C O P Y

Geology and Ground-Water Resources

of the

Fort Peck, Montana and Pocatello, Idaho Sites

by

Harold T. Stearns
Consulting Geologist, Hope, Idaho

January 31, 1949

Geologic and hydrologic features of the Fort Peck site, Montana.

by
Harold T. Stearns, Consulting Geologist
Hope, Idaho
January 31, 1949

Table of Contents.

Geology and ground-water resources of the Fort Peck site, Montana.

Introduction.

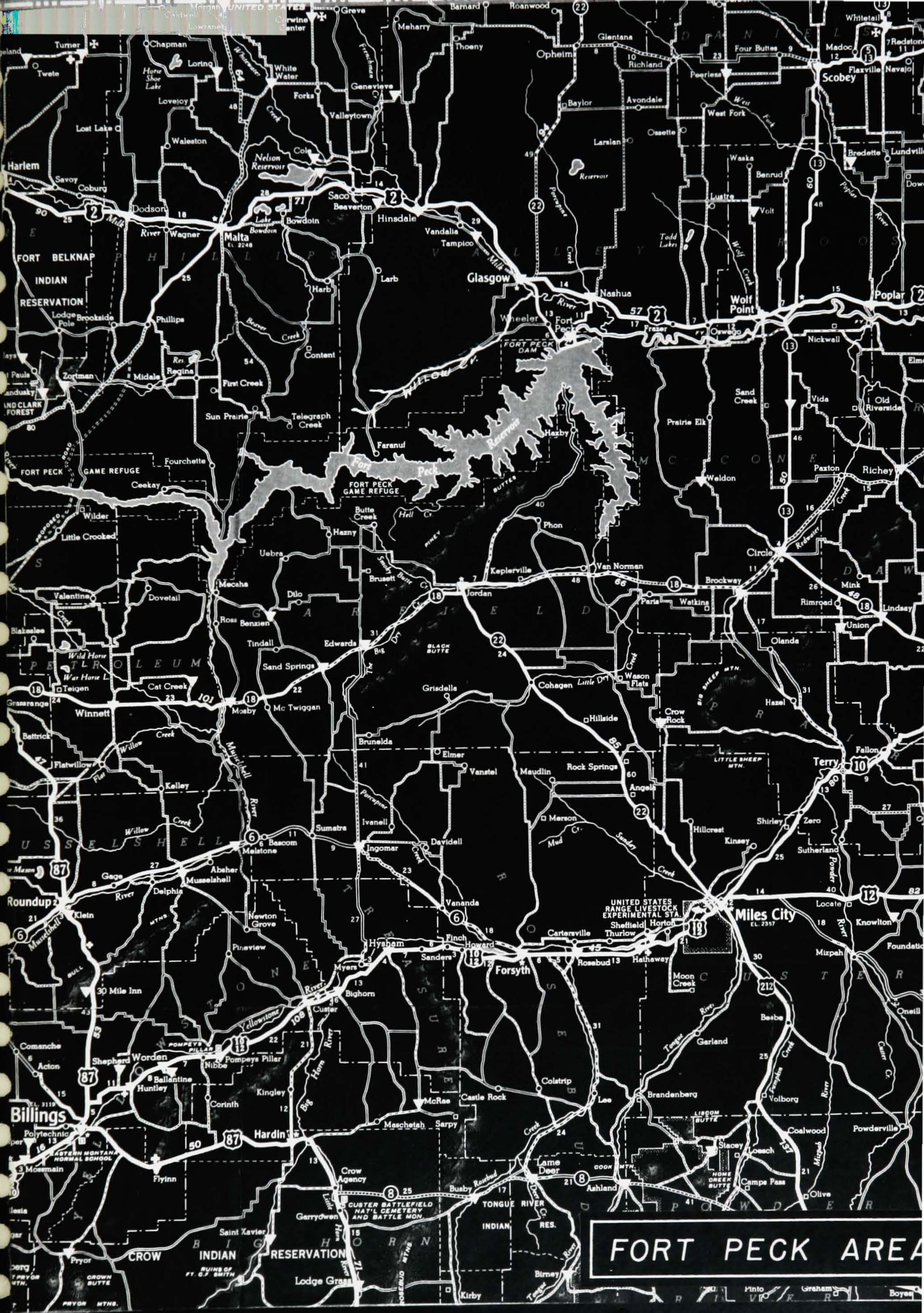
The Fort Peck site lies at an altitude of about 2275 feet in the Willow Creek basin on the northwest side of the Fort Peck Reservoir on the Missouri River about 20 miles southwest of Fort Peck and 25 miles in a southerly direction from Glasgow, Montana (see map attached). A paved road leads from Glasgow to Fort Peck and the main line of the Great Northern Railroad runs through Glasgow along Milk River. The region is sparsely populated, the main centers being Glasgow, pop. 4,000; Fort Peck, pop. 1,816; Nashua, pop. 943.

Willow Creek flows in a broad shallow valley draining northeastward into Milk River and parallel to the Fort Peck Reservoir but separated from it by a divide 100 to 500 feet high and 5 to 10 miles wide. The flat part of the valley floor averages 2 miles in width and slopes northeastward at the rate of 11 feet per mile. Dry farms lie north of the site on higher ground. Cattle and sheep range across Willow Creek Valley, which is partly covered with low brush. Along the stream channel, scattered and stunted deciduous trees grow. Clusters of scrubby pines lie near the reservoir. The area was studied by the writer on January 13 and 14, 1949 under adverse conditions with snow covering most of the ground.

Surface water.

Willow Creek, an intermittent stream, drains about 500 square miles of country which is underlain chiefly by rocks of low permeability; hence flash run-off is probably common in the spring months and during summer cloudbursts. The channel is 5 to 10 feet deep, cut into loose silty-clay alluvium. The U.S.D.A. has recently diked several of the adjacent flats to impound flash run-off. No measurements are available for the flow of Willow Creek. It was dry on January 14, 1949 but presumably it carries several hundred second-feet during the spring thaws and rains, and during floods, it may carry 1,000 second-feet or more. The lack of much vegetation along the stream suggests alkaline soil or flood-water erosion, or both.

The nearest surface water available to supply the proposed plant is the Fort Peck Reservoir. Normal full pool level of the


FORT PECK AREA
FORT BELKNAP INDIAN RESERVATION
FORT PECK GAME REFUGE
Fort Peck Reservoir
FORT PECK DAM
CROW INDIAN RESERVATION
TONGUE RIVER INDIAN RES.
UNITED STATES RANGE LIVESTOCK EXPERIMENTAL STA.
CUSTER BATTLEFIELD NAT'L CEMETERY AND BATTLE MON.
EASTERN MONTANA NORMAL SCHOOL
Harlem
Malta
Saco
Hinsdale
Glasgow
Nashua
Wolf Point
Poplar
Scobey
Opheim
Jordan
Circle
Terry
Miles City
Forsyth
Hysham
Roundup
Billings
Hardin
Winnett
Mosby
Melstone
Musselshell
Worden
Custer
Lame Deer
Ashland
Birney
Lodge Grass
Crow Agency
Pryor
Zortman
Phillips
Dodson
Savoy
Coburg
Wheeler
Fort Peck
Brockway
Richey
Vida
Lindsay
Ingomar
Sumatra
Cohagen
Vananda
Bighorn
Huntley
Shepherd
Broadus
Milk River
Musselshell River
Yellowstone River
Tongue River
Big Horn River
Powder River
Big Dry Cr.
Redwater Creek
Rosebud Creek
Little Missouri
M C C O N E
G A R F I E L D
P E T R O L E U M
V A L L E Y
P H I L L I P S
C U S T E R
R O S E B U D
D A N I E L S

reservoir is 2,250 feet. Use of water downstream may eventually cause a lowering of the reservoir of the order of 75 feet; hence the intake for the plant would have to be low enough to overcome the fluctuation in reservoir stage. Ice conditions in the winter, together with foundation problems, seem to exclude feasibility of a pump house built over the reservoir. Mr. Donald Maxwell's proposal 1/ to sink a shaft about 100 feet deep adjacent to the flow line and then tunnel out to the bottom of the reservoir seems the best method proposed to date to divert the water, although such a project would involve serious engineering problems, especially in view of the character of the bed rock described below.

Measurements of the Missouri River indicate that sufficient water to meet the demand would always pass the proposed intake. The water would have to be pumped over a divide approximately 200 to 400 feet high depending upon the exact site selected. Data from the Corps of Engineers indicate that the temperature of the water at the intake would range from 48 to 54 degrees F. at high reservoir stages. Presumably, at low stages, the temperature range would be appreciably lower.

The quality of the reservoir water is shown by a number of analyses in Piper's report 2/ and need not be repeated here.

The analyses show dissolved solids ranging from 363 to 516 p.p.m. and bicarbonate hardness from 150 to 199 p.p.m. Boron was 0.11 p.p.m. in one sample collected November 11, 1948 from about 50 feet above the bottom of the reservoir at the Fort Peck filtration plant. Samples collected before the completion of the reservoir indicate that the Missouri River, at times, contains as much as 808 p.p.m. of dissolved solids.

Geology.

General statement.- The site is underlain with dark gray to brown marine shale, known as the Bearpaw shale of Upper Cretaceous age, dipping gently southeastward on a gradient

1/ Oral communication, January 14, 1949

2/ Piper, A.M. Geologic and hydrologic features of the Fort Peck area, Montana. U.S.G.S. typewritten report, 1948 of 25 feet to the mile. The shale is overlain, in Willow Creek Valley, with a veneer of dark gray clayey alluvium derived chiefly from the erosion of the shale. The clay forms sticky gumbo, when wet. The shale beds range from 2 to 10 feet thick. The shale is characterized by its ability to slake upon exposure to air due to its high content of bentonite and gypsum. Locally it contains limy concretions, many of which contain fossils.

The bearpaw shale is 800 to 1,000 feet thick where not deeply eroded. Its surface is characterized by a dark gray gumbo clay, filled with tiny shrinkage cracks. Large shrinkage cracks were observed in a few places in Willow Creek Valley. The land surface is only slightly rolling and is suitable for building so far as terrane is concerned but there are places where gullies have developed a bad-land topography.

Forming the divide between Willow Creek and the Missouri River are flat-topped hills composed of drab colored sandstones and interbedded shales, called the Lance formation. This formation overlies the Bearpaw shale and is characterized by iron-stained concretions.

A thin veneer of glacial till lies north of the site and locally obscures the Bearpaw shale. It is clay containing pebbles and cobbles of foreign rock transported by glaciers. The thickness of the till is rarely more than 10 feet.

<u>Physical character of the shale</u>.- The Bearpaw shale is intricately cut by faults of small displacement at Fort Peck and may be at the site, also. The excavation for the spillway of the dam revealed 27 faults in a distance of 3500 feet. These faults have caused serious trouble with slippage. Some of the shale layers, especially along bedding planes, contain considerable bentonite, a clay mineral used commercially for its physical property of swelling when water is added. The layers of bentonite range from 0.2 to 1.4 feet thick. The measured movement on faults in the spillway section, by the Corps of Engineers, amounts to 35 feet. The shale, as seen at the spillway excavation, forms a dark colored, massive-appearing cliff cut by blocky jointing. The massiveness is deceptive as to quality for foundations.

Ground-water.

Water-bearing properties of the rocks.- The alluvial clay in Willow Creek is not water bearing. The underlying Bearpaw shale is virtually impermeable and serves as the caprock for the underlying Judith River sandstone which carries unpotable artesian water in small quantities. The Lance sandstone, overlying the Bearpaw shale, gives rise to small hillside springs and seeps. The glacial till is reported by Piper to supply small yields to farm wells. The city of Glasgow and the Great Northern Railroad obtain their water from a gravel bed at the base of the alluvial fill in the Milk River Valley. The gravel bed extends from 80 to 112 feet below the surface and yields water freely.

Quantity of ground-water.- The quantity of artesian water available in the Judith River formation is probably fairly large if developed over a large area but its poor quality, described below, rules out this supply.

The alluvium in the Milk River Valley yields 600 g.p.m. to two wells belonging to Glasgow. The three railroad wells have a 4-foot drawdown when pumped 16 hours a day. It is very doubtful whether a sufficient quantity of ground-water moves through the alluvial fill of the Milk River Valley to meet the requirements of the proposed plant because of the narrow band of gravel in this valley.

Quality of ground-water.- Samples were collected by Donald Maxwell, David Banta and the writer from several wells in the area and shipped to Alvord, Burdick and Howson of Chicago for analyses. Results have not yet been received. However, analyses of samples collected by Piper confirm field observations that both the ground-water in the alluvium of Milk River Valley and the artesian water in the Judith River formation are inferior waters. The Glasgow water, on November 12, 1948, contained 911 p.p.m. of dissolved solids; 344 p.p.m. of sulfate (SO_4) and 418 p.p.m. of bicarbonate (HCO_3); 0.45 p.p.m. of boron; and 1.4 p.p.m. of iron. The water stains porcelain in a single night and, when drawn from a tap, smells strongly of sulphur.

The artesian water from a well 487 feet deep in the NE1/4, sec. 8, T.26N., R. 39E contained 2,320 p.p.m. of dissolved solids; 871 p.p.m. of sodium; 1,180 p.p.m. of bicarbonate (HCO_3); 456 p.p.m. of sulfate (SO_4); 345 p.p.m. of chloride (Cl); and 3.9 p.p.m. of boron. Such water is obviously too corrosive to be of value even for cooling purposes.

It is concluded that suitable ground-water supplies for this site are not available and that the Fort Peck Reservoir water would have to be used.

Relation of the rocks to construction problems.

Foundations.- The only bedrock in the site is Bearpaw shale which has been shown by the heavy structures at Fort Peck to be possible for use as footings, although not entirely satisfactory. In spite of costly concrete foundation slabs, the gate structure at the dam has moved along its upstream edge as much as 0.6 feet during a 6-year period and the floor of the spillway has moved as much as 1.8 feet. 1/ It is not known whether the shale at the site in Willow Creek Valley is as broken by faults and crush zones as at the spillway but bentonitic zones are certainly present and these always are potentially dangerous in the presence of moisture. The Bearpaw shale is an unsatisfactory foundation rock but could be used, at large additional cost, if necessary.

Concrete aggregate.- The nearest gravel in quantity is at the Great Northern Railroad pit at Cole on a spur line from Saco, about 70 miles northwest of Fort Peck. It was used to construct the Fort Peck Dam but the plant has been moved. It is reported that the aggregate has excessive amounts of fines. Small quantities of gravel are obtainable from the alluvium filling Milk River Valley near Glasgow, Montana.

Rock.- The nearest available rock supply is at a quarry near Harlem, about 150 miles from Fort Peck. The rip-rap for the Fort Peck Dam came from this quarry.

Road Metal.- The problem of roads is serious because the gumbo clay forming the surface at the site cannot be travelled in wet weather. All roads would have to be surfaced with poorly assorted gravel from Glasgow or from the pit at Cole.

1/ FortPeck Dam spillway movement survey; Corps of Engineers, Fort Peck, Montana, 1947

<u>Disposal of waste fluids</u>.- Waste fluids could be dumped into the Missouri River, or into Willow Creek, which finds its way into the Missouri by way of Milk River. The soil and bedrock are too impermeable to allow percolation downward. Large evaporation pans could be made by bulldozing dikes around some of the broad clay flats in Willow Creek Valley but it is understood that this method of disposal would not be satisfactory.

<u>Earthquake hazards</u>.- Heck 1/ lists 27 strong earthquakes in Montana between 1852 and 1946. One additional earthquake occurred in 1948. Five were destructive in the vicinity of Helena. On May 15, 1909 a shock occurred southwest of Regina, Saskatchewan, Canada that was felt as far south as South Dakota. It must have been felt at Fort Peck, only 200 miles away but no official record of its intensity there is known. A search through the files of local newspapers in the Glasgow area would have to be made to learn its effect.

It appears that the earthquake hazard is not great in the Fort Peck area. However, bentonitic shale in foundations might shift and cause serious damage to structures if a quake came during a wet season when the ground is saturated. The quake would serve as a hair trigger force.

<u>Lignite deposits</u>.- Numerous beds of workable lignite crop out near Culbertson about 50 miles east of Fort Peck. Several of the beds reach 6 feet in thickness. The lignite field has been described by Smith, 2/, and an analysis published by him is given below. The lignite is a potential source of power for the proposed plant. Gas and oil in the Shelby area in western Montana are now available also and may be more economical for power.

1/ Heck, N.H., Earthquake history of the United States, Part 1. U.S. Coast and Geodetic Survey, Serial No. 609, 1947.

2/ Smith, C.D., The Fort Peck Indian Reservation Lignite Field, Montana; U.S.G.S. Bull. 381, pp 41-59, 1908

Proximate analysis and calorific determinations of lignite from the Bruegger mine, 3 miles north of Culbertson, Montana.
(F.M.Stanton, chemist in charge)

Laboratory number - - - -	7059
Sample as received:	
Moisture - - - - -	43.16
Volatile matter - - - -	22.03
Fixed carbon - - - -	28.99
Ash - - - - - -	5.82
Sulphur - - - - -	.29
Calories - - - - -	3,333
British thermal units - - -	5,999
Loss of moisture on air-drying -	38.70
Air-dried sample:	
Moisture - - - - -	7.28
Volatile matter - - - -	35.93
Fixed carbon - - - -	47.29
Ash - - - - - -	9.50
Sulphur - - - - -	.48
Calories - - - - -	5,437
British thermal units - - -	9,787

Harold T. Stearns, Consulting Geologist
Hope, Idaho
Jan. 31, 1949

Geologic and hydrologic features of the Pocatello site, Idaho.

by
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Table of Contents.

Geologic and hydrologic features of the Pocatello site, Idaho.

Introduction.

The Pocatello site lies at an altitude of 4930 feet, forty miles northwest of Blackfoot, Idaho with its center at the southwest end of the U.S. Navy Proving Grounds in Butte County near the northern edge of the Snake River Plains. The Navy reservation is outlined in red on the attached map. The land is nearly flat sloping about 10 feet to the mile towards the north in the direction of the Lost River Sinks. The area is crossed by a spur line of the Union Pacific System, running from Blackfoot to Mackay, Idaho (not shown on the map); and by U.S. Highway 20. Nearby towns are Idaho Falls, pop. 15,000; Blackfoot, pop. 3,700; Pocatello, pop. 18,000; and Arco, pop. 550. The figures are according to the 1940 census but these towns have grown appreciably since then.

The portion of the plain under consideration is virtually uninhabited, except at the Navy Proving Grounds where a small group of workers live. The plain is covered with scattered sage- and rabbit-brush and sparse grass. No merchantable timber lies close as the adjacent mountains have only stunted stands of juniper and pine. The general area was studied intensively by the writer from 1921 to 1930. (See reference list at end of report.) During the present investigation in January 1949, the ground was covered with snow and frozen to a depth of several feet; hence it was not practical to make a detailed geologic map of the site, nor to make test borings to determine the depth to rock.

Climate.

The climate of the site is semi-arid. Precipitation averages nearly ten inches annually. June to September are dry months. The yearly mean temperature is about 42 degrees F. The daily range of temperature is large with a difference between the mean daily minimum and the mean daily maximum of about 20 degrees during the winter and about 38 degrees during the summer, with much greater variations occasionally. The summers are characterized by hot days and cool nights. The temperature reaches 100, or even higher, for a few days at a time. Ordinary winter minimum temperatures are 10 to 20 degrees below zero. The mean relative humidity averages about 50 percent for the year. The prevailing wind is from the southwest and it blows almost steadily during the spring


POCATELLO AREA
Pocatello
Alameda
Idaho Falls
Blackfoot
American Falls
Burley
Rexburg
St. Anthony
Preston
NAVY WELLS
CRATERS OF THE MOON NAT'L MON.
FORT HALL INDIAN RESERVATION
IDAHO STATE COLLEGE
IDAHO
UTAH
B I N G H A M
B U T T E
C L A R K
J E F F E R S O N
F R E M O N T
M A D I S O N
B O N N E V I L L E
C A R I B O U
B A N N O C K
P O W E R
O N E I D A
F R A N K L I N
C A S S I A
M I N I D O K A
Arco
Mackay
Leadore
Dubois
Ashton
Rigby
Shelley
Firth
Aberdeen
Malad
Soda Sprs.
Lava Hot Sprs.
McCammon
Inkom
Downey
Arimo
Rockland
Oakley
Albion
Rupert
Heyburn
Paul
Yale
Grouse Creek
Snowville
Lewiston
Richmond
Smithfield
Montpel
Wellsville

months. High velocities are uncommon and tornadoes are unknown. Near the mouths of adjacent valleys the wind may blow from the northwest occasionally, especially during the winter months. Evaporation averages about 44 inches from openwater bodies, or nearly 3 feet after allowing for precipitation. Monthly evaporation records are available in U.S.G.S. Water-Supply Paper 774, P. 18, 1938.

Surface water.

No perennial streams cross the area but Big Lost River, in wet years, finds its way across the site to the Lost River Sinks (See map). The "sinks" are broad shallow natural evaporation pans extending along the north edge of the lava plain from the mouth of the Little Lost River to Birch Creek. Some of the water reaching the sinks escapes by deep percolation and the remainder is dissipated by evaporation. The sinks resulted from blocking by successive lava flows of the normal southeastward channels of the Big and the Little Lost Rivers and of Birch Creek. The sinks have low rims, about 5 feet high, caused by the wind blowing away silt. Mud Lake, a little to the northeast of the Sinks is the sink for Medicine Lodge, Beaver and Camas Creeks. The lake is now perennial due to ground-water inflow from Egin Bench, a heavily irrigated area near St. Anthony.

The summer flow of Big and Little Lost Rivers is used for irrigation. Flood water from Big Lost River is stored at Mackay for irrigation. These streams would not supply the proposed plants. The nearest large stream is the Snake River, 36 miles to the southeast. Its summer flow is all appropriated but stored water can be purchased in the Palisade Reservoir of the U. S. Bureau of Reclamation under construction on the South Fork of the Snake River. The quality of the surface water is variable, depending upon the quantity of melt water present. It is best in the spring and slowly increases in mineral content towards winter when salts, leached by irrigation water, are returned to the river. Hardness ranges from about 125 to 180 p.p.m. and boron ranges from about 0.01 to 0.08 p.p.m. Two analyses of the water from Lake Walcott at Minidoka Dam are given by Nace. 1/

1/ Nace, R. L. Preliminary report on ground-water in Minidoka County, Idaho; U.S.G.S. mimeographed report, page 30, 1948.

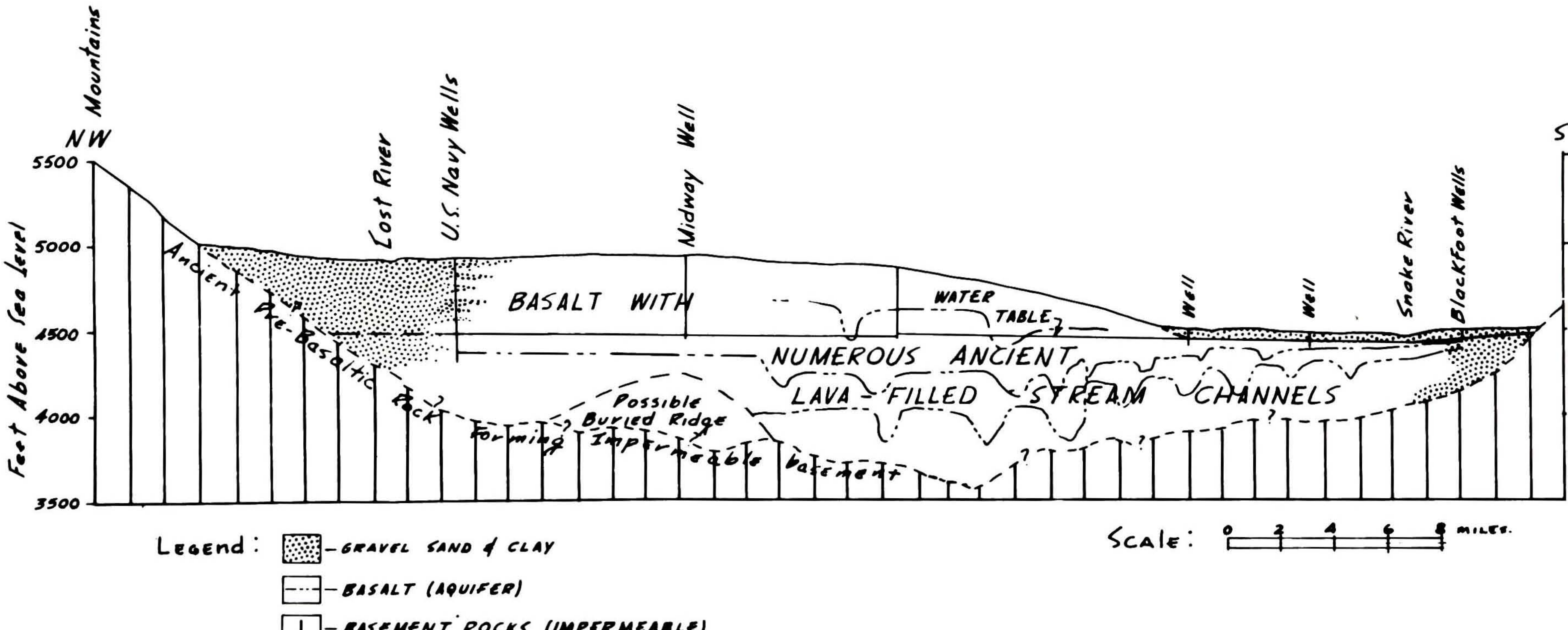
It is understood that analyses of water from American Falls Reservoir, collected by Nace in January 1949 and sent to the Salt Lake Laboratory of the U.S.G.S. will be made available soon.

Geology.

General statement.- The site is underlain for many hundreds of feet with jointed Pleistocene basaltic lava beds 10 to 150 feet thick, overlain with a thin veneer of gravel, sand and wind-blown soil (loess). The basalt crops out in all high knolls. Nowhere is there evidence of deformation. Hummocky, nearly bare, late lava flows lie on the west, the northwest and the south sides of the area (see map). Farther west, in the Craters of the Moon National Monument, the lava flows are black and fresh and are thought to be not much more than a thousand years old. The depth of wind-blown soil on the lavas is a clock for measuring the age of the lavas because the dust from the lake beds in western Idaho has been blowing across the Snake River Plains for thousands of years and the longer a lava flow has been erupted, the more soil it carries. The soil tends, however, to wash and blow from the knolls into the swales, hence will always be deeper in low places. The depth of soil has a bearing on excavations, roads, foundations, etc.

The log for Well 2, at the U.S. Navy Proving Ground, indicates about 2 feet of soil, 8 to 15 feet of stream-laid gravel and sand, 2 to 10 feet of clay, and then a basalt layer 36 feet thick. Below this lava is 18 feet of clay overlying a lava layer 67 feet thick. A 4-foot bed of clay, sand and gravel separates this lava from another 53 feet thick. Then 4 feet of clay followed by 152 feet of lava (probably more than one flow), 4 feet of clay, 41 feet of lava, 3 feet of clay, 97 feet of lava, 4 feet of red sand, 7 feet of cinders, about 133 feet of lava, 23 feet of clay, sand, and pea gravel, and 21 + feet of lava. Interstratified sand and gravel are not commonly found in the logs of wells farther away from the mountains. The lavas at the site interfinger with the sediments filling the Lost River Sinks, as shown in section A B attached.

Physical character of basalt.- Fresh surfaces of basalt are almost always blue-black or gray-black. Two types of basalt are found in the general area,- pahoehoe and aa. Pahoehoe basalt makes up over 95% of all the basalt in the Snake River



GENERAL GEOLOGIC SECTION

From NW to SE

THRU U.S.N. PROVING GROUNDS

Plain. It has a ropy, billowy surface, is filled with vertical fissures and commonly has a visicular crust a few inches to a few feet thick. This is the honeycomb lava described by the well drillers. Below the crust, the lava becomes progressively denser toward the bottom unless another flow unit is encountered. Flow units are layers erupted a few hours or a few days apart during the same eruption and they commonly lie one above the other.

The surface of aa lava is clinkery, spiny, and exceedingly rough. Dense irregular layers lie within the clinker. Aa lava is characterized by deflated irregular vesicles in contrast to pahoehoe, which has round vesicles. Aa lava is abundant in the adjacent Craters of the Moon National Monument and may be encountered in wells at the site.

All basalts in this area are closely alike chemically; hence the analysis of the one given below is typical:

Analysis of basalt from Craters of the Moon National Monument
(By U.S. Geological Survey Laboratory)

SiO_2	51.14	ZrO_3	0.12
Al_2O_3	13.95	Cl	trace
Fe_2O_3	2.15	F	0.10
FeO	12.97	FeS_2	0.15
MgO	2.21	NiO	trace
CaO	6.56	BaO	0.25
Na_2O	3.59	SrO	trace
K_2O	2.33	V_2O_3	trace
$H_2O +$	0.22		
$H_2O -$	0.12	Specific gravity	2.907
TiO_2	2.41		
P_2O_5	1.59		
MnO	0.44		
	100.30		

Physical character of the sediments.- The stream-laid sediments at the site were deposited by the Big Lost River which carries pebbles typical of the ancient sedimentary and igneous rocks in its drainage basin. Fine-grained gray limestone is abundant with lesser amounts of quartz diorite, basalt, andesite porphyry, and chert. The gravel is well rounded and well sorted. Niggerheads are scarce. These sediments become progressively finer grained northeastward until, in the "sinks", all the material is of clay and silt size. Mechanical analyses of aggregate from two gravel pits close to the Navy buildings are given below:

Aggregate mechanical analyses, U.S. Navy Proving Grounds, near Arco, Idaho.
(Analyses by Idaho Department of Public Works)

Percent passing by dry weight

	Pit 1		Pit 2	
	Gravel 59%	Sand 41%	Gravel 62%	Sand 38%
2½" sq.			100	
2 "	100		97	
1½"	98		87	
1 "	86		70	
3/4"	73		59	
1/2"	49		42	
3/8"	39		27	
No. 4	0		0	
F.M.	7.0		7.27	
Absorption	1.1		1.1	
% wear	18.5		19.5	
AASHO grade	A		A	
Wt. of dry Lse	125		123.8	
Spec. grav.	2.60		2.62	
No. 4		100		100
8		81		80
16		70		66
30		61		49
50		32		18
100		5		4
F.M.		2.51		2.83
Silt		2.5%		2.8%
Wt of dry Lse		103		103
Spec. grav.		2.60		2.58

Ground-water.

Water-bearing properties of the rocks.- The clay is impermeable. The sand and gravel carry water in the zone of saturation but at the site are not important water bearers. The chief aquifer is basalt which carries great quantities of water in its openings. The open spaces are listed in approximate order of water-carrying capacity as follows:

1. Open spaces at the contact of one lava flow with another or a lava flow with the underlying formation. Lava flows fail to fit tightly together due to the sticky character of lava when it comes to rest.
2. Interstitial openings in cinders, aa, and subaqueous lava, formed during deposition. Beds of aa and cinders rate high among the most permeable formations in the crust of the earth.
3. Open spaces in joints formed by shrinkage of the lava in cooling.
4. Tunnels, tubes and caves produced by liquid lava flowing out from under a hardened crust. Tunnels up to 50 feet in diameter are known in the Snake River Plains. A large tunnel lies near the Twin Buttes just south of the site.
5. Vesicles and cavities due to the expansion of gases during the cooling of the lava.
6. Tree molds resulting from lava surrounding a tree and solidifying before the tree has burned away. Many tree molds exist in the Craters of the Moon National Monument.

Form of the water table.- An insufficient number of wells exist in the area to prepare a water-table map. The water level in the two wells at the U.S. Navy Proving Ground is approximately 4458 feet above sea level or 472 feet below ground surface. At Cerro Grande, 6 miles due south, the water table has an altitude of 4430 feet. Other wells at Midway and Taber, to the southeast, indicate that the water table slopes southward, and at Midway southwestward, at the rate of about 5 feet per mile. It is believed that contours of the water table would roughly parallel the 4500-foot contour shown on Plate 19, U.S.G.S. Water-Supply Paper 774.

The Twin Buttes and Big Butte are relatively impermeable pre-basaltic volcanic masses which project through the basalt. They would stand as dry islands in the water table. Such data as exist indicate that the underflow of the Little Lost River, Birch Creek, and some of that of the Mud Lake basin, is moving southward under the site.

Quantity of ground-water.- An average of about 175,000 acre-feet of water is contributed annually to the zone of saturation under the plant site, plus an unknown amount of irrigation loss from Egin Bench, which reaches the Mud Lake basin. Big Lost River contributes about 226,000 acre-feet annually to the water table but much of this appears to move southward towards Snake River, a little west of the site.

A large proportion of the underflow can be recovered by properly spaced drilled wells as there is little pumping in the area. It is conservatively estimated that about 100 second-feet pass the north side of Twin Buttes from recharge east of the mouth of Big Lost River.

The Twin Buttes and Big Butte may be projections on a buried ridge of poorly permeable rock that separates the ground-water under the site from that under the main part of the plain south of the line of these buttes. Or the ridge may have been cut by a pre-basalt canyon of Big Lost River, in which case the ground-water south of the buttes could be made to move northward if the water table were lowered sufficiently, by pumping, under the site to cause the hydraulic gradient to slope northward.

It is estimated that 500 to 750 second feet flow southwestward underground in the first 10 miles southeast of the Twin Buttes, or from 50 to 70 second-feet per mile of cross section. Actually the water does not move uniformly through the basalt because it tends to follow the ancient lava-filled canyons of Snake River, which are more permeable than the adjacent slightly older basalts (see section A B). This great body of ground-water can be tapped 3 to 5 miles southeast of the line of the buttes, and perhaps closer.

Quality of ground-water.- The temperature of the ground-water in Well 2, U.S. Navy Proving Ground, on January 16, 1949, was 53.5 degrees F. and at the Taber Railroad Well was 54 degrees F. on January 18, 1949. New analyses of the water in the wells in this area are being made by the U.S.G.S. in their Salt Lake Laboratory, from samples collected in January.

The quality of the water in the basalt is good although slightly hard, as shown in the following analyses. All waters in the basalt are low in iodine and the incidence of goiter was great until the introduction of iodized salt. Nace 1/ reports that boron, in 12 analyzed well waters from the North Side Minidoka Project ranged from a low of 0.0 to a high of 0.12 p.p.m.

1/ Nace, R. L. Preliminary report on ground-water in Minidoka County, Idaho. Mimeographed report U.S.G.S. page 29, 1948.

Analyses of ground-water in the site area.
(Quantities in parts per million)

	Well 1 *	Well 2 *	Taber well **
Date sampled	7/17/47	7/17/47	10/15/25
ph	7.9	7.9	-----
Silica	37	34	14
Aluminum	.6	.6	-----
Iron	.02	.02	-----
Iron and aluminum oxides	-----	-----	3.9
Manganese	0	0	-----
Calcium	37	38	35
Magnesium	12	15	12
Sodium and potassium	15	3.9	17
Total alkalinity	132	122	156
Free carbon dioxide	3.2	3.0	-----
Sulphate	16	16	25
Chloride	20	20	14
Nitrate	-----	-----	2.0
Hardness as $CaCO_3$	142	159	137
Loss on ignition	34	44	-----
Total dissolved solids	241	229	230

* Analyses of Wells 1 and 2 by Sanitary Engineering Laboratory, 13th Naval District, Seattle, Wash.

**Analyses of Taber well by Consulting Chemist, Union Pacific System, Omaha, Neb.

Pumping tests and well records.- Records for wells in the vicinity of the site are published in U.S.G.S. Water-Supply Papers 774 and 775. Pertinent data for the two wells supplying the U.S. Navy Proving Grounds, drilled since these papers were published, is given below. They are housed in substantial brick and concrete structures. Drawdown tests on Well # 1 were made on Jan. 20, 1949 by the writer and David Banta by means of the pressure gage calibrated for this pump. Drawdown tests on Well 2 were made by the writer, R. L. Nace and David Banta on Jan. 18, 1949, by steel tape measurements.

Drawdown tests U.S.N. Proving Ground Wells.

Well 1 (Rate *590 G.P.M.)	Feet	Well 2 (Rate *150 G.P.M.)	Feet
Static level before pumping **	- 468	Static level before pumping	- 472
Drawdown after 4½ minutes	18	Drawdown after 6 minutes	10.2
" " 10 "	20		
" " 13 "	21		
" " 15 "	21	Drawdown after 65 minutes	10.1
" " 18 "	21		
Specific yield - - - 28 G.P.M.		Specific yield - - - 15 G.P.M.	

* Reported by U.S.N. from tests at time of installation
**Measured by R. L. Nace Dec. 29, 1949

U.S. Navy Proving Ground wells.

	Well 1	Well 2
Location	730 ft.S and 920 ft. W of NE cor. sec. 1, T.2N., R.29E., B.M.	2700 ft.S and 2100 ft.W of NE cor. sec. 1, T.2N., R.29E., B.M.
Drilled by	A.J.Schoonover and Son, Burley, Idaho	Roscoe Moss and Company, Los Angeles, California
Date drilled	Started 11/5/42, finished 1943	Started August 1943. Completed May 1, 1944
Depth	685 feet	681 feet
Aquifer	basalt	basalt
Depth to water	461.2 ft. on Dec. 29, 1948 below casing head plate 6.75 ft. below ground	464.7 ft. on Dec. 29, 1948 below casing head plate 7.5 ft. below ground
Altitude	About 4930 feet	About 4930 feet
Gage	613 feet of air line	- - - - -
Pump	6" submersible Byron Jackson	5" submersible Byron Jackson
Motor	150 Hp	60 Hp
Discharge	590 G.P.M. at time of installation	*150 G.P.M. at time of installation
Drawdown	21 feet, Jan. 20, 1949	10.1 feet, Jan 18, 1949
Casing	440 ft. of 16-in.	68 ft. of 20-in., 681 ft.of 16", 110 ft. perforated

* In 1944 the driller tested the well and reported 470 G.P.M. with a drawdown of 41 ft. or a specific yield of 11½ G.P.M.

Logs of U.S. Navy Proving Ground Wells.
(Copied from Navy blueprint)

Well 1 (Feet)	Formation	Well 2 (Feet)	Formation
0-2	Top soil	0-1	Sandy gravel
2-17	Gravel	1-5	Clay
17-28	Clay	5-12	Sand and gravel
28-50	Lava with clay filled cracks	12-14	Clay
50-59	Lava, clay and sand	14-50	Cracked lava
59-69	Clay and sand	50-68	Clay and end of 20" casing at 66 ft.
69-108	Solid lava		
108-134	Lava and cinders	68-105	Lava
134-139	Sand and clay	105-108	Hard lava
139-159	Lava	108-135	Lava
159-161	Cinder and lava	135-139	Clay and a little sand and gravel
161-169	Lava		
169-171	Cinders	139-150	Red Lava
171-181	Cinders and clay	150-155	Black lava
181-184	Cinders	155-159	Gray lava
184-211	Solid lava	159-161	Lava cinders
211-221	Broken lava	161-169	Black lava
221-231	Solid lava	169-179	Cracked lava
231-246	Coarse lava	179-192	Lava
246-265	Brown lava	192-196	Clay and lava
265-281	Soft lava	196-224	Lava
281-291	Hard lava	224-230	Lava crevices
291-321	Clay and lava	230-235	Cracked lava
321-341	Hard gray lava	235-240	Hard lava
341-349	Clay	240-244	Lava
349-352	Solid lava	244-299	Broken lava
352-371	Clay and cinders	299-325	Hard gray lava
371-381	Clay	325-330	Gray cracked lava
381-391	Hard gray lava	330-332	Soft lava
391-414	Clay	332-336.5	Lava
414-425	Clay and gravel	336.5-348	Broken lava
425-427	Cinders	348-352	Clay, cinders and lava
427-440	Clay and cinders	352-356.5	Brown lava
440-444	Solid lava	356.5-365	Brown lava and crevices
444-452	Blue lava, crevice	365-368	Hard red lava
452-462	Lava and water	368-377	Red broken lava
462-470	Blue lava, crevice	377-385	Hard red lava
470-522	Honeycomb lava, traces of soapstone, water thruout	385-387	Black cinders
		387-393	Lava and iron
522-562	Solid lava	393-396	Clay and lava

(table continued page 11)

(Feet)	Formation	(Feet)	Formation
562-588	Clay, lava and water	396-409	Hard gray lava
588-611	Solid lava	409-417	Broken lava
611-665	Red honeycomb lava with water	417-439	Hard gray lava
665-677	Lava, cinders and water	439-454	Blue lava
677-685	Red lava cinders	454-473	Lava
		473-475	Blue lava and water
		475-490	Brown lava
		490-493	Hard lava
		493-497	Red sand and cinders
		497-504	Cinders and lava
		504-509	Lava
		509-525	Cinders and lava
		525-550	Lava
		550-556	Cinders and lava
		556-568	Hard lava
		568-598	Lava
		598-602	Honeycombed lava
		602-615	Lava
		615-620	Hard lava
		620-628	Honeycombed lava
		628-634	Honeycombed lava
		634-640	Clay and lava
		640-650	Clay
		650-660	Clay, pea gravel and sand
		660-665	Lava
		665-681	Hard lava

Method for developing water.- The demand for water at this site, if selected, is to increase from one and a half mgd in 1949 to fifteen mgd in 1955, with an ultimate demand of about twenty three mgd. Drilled wells similar to those belonging to the U.S. Navy but scattered over the plant area and equipped with large pumps would appear to be the most economical way to meet the demand for water. As an emergency firm supply, it is recommended that a Maui-type well 1/, be sunk along either the highway or the railroad 10 to 12 miles southwest of the site and the water pumped to the site through a sinuous pipeline following low ground to avoid rock excavation.

1/ Stearns, H. T. Supplement to the Geology and Ground-water Resources of the Island of Oahu, Hawaii. Hawaii Dept. of Public Lands, Division of Hydrography, Bull. 5, Dec. 1940

The exact location of the shaft should be determined by a test well as it might be possible to develop 23 mgd from a shaft without going so far from the site. A shaft 8 by 8 feet and about 575 feet deep with its floor perforated with wells or having a tunnel driven horizontally into the main aquifer should develop all the water required. Such a well has many advantages and is more economical than a battery of drilled wells as each drilled well has to penetrate about 500 or more feet of dry rock before water is encountered. The pumping lift would be of the order of 575 feet.

Relation of the rocks to construction problems.

Foundation.- A layer of basalt 25 to 35 feet thick underlies the surficial sedimentary deposits. This rock will make an excellent bearing for heavy structures.

Concrete aggregate.- Basalt, when crushed, makes excellent aggregate except the scoriaceous top of the flow, which is either discarded in the quarrying operation or worm out in the crusher. However, underlying a large part of the site is a gravel bed, under a 2- to 5-foot soil cover, which has been used extensively by the Navy for aggregate. Mechanical analyses are given earlier in this report. None of the buildings which have been built since 1943 show any signs of "growing" concrete such as can be seen at American Falls Dam, built of Snake River aggregate. Vast quantities of clean gravel and sand crop out in Big and Little Lost River Valleys also; hence there are unlimited supplies close at hand.

Cinders.- Several cinder cones lie in the area. These have proven valuable for making light-weight concrete and blocks for building. Such blocks have the advantage of being nailable.

Road metal.- The gravel deposits described above make satisfactory roads and, when oiled, make excellent pavement. Cinders also are used for road metal in the Snake River Plains but they become too dusty when subjected to heavy traffic.

Disposal of harmless waste fluids.- Uncontaminated waste fluids can be dumped into the lava beds where they will slowly percolate to the basal water table and find their way to the Snake River Springs. The rate of movement of the ground-water is of the order of one half mile per year, based upon the time it took the Egin Bench water to reach Mud Lake, Idaho. 1 /

1 / U.S.G.S. Water Supply Paper 818, page 4.

Earthquake hazards.- No faults break the surface rocks at the site but the mountains nearby are crossed with numerous faults, most of which are very ancient geologically. However, Idaho has had 15 earthquakes between 1852 and 1945. None were strong enough to cause anything but minor damage to buildings. Four had their epicenters about 100 miles southeast of the site and three had their epicenters about 100 miles west of the site. The other 8 were farther away. They were all weak quakes with a force of 4 to 5 on the Rossi-Forel scale. Movable objects at the site would probably have been disturbed by some of these quakes, but the earthquake hazard in this region is not considered great. Precautions against small disturbances should be taken in the installation of fragile equipment.

Harold T. Stearns, Consulting Geologist
Hope, Idaho.

Reference list:

Stearns, H. T. and Bryan, L.L., Preliminary report on the geology and water resources of the Mud Lake Basin, Idaho; U.S.G.S. Water-Supply Paper 560D-pp 87-132, 1925.

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H. T. Stearns and Bryan, L. L. and Crandall, Lynn; Geology and ground-water resources of the Mud Lake region, Idaho, including the Island Park area; U.S.G.S. Water-Supply Paper 818, 124 pp. 1939.

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CONSULTANT'S PRELIMINARY REPORT

COMPARISON OF THE POCATELLO AND FORT PECK SITES

By Harold T. Stearns, Consulting Geologist
Hope, Idaho

Comparison of The Two Sites

U.S. Navy Proving Grounds Idaho	Fort Peck Area, Montana
1. Aggregate (See tests at conclusion of comparison) Pit run gravel in unlimited quantity on the site and in adjacent valleys. No processing plant in the area. Used for constructing heavy concrete structures by the U.S. Navy.	1. Aggregate Nearest gravel in quantity at Great Northern RR. pit at Cole on a spur line from Saco, about 70 miles NW of Fort Peck. Was used to construct Fort Peck dam. No plant at Cole now.
2. Rock Unlimited quantities available on the site.	2. Rock Nearest rock supply at quarry near Harlem, Montana about 150 miles from Fort Peck.
3. Foundations Basalt on the site at depths of 0 to 25 feet	3. Foundations Shale at site full of numerous small faults which

will make excellent foundation for the heaviest structures planned.

3A. Altitude - Average 4930 feet.

4. Soil cover

Wind blown and stream-deposited silts and gravels ranging from 0 to 25 feet over most of the area. In the "sinks" the depth of silt is several hundred feet. Sand dunes in places 1/2 to 3 feet high in long strips oriented in the direction of the prevailing wind.

5. Vegetation

Sagebrush and rabbit brush with greasewood near the "sinks". Considerable grass in places.

move when heavily loaded. The shale contains bentonite which swells and "slakes" when wet.

3A. Altitude - Average 2575 feet.

4. Soil cover

In Willow Creek Valley the soil cover is transported bentonitic clay (gumbo) from 1 to 20± feet deep. Adjacent to the valley, bentonitic residual clay from 0 to 10 feet thick and sandy textured soil on the hills between Willow Creek Valley and the reservoir.

5. Vegetation

Dwarfed brush and a little grass sparsely distributed between bare spots. A few willows along the Creek and scrub pines near the reservoir.

6. Soil

Fertile soil in which most plants living at this altitude will grow if provided with adequate water and given wind protection.

7. Prevailing winds from the SW. Strongest during the spring months Dust storms not infrequent. Hurricanes unknown. All laboratories, etc. where dust is injurious should have no windows and be air conditioned. Persons living in this part of Idaho are used to the wind but outsiders frequently leave jobs because of the wind.

8. Sunlight abundant and the climate healthy.

6. Soil

Strongly alkaline in the lowlands but produces wheat in the uplands north of Willow Creek.

7. Prevailing winds reported from the NW. Drefts of snow indicate strong velocities at times. No drefting sand because of absence of this material in most of the area.

8. Not familiar with the climate at this site. Probably

Respiratory diseases reported to be low. Temperatures low in the winter but the low precipitation ranging from about 4 to 12 inches annually makes the cold endurable.

9. Climate - Semi-arid

Rainfall scarce, most of the precipitation falling as snow.

10. Thunderstorms

Local thunderstorms occur during hot months.

11. Accessibility

Railroad and paved highway at the site.

12. Terrane

Relief rarely more than 5 feet. Essentially a flat plain. No gullying except in channel of Lost River.

lower temperatures than at the other site. See U.S. Weather Bureau Reports.

9. Climate - Semi-arid

No personal experience.

10. Thunderstorms

No personal experience.

11. Accessibility

Railroad and paved road close to site.

12. Terrane

Relief is that of a broad open valley with Willow Creek incised in its flood plain 5 to 10 feet. Numerous small gullies. Hills about 200 feet high separating the reservoir from

	Willow Creek Valley.
13. Flood possibilities No floods possible at the site but the "sinks" to the north are covered with several feet of water during wet years.	13. Flood possibilities Evidence of water over the lowlands of Willow Creek Valley.
14. Road Metal Gravel available at the site. Cinders available in nearby Cones for secondary roads.	14. Road Metal Poorly assorted gravel available at Glasgow. Some clinker available from burned lignite beds.
15. Concrete blocks Lava cinders available nearby for making lightweight concrete and nailable concrete building blocks.	15. Concrete blocks Clinker deposits or "scoria" that has resulted from prehistoric burned lignite beds about 100 miles southeast.
16. Surface water In Snake River 36 miles away which is at present all appropriated. The Palisade dam which is to be	16. Surface water Available in Fort Peck reservoir nearby. Considerable engineering problem to divert the water because of reservoir

built soon on the South Fork will make water available.	fluctuation of 100 feet.
17. <u>Quality of surface water</u> Variable depending on time of year. Total hardness ranges from about 125 to 180 p.p.m. Boron ranges from 0.01 to 0.08 p.p.m.	17. <u>Quality of surface water</u> Variable depending on time of year and depth of diversion in the reservoir which is stratified chemically. Total hardness ranges from about 150 to 270 p.p.m. Boron was 0.11 p.p.m. in a sample collected from a bleeder equivalent to 50 feet above the bottom of the reservoir.
18. <u>Pumping left for surface water</u>. About 430 feet.	18. <u>Pumping left for surface water</u>. About 350 feet.
19. <u>Ground water</u>	19. <u>Ground water</u>
A. Quantity: Supply large and more than adequate.	A. Quantity: Supply small and inadequate.
B. Aquifer: Fissured basalt	B. Aquifer: Sandstone (Judith R.)

	under the Bearpaw shale.
C. Static level 450 to 500 feet below gr.	C. Static level Wells will flow
D. Rate of movement Average about 1/2 mile per year.	D. Rate of movement Unknown
E. Method for recovery Drilled wells 12 inches or more in diameter and vertical shafts. Percussion or cable tool drilling preferable.	E. Method for recovery Drilled and bored wells. Rotary drilling preferable.
F. Cost $25 to $50 per foot depending on size. Includes casing.	F. Cost Estimated to be $10 to $20 per foot depending on size. Includes casing.
G. Type of pump Deep-well turbine	G. Type of pump Horizontal Centrifugal or deep-well turbine
H. Quality of G.W. Excellent but	H. Quality of G.W. Artesian water not

slightly hard in the basalt. Total solids range from about 200 to about 300 p.p.m. Hardness from 130 to 250 p.p.m. Boron from 0.0 to 0.12 p.p.m.

I. Temperature

$52^{\circ}F \pm 2^{\circ}$

J. Depth necessary

600 to 750 feet.

K. Disposal of waste water

Water could be evaporated in the "sinks" or sunk into the basalts SW. of the site.

potable. Total solids around 2300 p.p.m. Chlorides 345 to 900 p.p.m. Boron 3.9 to 4.65 p.p.m. Soft. Water in the alluvium at Glasgow is hard. Total solids 911 p.p.m., total hardness 387 p.p.m. Boron 0.29 p.p.m.

I. Temperature

48° to $59^{\circ}F$ in deep Artesian wells 48° F $\pm$ $2^{\circ}F$ in shallow wells.

J. Depth necessary

500 $\pm$ feet for Artesian water. 110 feet for water in alluvium at Glasgow.

K. Disposal of waste water

Water would have to be wasted into the Missouri River.

20. Faults	20. Faults
No faults break the surface rocks which are Pleistocene in age.	Numerous small faults cut thru the rocks and these have caused movement of the structures at Fort Peck.
21. Mining	21. Mining
No mines at the site. Mines are numerous 50 miles or more north, NE. and NW. of the site. A few prospect tunnels lie within 15 miles to the north.	No mines at the site and none shown on maps within 50 miles of the area.
22. Value of lands	22. Value of lands
The grazing land was sold by the counties at 10¢ an acre during the late years of the depression. The best grazing land would not bring more than $8 to $10 an acre now Most of it is worth about $1.00 an acre.	Unknown but not large for the grazing land. The dry farm wheat lands are valuable.

The dry farm wheat lands cover a tiny area in the vicinity of the site and rarely mature a crop. Local reports are that they operate to collect benefits under AAA. Farming in the Lost River Valleys to the North is, however, successful.

23. Analysis of rock

Typical basalt (Craters of the Moon)

By U.S.G.S. lab.

SiO_2 = 51.14

Al_2O_3 = 13.95

Fe_2O_3 = 2.15

FeO = 12.97

MgO = 2.21

CaO = 6.56

Na_2O = 3.59

K_2O = 2.33

H_2O+ = 0.22

H_2O- = 0.12

23. Analysis of rock

Not available. Contains abundant bentonite, a clay used for its ability to swell. Also contains abundant gypsum in its seams.

TiO = 2.41

P_2O_5 = 1.59

MnO = 0.44

100.30

ZrO_3 = 0.12

Cl = trace

F = 0.10

FeS_2 = 0.15

NiO = trace

BaO = 0.25

SrO = trace

V_2O_3 = trace

Specific gravity 2.907

24. Seismic activity

Idaho has had 15 earthquakes between 1852 and 1945. None were strong enough to cause serious damage to buildings. Four had their epicenters about 100 miles SE. of the site and 3 lay 100 miles west and northwest of the site. Earthquakes of equal intensity may therefore

24. Seismic activity

Montana has had 28 strong earthquakes between 1852 and 1948. Helena and Butte are chief epicenters where considerable damage to buildings has occurred. Slight damage such as disturbing movable objects may be expected. However, the history of earthquakes in the Western U.S. is short and new epicenters may develop.

be expected at both sites. The hazard at both sites should not be discounted for fragile or easily damaged equipment such as installed in research laboratories.

Aggregate Analysis (Mechanical)
Gravel from pit 1 on U.S. Navy Proving Ground
Made by Idaho Dept. of Public Works

Percent passing by dry weight

Gravel 59%		Sand 41%	
2" sq.	100	No. 4	100
1-1/2"	98	8	81
1"	86	16	70
3/4"	73	30	61
1/2"	49	50	32
3/8"	39	100	5
No. 4	0	FM	2.51
FM	7.0	silt	2.5%
Spec. grav.	2.60	Spec. grav.	2.60
Absorption	1.1	Wt. of Dry Lse.	103.0

% wear 18.50 AASHO grade A

Wt. of Lse. 125

Dominant rock is limestone with lesser amounts of quartz diorite, basalt, andesite porphyry, and chert.

Aggregate Mechanical Analysis

Gravel from pit 2

Gravel 62%		Sand 38%	
2-1/2" sq.	100	No. 4	100
2"	97	8	80
1-1/2"	87	16	66
1"	70	30	49
3/4"	59	50	18
1/2"	42	100	4
3/8"	27	FM	2.83
No. 4	0	Silt	2.8%
FM	7.27	Spec. grav.	2.58
Spec. grav.	2.62	Wt. dry Lse	103.0
Absorption	1.1		
% wear	19.5 AASHO grade A		
Wt. of dry Lse.	123.8		

SOCIAL AND ECONOMIC CHARACTERISTICS

of the

FORT PECK, MONTANA, AND POCATELLO, IDAHO, SITES

by

GEORGE SUMMERFIELD
Consultant

Detroit, Michigan
February 1, 1949

PHYSICAL AND SAFETY CHARACTERISTICS

FORT PECK SITE

ISOLATION

POPULATION DISTRIBUTION AND INDUSTRIAL ACTIVITY

14-Mile Radius: Approximately 30 people live within the 14-mile radius on this site, scattered throughout the area. No industrial activity exists in this area.

50-Mile Radius: Approximately 25,000 people live in this area in which there are no industrial plants employing in excess of 25 people with the exception of the Fort Peck project. Glasgow, the largest town in the area, has 6 industrial establishments employing a total of 78 persons, among which are 2 machine shops, a broom factory and tin shop.

Other towns in this area are: Frazer with 300 people, Nashua with 1,000, Hinsdale with 325, Saco with 452, and Jordan with 677 population.

Other than the noted exceptions employment is confined to farming, livestock raising, and retail and similar pursuits.

100-Mile Radius: Approximately 34,000 people live in the area between the 50 and 100-mile radii. Labor employed in this area approximate 12,000 in number of whom about 9,000 were employed in industry.

No industries employing more than 25 people were discovered in this area which has only 5 towns of over 300 population; Opheim with 300, Scobey with 1,300, Wolf Point with 1,900 and Malta with 2,215. The primary activities in this area are farming and livestock raising and employment is of a seasonal nature.

200-Mile Radius: Approximately 140,000 people live in the area between the 100 and 200-mile radii. All employed labor in this area totaled 51,000 of whom about 25,000 were employed in North Dakota.

Industrially Miles City has a C.M. St. Paul R.R. machine shop, 2 saddleries, a dairy products company and a construction company. Lewistown has 2 flour mills, a U.S. Gypsum plant, a lumber mill, a cement company, and oil, coal, copper, gold and silver production. Havre has a Great Northern R.R. shop, oil and gasoline and is the headquarters of a merchandising chain. Great Falls has Anaconda Copper Company, Great Falls Iron Works, oil and refining company, Great Northern R.R. shops, General Mills, a meat packing plant and a dairy products plant. Billings has 3 refineries, 2 meat packing plants, Eaton Metal Products Company, a tool and supply company and a canning company. Williston, North Dakota has Great Northern R.R. shops, coal mines and dairy product plants.

SUMMARY

There is no concentration of cities or great population concentration anywhere within the 200-mile radius, no industries of size are closer to the site than 150 miles and such industries as there are within the area are almost wholly connected with the products of farms or mines.

ADMINISTRATIVE AND OTHER CHARACTERISTICS

FORT PECK SITE

POPULATION AND SOCIAL-ECONOMIC FACTORS

PROXIMITY TO COMMUNITIES WITHIN 100 MILES

Accessibility To Wholesale Centers:

The site is accessible to the secondary wholesale centers of Havre, approximately 170 miles and Great Falls, approximately 280 miles, Billings and Helena, both approximately 370 miles. The most accessible primary wholesale center is Minneapolis-St. Paul, approximately 525 miles distant.

Communities:

All of the area covered by a 14-mile radius on this site lies within Valley County, which in an area of 5,072 square miles has a population of about 15,600 some 9,000 of whom live in the towns of Fort Peck and Glasgow, 1,000 in Nashua and the remainder are scattered on farms, ranches and in small towns throughout the remainder of the county. About 1,290 ranch and farm operators live in Valley County. Of the approximately 12 dwelling units in the site area four are either unoccupied or occupied only on a seasonal basis. It is believed that not more than 30 persons reside permanently within the site area.

Urban population centers in Glasgow with a population of 5,000, Fort Peck (an Army installation) with 4,000 people and Nashua with 1,000.

TOWNS OF 300 OR MORE POPULATION WITHIN THE 50-MILE AREA

Glasgow	5,000
Fort Peck	4,000
Nashau	950
Hinsdale	450
Frazer	500
Jordan	500
Saco	452

CITIES OF 1,000 OR MORE POPULATION WITHIN THE 50- TO 100-MILE AREA

Scobey	1,311
Wolf Point	1,960
Poplar	1,442
Malta	2,215

CITIES OVER 1,000 POPULATION IN THE 100- TO 200-MILE AREA

MONTANA

Plentywood	1,574	Roundup	2,644
Sidney	2,978	Big Timber	1,533
Glendive	4,524	Harlowtown	1,547
Terry	1,012	Lewistown	5,874
Baker	1,304	Great Falls	29,928
Miles City	7,313	Fort Benton	1,227
Forsyth	1,696	Havre	10,000
Hardin	1,800	Chinook	2,051
Billings	23,261	Harlem	1,166
Laurel	2,754	Black Eagle	1,000

NORTH DAKOTA

Williston	5,790	Crosby	1,300
Kenmare	1,500	Beach	1,300

Family Income: Net buying income per family in 1947 averaged $4,644.

Farm Income: Farm income in 1945 totaled $1,186,347 or an average per farm of $4,784.

Labor: The total labor estimated for Valley County, except farm, for 1948 was 4,300. Construction 750. Wholesale and retail 730.

Expandable Living Facilities:

Within the area covered by a 14-mile radius there are no expandable living facilities even though such close proximity of residences be desirable. Other than the development a complete new residential and shopping center the assimilation of new construction and operating personnel must fall upon the towns of Glasgow, Nashua and Fort Peck. Equal distribution of a new population on the order of 25,000 persons among the three towns would result in at least a doubling of the present population with a resultant economic pressure upon the native population as well as upon the newcomers which must result in an excess charge agains the construction and operating cost of the project.

GLASGOW: Approximately 10 miles from the 14-mile area is a town of 5,000 and has:

Housing: Glasgow district 1,694 units, 6 hotels with 215 rooms, 70 tourist cabins.

Water: Municipal system from wells supply 760 units. Storage and pumping would need to be enlarged for any additional load.

Sewers: Municipal system covering same area as water, no treatment, discharges to Milk River. Heavy rains cause backing up.

Schools: 1 junior high, 1 high school. Combined enrollment 456. 2 grade schools, enrollment 568.

Recreational Facilities: 2 theatres seating 800. Municipal Golf Course, Skeet Shooting Club, Swimming pool, Bowling alley, Tennis courts, auditorium and municipal park and playground.

Medical & Hospital Facilities: Deaconess Hospital, 60 beds, 2 clinics and hospital for aged. 3 medical doctors and 3 dentists.

Religious Facilities: Baptist, Congregational, Christian Science, Lutheran, Nazarene, Catholic, Christian, Methodist, Episcopal and Glasgow Tabernacle churches have their own buildings in Glasgow.

Stores: 128 retail stores, 12 grocery, 6 beauty shops, 3 drug, 12 automotive, 14 filling stations, 5 lumber and hardware. 16 wholesale establishments.

Industries: 6 employing 78 persons, 2 machine shops, 1 broom factory, and 1 tin shop.

NASHUA: Approximately 14 miles from the 14-mile area has 1,000 people and has:

Housing: 438 units.

Water: None

Sewers: None

Recreational Facilities: One theatre seating 288.

Religious Facilities: Catholic

Schools: 1 high school and 1 eight grade school.

Stores: 3 groceries, 4 filling stations, 1 drug and 3 lumber and hardware.

FORT PECK: A military establishment nearly contiguous to the 14-mile area has a population of 4,000. Presently a construction program extending sewers, water and roads is underway. Much of the housing in the area is of temporary character, upon which modernization work is now being done. Because of the nature of this town it is not believed that any substantial population increase can or should be added.

Of the remaining towns in the 200-mile area only 5 are within a 100 miles. Five more are near the 100-mile circle and the remaining eleven are from 150 to 200 miles distant.

MALTA: Is in Phillips County and has an estimated population of 2,215. There are 17 small industries in Malta; 7 food products companies, 3 seed and nursery, 3 sheet metal and machine shops, 2 gold mining companies, a sign company and an angora wool products plants.

Schools: A 1-8 grade school with 12 teachers and 448 pupils and an 8-12 grade school with 15 teachers and 187 pupils.

Medical: There are no hospital facilities in Malta.

Churches: There is a Catholic mission, Methodist, and an Epissopal church.

Recreation: The Palace Theatre seats 265 people.

WOLF POINT: Is in Roosevelt County and is about 60 miles distant. A town of about 2,000 people, there are six small industries consisting of 3 food producers, a machine shop, a concrete products plant and an insulation manufacturer.

Schools: The grade school in Wolf Point has 22 teachers and 566 pupils. The high school employs 14 teachers for 206 pupils.

Medical: A Lutheran Hospital with 18 beds is located here.

Churches: There is a Catholic, Lutheran, and Methodist church.

SIDNEY: Is a village of 2,900 in Richland County and has 11 food industries including a meat packing plant and a sugar mill, 3 machine shops, a sheet metal works, 2 feed producers, greenhouse and a fur company. There are no medical facilities.

Churches: Two churches are listed for Sidney.

Schools: The 1-12 grade schools employ 40 teachers for 1,046 students.

Recreation : 2 theatres with 378 and 238 seats.

HARLEM: Is in Blaine County, has a population of 1,166, and has 14 listed industries. A pump manufacturing plant, farm machinery, cabinet, canvas and leather, feed processor, a seed company and a small jewelry shop compose the industrial total. There is a gold mine, a coal mine, a natural gas plant and a rock quarry, 3 food producing companies complete the list for Harlem.

Medical: The Fort Belknap Indian Hospital has 47 beds.

Churches: There are four churches in Harlem.

Schools: The elementary school has 13 teachers and 389 students. The high school has 7 teachers and 127 students.

Recreation: The Grand Theatre has a seating capacity of 280.

CHINOOK: Is also in Blaine County and has 2,051 people. There are 13 food producing plants, including a sugar mill and a flour mill, 3 coal mining companies, an oil refinery, a sheet metal shop, and 1 feed producer and 1 seed grower.

Schools: The 1-8 grade school employs 18 teachers for 454 pupils and the 8-12 grade school 10 teachers for 247 pupils.

Medical: There are no hospital facilities in Chinook.

Churches: One church is listed for Chinook but it is safe to estimate that there are more.

Recreation: The 3 theatres are of 200, 220, and 486 seating capacity.

FORT BENTON: Is in Choteau County, is a village of 1,227 people and has no listed industry. There is one Episcopal church. The St. Clare Hospital with 40 beds and the Capital Theatre, 266 seats. The schools employ 18 teachers for 383 students 1-12 grades.

HAVRE: Is in Hill County and has a population of 10,000. The industries include 12 food and beverage companies, 2 greenhouses, a feed producer, brick yard, leather manufacturer, and a hatchery. Also the N.P. R.R. shops. There are 156 stores and 11 wholesale outlets.

Medical: The two hospitals in Havre are Sacred Heart with 125 beds and Kennedy Hospital with 60.

Schools: The elementary school has 40 teachers and 953 students and the high school has 21 teachers and 475 students. There is also a Catholic school. The Northern Montana College enrollment 400.

Churches: Churches include Catholic, Lutheran, Baptist, Christian and Methodist.

Recreation: There are two theatres with a combined seating of 1,014.

PLENTYWOOD: Is in Sheridan County and has about 1,500 people. There are no listed industries. Sheridan Memorial Hospital with 18 beds is located in Plentywood. There are four churches, no theatres and the 1-12 grade schools employ 18 teachers for the 449 students.

OPHEIM: Is in Valley County and has only 344 people. There is no listed industry, no hospital, and the only theatre is closed. The grade school has 4 teachers and 87 pupils and the high school, 5 teachers and 64 pupils.

POPLAR: Is a village of 1,442 in Roosevelt County and about 75 miles away. It has 5 food industries, a wood working shop, 2 machine shops and a printing office. The Fort Peck Indian Hospital is located here. The two schools employ 24 teachers for 351 elementary and 39 high school pupils. There are two churches in Poplar and the Fort Theatre seats 300.

SCOBEY: Is in Daniels County and has a population of 1,300. The two industries are a bakery and a flour mill.

Schools: The 1-8 grade school has 9 teachers and 320 pupils and the high school has 9 teachers and 150 pupils.

Churches: There is a Methodist and an Episcopal church in Scobey.

Medical: There are no medical facilities.

Recreation: The Rex Theatre has a seating capacity of 350.

ROUNDUP: Has 2,644 population and is located in Musselshell county just over the hundred mile radius. Nine food processing plants, 8 coal mining companies, a concrete products company, greenhouse, and a tin smith.

Schools: The 1-12 grade schools have 24 teachers and 478 students. Also a Catholic school.

Churches: Catholic, Baptist, Episcopal, Lutheran, Methodist.

Recreation: American Theatre with 450 seats.

GLENDIVE: Is a Dawson County town of 4,524 population. The major industries are food processing plants including 2 bakeries, 6 dairy products, 2 flour mills, a commercial freezing plant and an ice manufacturing plant, five ice cream companies and three meat packing concerns. There are two honey processors, 11 livestock growers, and a bottling works, a mining company, a sign company, seed producer and a lapidary complete the industries.

Schools: 1-8 grade school has 30 teachers and 714 students. The Dawson County High School has 18 teachers and 370 students.

Medical: The Glendive General Hospital has 30 beds and the North Pacific which is run by the railroad has 57 beds.

Churches: A Catholic Mission and 3 Protestant churches are in Glendive.

Recreation: The two theatres in Glendive have a total seating capacity of 902.

TERRY: Is a small village of 1,000 in Prairie County and has 3 food product plants, a small iron works, a machine shop, 3 lignite coal mining companies, a feed manufacturing plant, 2 agate souvenir manufacturing plants and a body repair shop.

Schools: The 1-12 grade schools have 16 teachers and 339 students.

Medical: Lutheran Good Samaritan Hospital has 15 beds.

Churches: There are two Protestant churches in Terry.

Recreation: Rialto Theatre has 290 seats.

HARDIN: Is in Big Horn County and has 1,800 people. Seven food processing plants, including a sugar mill, 3 food producers, a greenhouse, cement block company, and a heating and cooking gas manufacturing concern are located in Hardin.

Schools: The elementary school has 36 teachers and 946 pupils and the high school has 15 teachers and 252 pupils. There is a Catholic School.

Churches: The Lutheran, Episcopal, Catholic, Baptist and Methodist Churches have buildings in or close to Hardin.

Medical: The Big Horn Community Hospital has 24 beds.

Recreation: The Harriet Theatre has a seating capacity of 450.

LAUREL: Has a population of 2,700. It is in Yellowstone County, almost 200 miles from Fort Peck. The chief industries are an oil refinery and a dairy.

Schools: The 1-12 grade schools employ 36 teachers for 1,031 students.

Churches: There is an Episcopal and Catholic church.

Medical: Laurel has no hospital facilities.

Recreation: The Royal Theatre has 400 seats.

BAKER: Is in Fallon County and is about 190 miles from the site. The population of Baker is 1,300. Except for 2 tin smith shops and a manufacturer of oxygen and carbonic gas, the industries are food and dairy products. There are no hospital facilities in Baker and only one church is listed. The schools have 21 teachers for 401 pupils and the Lake Theatre has a seating capacity of 300.

BILLINGS: Is one of the two cities of any size in the entire area and is in Yellowstone County, nearly 200 miles from Fort Peck. It is listed second to Great Falls as the trading area for that site. There are 493 stores and 99 wholesale outlets with a total retail sales figure of $23,220,000 for 1948. The industries include a furniture manufacturer, 7 iron and steel product plants, 5 machine shops, 2 mill work industries, 2 leather products companies, 2 mattress manufacturers, 3 trailer companies, 2 oil refineries, 3 sheet metal, 2 sign manufacturers, a soap company, a flour mill, a sugar mill, an insulation manufacturer, 3 fur processors, 3 greenhouses, 1 clothing company, 7 printers, 2 souvenir products companies, a mining company and 5 ice cream producers.

Schools: The schools employ 219 teachers for 5,913 pupils. There is a Catholic school and two colleges, Rocky Mountain and Eastern Montana State Normal.

Medical: There are two hospitals with 78 and 185 beds. There are about 16 doctors in Billings.

Churches: Churches of 19 denominations have buildings in Billings.

Recreation: Four theatres operate with over 1,500 seats.

The other trading area in the 200 miles is Great Falls, in Cascade County. Glasgow is listed as a part of this area.

GREAT FALLS: Has a population of 44,000 according to the latest estimate. The trading area population is 166,786 and includes Havre, Lewiston, Cut Bank, Glasgow, Shelby, Chinook, Malta, and Wolf Point. There are a total of 574 retail stores and 85 wholesale outlets with a sales total of $61,276,000 for 1948. The industries include 9 bakeries, 4 bottling works, 13 dairies, 4 candy manufacturers, a flour mill, turkey processing plant, 2 feed companies, 2 mattress manufacturers, 4 dental supply houses, an oil refinery, a cabinet shop, 5 mill work plants, 3 tin shops, 2 machine shops, 2 canvas products companies and the R.R. shops of the Great Northern Railroad.

Schools: The elementary schools employ 165 teachers for 4,547 pupils. The high schools employ 60 teachers for 1,555 pupils. There are 5 Catholic schools and two colleges, College of Great Falls and the State College for the Deaf and Blind.

Medical: There are 2 hospitals with 235 and 200 beds.

Churches: 20 denominations including 5 Catholic churches.

Recreation: Four theatres in Great Falls, 2 seat 1,500-2,000 and 2 seat 700 to 1,000.

MILES CITY: Is in Custer County and has a population of 7,313. The industrial plants consist of 16 food companies, 2 greenhouses, a mill work shop, 2 sheet metal works, 2 hatcheries, a mattress manufacturing company, a cabinet shop, sign company and a canvas products plant. There are also a jewelry manufacturer, a leather goods producer and the R.R. shops of the St. Paul & Pacific R.R. There are 148 stores and two wholesale houses.

Schools: The elementary school employs 39 teachers for 951 students. The high school (Custer County) has 29 teachers for 485 students. There is a Catholic School and the Custer County Jr. College.

Medical: Miles City Hospital (Holy Rosary) 135 beds.

Churches: Methodist, 7th Day Adventist, Baptists, Lutheran, Episcopal, Catholic, L.D.S., and Presbyterian.

Recreation: 3 theatres with a total of 1,491 seats.

FORSYTH: Is a village in Rosebud County, has 1,600 people and has 6 food producing plants, a feed manufacturer, coal mining company, tin shop, and a plant for processing building logs.

Medical: Rosebud Community Hospital with 26 beds.

Church: There are two Protestant churches in Forsyth.

Schools: The schools 1-12 grades employ 21 teachers for 432 pupils.

Recreation: Roxy Theatre seats 500 persons.

CULTURAL QUALITIES OF THE AREA

50-MILE RADIUS FORT PECK SITE

COUNTY	POPULATION	LABOR TOT. 1948 FORCE (a)	CONSTRUCTION 1948	HOUSING UNITS
Valley	15,000	4,571	736	5,094
Garfield	2,100	901	21	891
Phillips	7,892	2,574	87	2,657
Total	24,992	8,046	844	8,642

(a) This includes self-employed, farm labor and all classes.

Schools: Total 18 public schools, 9 are 12 grade schools.

There are 146 teachers and 2,278 elementary and 943 high school pupils. Also 3 Catholic schools.

Medical & Hospital: There are two hospitals in the area and two more at short distance. There is one resident doctor for every 1,500-3,000 people (AMA)

Churches: There are about 41 churches of almost all sects, including 7 Catholic churches or missions, 22 churches are in Glasgow--Methodist, Lutheran, Baptist, Episcopal, Latter-day Saints, Christian, and Seventh Day Adventists also have one or more in the area.

Theatres: There are 7 theatres in the area--total seating capacity 2,675.

RETAIL TRADE AND FARM INCOME 1945 - 1946

County	Stores	SALES Add 000	FARM INCOME	AVERAGE PER FARM
Valley	276	$13,726	$8,420,465	$7,393
Garfield	37	843	2,674,356	5,491
Phillips	114	5,774	4,790,462	5,184
	427	$20,343	$15,885,283	

SUMMARY

Housing is in short supply in the area, there having been little new construction in the past ten years. Schools are carrying almost the maximum load, requiring new facilities to serve any sizable new student body.

Both doctors and hospitals are overburdened in the area and incapable of caring for any new load. There are enough churches in the area to provide a nucleus around which could be built required additional facilities.

There are almost no recreational facilities in the area except of an outdoor character necessitating the provision of a full range of facilities.

AVAILABILITY OF LAND

Existing Installations:

Within the site area no private installations of any kind exist other than a dozen or so dwelling units. A primitive dirt road crosses the southeastern portion of the site leading to Fort Peck and two others enter the area, one in the north quadrant and one in the southwest quadrant.

Land Ownership Characteristics:

Within the 14-mile radius approximately 90% of the land is publicly owned, that which is privately held is of poor character good only for upland summer grazing and worth an average value of $2.75 per acre.

No difficulty is foreseeable in the initial acquisition of the site; however, some disadvantage attaches to the site by reason of planned irrigation in the area for which preliminary work has been started. The irrigation of the Glasgow Bench area will affect nearly 60,000 acres of land that lies well within the 50-mile radius. It is estimated that this project when completed will bring an additional 700 farm families into the area.

AVAILABILITY OF MANPOWER AND MATERIALS

MANPOWER

Within the area covered by the 200-mile radius a total of 3,636 construction workers were resident employees in 1948. For the entire State of Montana a total of about 10,500 were employed in construction with such labor being in short supply. No easing of demand for this labor is seen since projects under construction will demand this number or more for the next year or two. The Hungry Horse Dam project alone will require 4,000 workers shortly after the opening of the construction season.

Of the total of 71,284 employed labor force it is estimated that 9,000 may be classified as operatives, a figure 5% below the national average and reflecting the lack of industrialization of the area. It is estimated that less than 7,000 may be classed as craftsmen, almost 3% below the national average. Because of this condition some difficulty may be expected in the recruitment of reasonably qualified labor within the area.

OPERATIONAL COSTS

There is no appreciable difference in the operating wage scale between the two sites, the proximity of the two states having resulted in a considerable interchange of labor especially among those workers who are seasonally employed, who constitute about one quarter of the labor force.

ECONOMIC ADVANTAGE OR DISADVANTAGE ACCRUING TO EITHER SITE BY REASON OF AREA-LOGICAL FACTORS

Any project with isolation requirements such as presented by the subject project must bear an excess cost burden that would not be present if the isolation requirements were removed. Not only are excess costs suffered in acquiring and transporting materials to the site, but a burden of direct or indirect excess cost on behalf of the constructing and operating labor for the project results.

Extreme housing shortage results in higher rental or purchase charges while the same conditions that cause the housing shortage are creating a demand market for foodstuffs and the other necessaries.

The rapid accrual of 25,000 additional persons in an area where not more than 10,000 had resided previously cannot but set up a competitive price condition, especially in view of the still generally short supply of goods and the difficulty of obtaining increases in either wholesale or retail allotments. Such a condition would prevail at the Fort Peck Site where access to either wholesale or retail markets is not of the best.

At the Pocatello Site a concentration of cities and towns along the American Falls Reservoir and the Snake River provides a housing and population concentration which, within a radius of about 55 miles from the site, amounts to about 125,000 persons. Obviously the assimilation of 25,000 additional people into this area is capable of accomplishment with far less economic dislocation than would be the case at Fort Peck, especially in view of the far better wholesale and retail market access. It is expected that from this area a considerable number of workers could be drawn, diminishing the problem by that number.

A directly comparable situation existed and to the same degree in the area around the Hanford works, where in less than two years time something on the order of a 600% population increase was added to towns developed by the project owners, with controlled rentals. Still within the area the cost of living rose 20%, a rise that was reflected in direct wage cost to the owners or in indirect cost through the turnover of personnel. Such experience is not uncommon and it is believed that at least a 10% construction and operating cost penalty would be incurred with the selection of the Fort Peck Site.

PHYSICAL AND SAFETY CHARACTERISTICS

POCATELLO SITE

ISOLATION

POPULATION DISTRIBUTION AND INDUSTRIAL ACTIVITY

14-Mile Radius: Approximately 110 people live within the 14-mile radius, none of whom are closer than 10 miles from the center. No industrial activity exists in this area.

50-Mile Radius: Approximately 68,000 people live in this area in which there are no plants employing more than 500 people, only two employing more than 250 people, and only 36 that employ from 25 to 250 people of which 9 are seasonal in operation. The majority of these plants are 30 miles or more from the site and are mostly feed processing plants subject to seasonal fluctuation, even those 2 employing over 250 persons both of which are sugar plants.

100-Mile Radius: Approximately 111,000 people live in the area between the 50 and 100-mile radii. All labor employed in this area in 1948 totaled 14,381 persons of whom 1,996 were engaged in manufacturing. At Pocatello there are 20 industrial plants employing 25 or more persons including 7 which employ more than 100 persons and which are; the Wasatch Oil Co., Simplet Fertilizer Co., a Portland Cement plant, Union Pacific R.R., Kraft Cheese Co., Naval Ordnance Plant, and Idaho Creameries. At American Falls the Idaho Power Co. employs over 25 people and in Jerome a wood products company employs over 25 people, Idaho Products with over 50, Cinder Products Co., over 50, and a seed company employs over 100. At Hailey the Triumph Mine employs over 250 persons and Burley-Rupert has 2 brick and sand companies, 2 dairy products companies, a sugar factory, an alfalfa mill, and large wheat and potato flour mills, St. Anthony has 3 seed companies employing over 50 persons each, a flour mill employing nearly 100, 2 lumber mills each employing nearly 100, a starch factory with over 100 people, and 4 potato growers and producers each employing from 250 to 600 people and 2 lumber mills employing over 50 people each. At Rexburg there are two lumber mills with over 50 employees each and two large creameries. Twin Falls has a sugar mill employing 400 people, 5 seed companies, a turkey hatchery with

120 employees, a farm equipment manufacturer, 1 flour and 1 starch mill, a trailer manufacturer and 3 leather good manufacturers.

200-Mile Radius: Approximately 815,000 persons live in the area between the 100 and 200-mile radii. All employed labor in this area in 1948 totaled 211, 975 persons of whom 5,087 were employed in manufacturing in Idaho. These figures of employment do not include that portion of the area lying outside of the State of Idaho. The total of employed persons in the area outside of Idaho for 1946 was 104,989 employed in industry including 55,154 employed persons in Salt Lake County. The total employment in manufacturing and industry for this area, exclusive of Salt Lake, was 54,192. Exclusive of the Salt Lake area, which lies just outside of the 200-mile radius, no heavy concentration of industry may be found in the area, industry being largely confined to feed and meat processing and packing and lumber products.

Boise has 6 steel fabricating and manufacturing companies, 5 concrete and brick plants, 2 lumber products, 1 flour mill, 5 meat packing, and 4 machine shops. Buhl has 1 planing mill employing over 25 people, 1 machine shop, and 1 food processing plant with 300 employees. Caldwell has 2 machine shops, 2 bakeries, 7 seed companies, and 1 bait manufacturing company. Cascade has 1 lumber mill and a mine, each employing over 250 people. Council has 2 lumber mills with over 100 employees each and Emmett has 1 lumber mill employing 500 people and a toy factory with 100. Nampa has a sugar mill, 6 seed companies, 2 machine shops, 7 meat and poultry processing plants, 3 dairy products, and a U.P.R.R. shop. Payette has 5 fruit and vegetable processing plants employing nearly 4,000 people seasonally and 3 lumber mills with over 25 people each. Wendell has 4 food processing plants employing a total of 120 people, 6 hydroelectric plants in and nearby, 2 fertilizer plants and 2 manufacturing plants employing over 25 people each. Weiser has an iron works employing 50 persons and a flour mill.

Butte, Montana has Anaconda Copper Co., Sullivan Valve Co., Western Boiler Works, Domestic Manganese Co., North Butte Mining, and a meat packing plant. Bozeman, Montana industry is confined to food processing plants.

In Ogden, Utah, there are 4 permanent war plants, knitting mills, canning plants, an iron works, stoker manufacturer, auto body plant, and a sugar plant. Logan, Utah has three milk processing plants, 4 knitting mills, 3 clothing manufacturers, farm wagon plants, sugar mills, and milk processing plants.

SUMMARY

Other than in the area along the American Falls

Reservoir extending from Burley-Rupert to St. Anthony, there is no concentration of cities or heavy industrialization within the area. Most numerous and employing the greatest number of people are those industries related to farm production, fruit, vegetable, meat and dairy processing and sugar beet processing. Lumber products, mining, and seed production provide most of the rest of industrial employment, with mass fabricating or manufacturing almost nonexistent throughout the entire area.

ADMINISTRATIVE AND OTHER CHARACTERISTICS

POCATELLO SITE

POPULATION AND SOCIAL-ECONOMIC FACTORS

PROXIMITY TO COMMUNITIES WITHIN 100 MILES

The site at a distance of approximately 22 miles from Arco, 55 miles from Pocatello, 45 miles from Blackfoot, and 50 miles from Idaho Falls is well within easy access to the centers of population and shopping centers that lie along the Snake River and American Falls Reservoir Banks extending from Burley-Rupert on the south to Rexburg and St. Anthony on the north.

Accessibility To Wholesale Centers:

The site is accessible to the secondary wholesale centers represented by Pocatello, Twin Falls, Idaho Falls, Burley-Rupert, and within 200 miles of the primary wholesale markets of Salt Lake City and Boise-Caldwell, both of which are major wholesale distribution points for the several surrounding states.

Communities:

Within the area covered by a 14-mile radius on this site lie portions of Butte, Bingham and Jefferson Counties. Less than 10% of the area covered lies in Bingham and Jefferson Counties which in the areas included possess no population or dwelling units. Butte County in which the remainder of the area falls is sparsely populated, the entire county having only 200 residents, of whom about 100 live in the Howe-Berenice area comprising total dwelling units numbering 78 of which approximately one third are outside of the precise 14-mile radius. Of the dwelling units inside of the area none are closer than ten miles to the center of the site. The majority of the remaining county population is distributed in the area around Arco and Moore (Arco having a population of 548 and Moore approximately 300) and on scattered farms near Martin, Craters of the Moon, and along the edge of the Big Lost River Game Preserve. In the entire county of Butte it is estimated that 600 families occupy the 2,048 square miles of land or 0.3 families per square mile. Farm families in the county number 266.

Family Income: Net buying income per family in 1947 averaged $2,444 to provide a level of living index of 126.

Farm Income: Farm income for 1946 totaled $1,364,178 or an average of $5,207 per farm.

Labor: The total labor shown for the Butte County area, except farm for the first quarter of 1948, was 77. Mining was 15, manufacturing 6, transportation and utilities 9, service 7, insurance and real estate 7, and wholesale and retail trade was 33.

Expandable Living Facilities:

Within the area covered by a 14-mile radius there are no living facilities capable of economic expansion should such close proximity of residences be desirable. It is believed that economical assimilation of both construction and operating personnel can be had in a natural accrual to the existing population and social structure of these towns which surround the site and which are already equipped with adequate wholesale and retail shopping facilities to care for reasonable population increase without undue economic penalty upon either the native population or upon new arrivals.

TOWNS OVER 300 POPULATION WITHIN
THE 50-MILE AREA

Roberts	319	Arco	548
Menan	432	Moore	300
Lewisville	371	Mackay	776
Rigby	1,978	Idaho Falls	19,000
Ucon	449	Blackfoot	5,500
Iona	518	Aberdeen	1,500
Shelley	1,800	Dubois	332

CITIES WITH 1,000 OR MORE POPULATION WITHIN
THE 50 TO 100-MILE AREA

Rupert	3,167	Shoshone	1,366
Soda Springs	1,087	American Falls	1,439
St. Anthony	2,719	Pocatello	31,000
Ashton	1,203	Alameda	2,691
Burley	6,500	Hailey	1,443
Driggs	1,040	Rexburg	4,200

CITIES WITH 1,000 OR MORE POPULATION WITHIN
THE 100 to 200-MILE AREA

IDAHO

Salmon	2,439	Wendell	1,001
Cascade	1,029	Jerome	7,000
Emmett	4,000	Twin Falls	17,500
Boise	34,300	Filer	1,239
Nampa	16,000	Malad	2,713
Caldwell	13,000	Preston	4,236
Montpelier	2,824	Mountain Home	1,193
Glenns Ferry	1,290	Gooding	2,568
Buhl	3,500	Meridian	1,465

CITIES WITH 1,000 OR MORE POPULATION WITHIN THE 100 to 200-MILE AREA

MONTANA

Anaconda	11,004	Dillon	3,014
Butte	37,081	Bozeman	8,665
Warmsprings	2,100	Deer Lodge	3,278
Walkerville	2,100	Livingston	6,642

UTAH

Brigham	5,641	Lewiston	1,804
Ogden	43,688	Morgan	1,078
Logan	11,868	Providence	1,110
Tremonton	1,443	Hyrum	1,874
Smithfield	2,461	Wellsville	1,402
Richmond	1,131		

WYOMING

Evanston	3,600	Kemmerer	1,900
Cumberland	1,200		

ARCO: Is approximately 9 miles from the 14-mile area, and is a town of 548 people which has: 2 groceries, 1 general merchandise and grocery, 1 dry goods store, 1 shoe store, 1 drug store, 1 lumber yard, 1 bank, 7 auto and gas stations, 1 electric shop, 1 beauty shop, 1 hardware and furniture, 1 bakery, 1 restaurant, and 1 sport shop.

Housing: Approximately 150 nonfarm homes.

Water: Municipal system capable of serving 650 people. Well supply.

Sewers: No sewer system.

Schools: Independent schools. High school, average attendance 75; elementary school, average attendance 166. Two independent schools at Moore--high and elementary, average attendance 140.

Recreation: The Walker Theatre seats 250. Masonic Temple.

Medical: Resident doctor. No hospital.

Religious: Most residents of the area are of the Mormon faith. Catholic residents of Arco attend church at Mackay. 1 Episcopal.

SHELLY: Approximately 25 miles from the 14-mile area, is a town of 1,800 and has:

Housing: 432 units.

Water: Water system servcs 1,800 people. Wells not treated.

Sewers: Municipal system serves 1,800, not treated, discharges into Snake River.

Schools: Joint independent high school and elementary, average attendance 776. Shelly district has 4 small grade schools averaging 18 attendance.

Medical & Hospital Facilities: No registered hospital or doctor.

Recreational Facilities: Virginia Theatre seats 500.

BASALT: Approximately 30 miles from the 14-mile area, is a town of 250 people--has no water or sewer system. Has 1-8 grade school with average attendance of 118.

Medical & Hospital Facilities: None.

Recreation Facilities: None.

IDAHO FALLS: A town in Bonneville County approximately 28 miles from the 14-mile area, has a population of 19,000 people, and has:

Housing: 128 motor court units.

Water: Municipal wells serving 19,000 people, not treated.

Sewers: Municipal system serving 11,000 people, not treated. Discharge into Snake River.

Schools: 1 high school, 6 eight grade schools and 2 one to twelve grade schools, a Catholic school with 154 pupils.

Medical & Hospital Facilities: Latter-day Saint and Sacred Heart Hospitals.

Recreational Facilities: A city zoo, golf course and parks, 4 theatres seating 3,000 people.

Religious Facilities: A Mormon Temple is located here, also Catholic, Lutheran, Methodist, Baptist, Christian, Presbyterian, Christian Science, and Episcopal churches.

Stores: 37 apparel, 21 automotive, 7 drug, 50 eating and drinking, 27 filling stations, 15 furniture, 40 grocery, 14 hardware and lumber.

Wholesale: 5 grocery, 5 meat, and 10 others.

Industries: Idaho Sugar, 2 seed companies, 1 alcohol, 1 packing and 1 concrete products.

TERRETON: A town of 260 people just over 8 miles from the 14-mile area is a farm community having no Municipal water system or sewers. There is a school, 3 stores, a post office, and a portable theatre. There are 160 housing units in the township, of which 139 are farm dwellings.

ABERDEEN: A town of 1,500 people, is approximately 35 miles from the 14-mile area, and has:

Water: Municipal system, wells not treated, serves 1,000 people.

Sewers: Municipal system. Septic tank designed for 445, serves 800 people. Disposal in Jackson Creek.

Schools: Class A high school, 257. Eight grade, 413. Springfield 8 grade, average attendance 76.

Medical & Hospital Facilities: 2 Medical doctors. No hospital.

Recreational Facilities: 2 theatres seats 525.

Religious Facilities: 1 Lutheran, 1 Catholic, 1 Mormon, 1 Christian, and 1 Methodist.

Stores: 2 elevators, 2 hardware, 1 plumbing, 1 pump, 1 farm implement, 8 auto, 3 grocery and general, 1 drug, 1 radio, 2 restaurant, 2 beauty shops, 1 meat market, 1 jewelry, and 1 lumber.

Wholesale: 3 oil and 2 grain elevators.

Industries: Kraft Cheese and 6 potato shippers.

POCATELLO: A city of 31,000 people in Bannock County, is approximately 50 miles from the 14-mile area, and has:

Housing: 5,700 dwelling units, 34 hotels and tourist courts totaling 774 hotel rooms and 236 tourist court units.

Water: Municipal system serving about 5,000 meters, 4 reservoirs storing 15,865,000 gals. Average daily summer consumption 7,500,000 gals. 73 miles of mains. Chlorinated.

Sewers: 33 miles of sewers serving Pocatello, untreated, discharges into Portneuf River.

Schools: Idaho State College (degree granting in Liberal Arts and Pharmacy Schools) enrollment 1,800 students 1948. 1 high school, 1 business college, 1 parochial school, 2 junior high schools, and 12 elementary public schools. 6,400 students in public schools.

Medical & Hospital Facilities: Pocatello General and St.

Anthony's totaling 175 beds. Infirmaries are operated at the Naval Ordnance Plant. U.P. Railroad shops and Idaho State College.

Recreational Facilities: Professional baseball, bowling, golf, (municipal) roller skating, ballroom, boating, and community concert. 7 theatres with total seating of about 5,000. 3 auditoriums with total seating capacity of 6,300.

Religious Facilities: 22 denominations have church facilities in Pocatello.

Stores: 27 apparel, 18 automotive, 8 drug, 64 eating, 7 drinking, 43 filling stations, 18 furniture, 58 grocery, 13 hardware and lumber.

Wholesale: Grocery 3, meat 4, others 47.

Industries: 7 bakeries, 3 beverage, 5 building materials, 11 feed processers, 7 general contractors, 2 optical, 1 fertilizer, 1 chemical, and 1 oil. Simplet Fertilizer has under construction a $6,500,000 new plant.

BLACKFOOT: Is the county seat of Bingham County and is about thirty miles from the 14-mile area. It has an estimated population of 5,500 persons.

Housing: There were 1,181 housing units in 1940. About 150 units have been built since. 500 more are needed at present; however, some of the need would be taken care of if the people working in Pocatello and living in Blackfoot could find housing in Pocatello.

Water and Sewers: The sewage system serves 5,000 people, it is not chemically treated and discharges into the Snake River. The water system serves 5,000 people and the source is deep wells.

Schools: The grade school in Blackfoot has an average attendance of 919 pupils and the grade school in the Blackfoot district 300 pupils. The high school averages 469 attendance. There is also a Catholic school with 145 pupils.

Religious Facilities: There is a Catholic church and 5 Protestant churches.

Recreational Facilities: Three theatres with a combined seating of 1,550 are available.

Stores: There are 39 stores, 9 service establishments, and 30 filling stations, garages, etc. Also 10 wholesale outlets.

Medical & Hospital Facilities: The State Mental Hospital with 750 beds, the Parsons Hospital, and Blackfoot Hospital are in

Blackfoot. There are 12 medical doctors in private practice.

SHOSHONE: Is the county seat of Lincoln County and has an estimated population of 1,366 persons.

Housing: There were 401 housing units and 2 farm housing units included in Shoshone at the last census.

Water & Sewers: There is no sewer system in Shoshone. The water is taken from Little Wood River, chemically treated and approved by the Health Department. The system serves 1,400 persons.

Religious Facilities: Shoshone has one Catholic and three Protestant churches.

Medical & Hospitals Facilities: Four medical doctors are available but there is no hospital.

Schools: Public schools through high school are available.

Recreational Facilities: Shoshone has one theatre, the Rex, seating 500 persons.

HAILEY: Is the county seat of Blaine County and has an estimated 1,500 population. Lead and silver mines are in the area.

Housing: There were 478 units in 1940 and since the population has only increased about 50 persons since there has been little building or need of it.

Schools: The grade school has an average student attendance of 249 and the high school average is 142 students.

Medical & Hospital Facilities: The Hailey Clinical Hospital with 22 beds and two medical doctors are available.

Water & Sewers: There is no sewer system and the water system which serves 1,500 is from wells and springs.

Recreational Facilities: One theatre seating 400 is operating and one seating 300 is closed.

Religious Facilities: There is one Catholic and two Protestant churches in Hailey.

AMERICAN FALLS: Is the county seat of Power County and is a purely agricultural and trading center. The population was 1,439 in 1940 and is estimated at 1,800 to 2,000 in 1948. The town was moved when the reservoir was built.

Housing: There were 460 housing units in 1940 and there has been very little building since. The town is not even under rent control.

Water & Sewers: The water system from wells and springs is not chemically treated and not approved. It serves 1,600 persons. The sewage system serves 1,200 population and is discharged to the Snake River.

Schools: Public schools from 1 to 12 grades are available.

Medical & Hospital Facilities: One twenty-three bed hospital and three medical doctors.

Religious Facilities: One Catholic and four Protestant churches are in American Falls.

Recreational Facilities: The Iris Theatre seats 325. There is also the Trenner Memorial Park with a miniature power plant and other unusual features.

ASHTON: Is a town of 1,203 in Fremont County and is the home of the famous Dog Derby which has been held annually on February 22nd since 1917.

Housing: 314 housing units were available in 1940 and very little building has been done since.

Sewer & Water: The sewage system is the Imhoff tank type designed to serve 900, now serving 1,050. The system discharges into the Henry's Fork of the Snake River. The water system is from wells, chemically treated and approved by the Health Department. It serves 1,200 people.

Schools: Public schools to the eighth grade are available.

Medical & Hospital Facilities: There are two medical doctors but no hospital facilities in Ashton.

Recreational Facilities: The Star Theatre seating 400 persons.

Religious Facilities: There are three Protestant churches in Ashton.

RIGBY: Is the county seat of Jefferson County and has an estimated population of 1978. The Chamber of Commerce estimate is 500 higher. The town was planned and developed by Mormons and is still a predominantly Mormon center.

Sewer & Water: The city water system has three deep wells. There is no chemical treatment of the water and it is approved by the Department of Health. The sewage system is of the Imhoff tank type, discharging into a lagoon. It was designed to serve a 1,590 population.

Housing: There were 529 housing units in 1940, plus 8 farm units included in the town. There has not been much building since, and 50 to 100 units are needed to take care of present needs. There is one hotel.

Medical & Hospital Facilities: There are 5 medical doctors in Rigby but no hospital facilities.

Schools: Public schools through the twelfth grade are available.

Recreational Facilities: There are two theatres in Rigby, the Main seating 500 and the Royal also seating 500.

Religious Facilities: This is a Mormon center.

The following towns are also in Jefferson County:

ROBERTS: Is a village of 319 population, has a water system serving 300, and has no sewage system. There were 204 housing units in the township in 1940, 112 of them farm units.

MENAN: Has a population of 432, and has neither water or sewer system. Of the 257 housing units in the township, 175 are farm units.

LEWISVILLE: Has a population of 371, and also has neither water nor sewer system. There were 216 housing units in Lewisville township in 1940 and 147 of them were farm units. All of these towns have limited shopping facilities, no expandable housing, and have imposed upon them a disadvantage of excess highway distance to the site.

Further out in the 100-mile radius are:

ST. ANTHONY: Is in Fremont County and is a town of 2,800 population. It is an agricultural and food processing center, and there are two large saw mills.

Water & Sewers: A city sewer system serves 1,700 population, drains into the Snake River. The water supply comes from wells and is chlorine treated and approved by the Department of Health. 2,800 persons are supplied with water.

Housing: There were 741 units at the last census and very few have been added since. There are two hotels.

Schools: Public schools through the 12th grade are available.

Medical & Hospital Facilities: Resident doctor. Hospital in nearby Rexburg.

Religious Facilities: Catholic, Episcopal, L.D.S., Methodist, Christian, and Baptist churches are available.

Recreational Facilities: There is no theatre in St. Anthony but Rexburg and Idaho Falls, both short distances, have theatres. Outdoor sports of all kinds are popular in the vicinity.

Schools: Idaho State Industrial School is near the edge of town.

REXBURG: Is in Madison County and has about 3,500 people. It is a Mormon community founded by an early Mormon settler named Ricks, for whom the college is named.

Sewer & Water: Municipal sewer system serves 2,550 population, empties into the Teton River. Water from deep wells is piped to 3,750 people. The source is deep wells and is approved by the State Department of Health.

Housing: There were 894 dwelling units in 1940 and only about 20 have been added since.

Schools: Public schools through the 12th grade are available. Ricks College, L.D.S. 3 year college is there also.

Medical & Hospital Facilities: Rigby Hospital, 2 doctors, and a dentist.

Religious Facilities: A Catholic mission, 2 protestant churches and a Mormon organization.

Recreational Facilities: 2 theatres seating 1,280. City Parks.

WENDELL: Is in Gooding County and has a population of 3,000. There are forty business establishments and a hotel.

Sewers & Water: There is no municipal sewer system. Water is piped to only one third of the residents. The source is wells and it is chlorine treated.

Schools: There are two schools, one to the 12th grade.

Medical & Hospital Facilities: St. Valentine's Hospital, 32 rooms.

Religious Facilities: There are 5 churches of various faiths.

Recreational Facilities: 2 theatres and a city park.

GOODING: Is in Gooding County and is a town of 3,300. It has 22 stores, 26 service businesses and 3 cafes, and a hotel.

Sewer & Water: There is no city sewer system. Water from deep wells serves 3,000. It is chlorine treated and approved by the Health Department.

Schools: 4 schools including a high school.

ilities: Gooding Memorial Hospital, Gooding County Hospital, and The Idaho State T.B. Hospital. Also the State School for the Deaf & Blind.

Religious Facilities: There are churches of eleven denominations in Gooding.

Recreational Facilities: 2 city parks, a large swimming pool, and 2 theatres.

TWIN FALLS: Is in Twin Falls County and has a population of 17,500. It is a trading center for the highly agricultural Magic Valley as the irrigated Hagerman Valley is now called. There are 400 stores and 22 wholesale outlets in the city and three hotels.

Water & Sewer: The city sewer system serves 10,000. The system discharges into Rock Creek. City water from the Snake River is chemically treated and approved by the Health Department. It is piped to 13,000 residents.

Medical & Hospital Facilities: Twin Falls General and the Medical Arts Clinic operated by two local doctors are available.

Schools: Public grade and high schools and a Catholic school supply the educational facilities.

Religious Facilities: There are churches of eleven denominations in Twin Falls.

Recreational Facilities: 4 city parks, a swimming pool, a golf course and 3 theatres, total seating 1,738, plus 3 radio stations give Twin Falls claim to the best facilities of the kind in central Idaho.

BUHL: Is also in Gooding County and has grown in population from 2,414 in 1940 to an estimated 3,500 today. There are 109 stores and 19 wholesale outlets and 2 hotels.

Water & Sewers: Water from deep wells and the Snake River supply 2,500. Sewers now serve 2,300 and $77,000 is being spent to enlarge the system.

Schools: Three public schools through the 12th grade and two Parochial Schools make up the school system.

Medical & Hospital Facilities: There is no hospital but several nearby towns have one or more. There is at least one doctor and Buhl requested another through the A.M.A.

Religious Facilities: There are 10 churches of various faiths in Buhl.

s: A park with a swimming pool, a golf course and a theatre seating 600.

JEROME: Is in Jerome County and is a town of 3,500.

Water & Sewers: Water from 3 deep wells supply the community. The sewers are being extended and it is planned to run them all the way to the city limits as soon as possible.

Schools: There are 3 schools including a high school.

Medical & Hospital Facilities: There is a 50 bed hospital in Jerome.

Religious Facilities: Churches of 16 denominations hold services in the town.

Recreational Facilities: There is one theatre in Jerome.

RUPERT: Is in Minidoka County and is part of what is known as the Rupert-Burley area. These two towns are a trading and processing center for the fertile irrigated valley. The population was 3,167 in 1940, now estimated 4,050.

Water & Sewers: The water is from wells and supplies 3,250 persons. It is chemically treated. The sewage system serves 3,100 and was designed for a 3,500 capacity. It is a primary type discharging to a drainage canal.

Medical & Hospital Facilities: There is no hospital in Rupert but several close towns have one or more. There is a resident doctor.

Schools: There are two 1-8 grade schools and a high school in Rupert.

Religious Facilities: 13 denominations have church facilities in Rupert.

Recreational Facilities: A city park, civic auditorium, and a theatre seating 550 are also there.

BURLEY: Is in Cassia County and has a population of 6,000. There are 4 hotels and at the last census 1,445 housing units, an estimated 98-100 have been added since.

Water & Sewers: Water is supplied from deep wells to the entire city. It is chlorine treated and approved by the Health Department. The sewage system serves 4,500. Discharges to the Snake River.

Schools: 4 public schools including high school and State Normal College are the Burley educational facilities.

llities: The Cottage Hospital with 32 beds, 3 doctors, and 2 dentists serve the medical needs.

Religious Facilities: Methodist, Christian, Episcopal, Catholic, Presbyterian, Christian Science, Church of God, and the L.D.S. have churches.

Recreational Facilities: A city park, golf course, B.P.O. and I.O.O.F. halls are part of the recreational facilities.

CULTURAL QUALITIES OF THE AREA

50-MILE RADIUS POCATELLO SITE

COUNTY	POPULATION	LABOR (TOT.) 1948 EMPLOYEES (a)	EMPLOYEE CONSTRUCTION 1948 LABOR	HOUSING UNITS 1940
Clark	800	57	---	300
Jefferson	9,300	417	44	2,625
Butte	2,000	84	---	568
Blaine	4,500	594	134	1,708
Madison	7,500	729	65	2,274
Bonneville	22,800	4,582	537	6,812
Bingham	20,100	1,625	201	5,328
Lemhi (part) & Custer	846	79	2	376
			add.	830
Total	67,846	8,067	883	20,821

(a) The total labor force including farm, self-employed 20,980

RETAIL TRADE DATA 1946

FARM INCOME 1945

COUNTY	INCOME $	AVERAGE PER FARM	STORES 1940	SALES 1947 in thou- of $
Clark	770,793	6,645	18	522
Jefferson	6,109,017	4,330	114	5,195
Butte	11,364,178	5,207	33	1,096
Blaine	1,906,756	5,977	132	6,122
Bonneville	10,944,390	6,308	295	13,257
Bingham	12,278,584	5,334	214	6,814
Madison	5,399,430	6,641	97	35,204
Total	38,773,148		903	68,210

Schools: 94 schools in area including 17 high schools and 2 Catholic schools.

.st, 5 Baptist, 7 Episcopal, 3 Lutheran, 10 Catholic. There is a Morman Temple in Idaho Falls and wards in each community.

Theatres: 22 theatres in the area.

Hospitals: 8 in the area.

SUMMARY

Housing in the area is in very short supply, no building of any consequence having oocurred in the past ten years; while the schools, adequate for present needs, could not well assimilate any sizeable new student body. Both hospitals and doctors would be required in the area to care for a considerable population increase.

Existing churches would provide for the needs of the area on a temporary basis, leaving the required new ones for natural development.

Other than in the nature form of recreation, in which the area is abundant, facilities are woefully inadequate to care for the needs of any proposed new population.

AILABILITY OF LAND

Existing Installations:

Within the site area no private installations, other than the few homes hitherto mentioned, exist. Public installations in the area are confined to a Naval Proving Station covering some 173,000 acres with some improvements, including wells and a primitive dirt road that joins U.S. Interstate Highway 20 inside of the area and crosses the site northward to Dubois and an improved road that connects Howe with U.S. Interstate Highway 93 to the northwest.

Land Ownership Characteristics:

All of the land contemplated for the project site falls within the boundaries of the Naval Proving Station, while the remainder that lies inside of a 14-mile radius is publicly owned as national park, national forest or grazing land, with the exception of those few privately owned farms in the Howe-Berenice area at the northern boundary of the 14-mile radius. The average acre size per farm in Butte County, in which these farm homes lie, is 527 acres, valued at an average acre price of $23.91 per acre, utilized primarily for summer grazing.

No difficulty is foreseeable in the initial acquisition of the site and there appears to be no prospect that immediately adjacent lands will become more valuable by reason of irrigation or other improvement. No expensive existing installations need be purchased or removed, and there is little prospect that population will so far encroach upon the site area as to be a matter for concern.

MANPOWER

Within the area covered by the 200-mile radius a total of about 15,000 construction workers were resident employees in 1948 with such labor being in short supply, requiring the importing of labor in some cases from distances of over 500 miles. No easing of this situation is foreseen in the immediate future by the State Employment Service or trade union heads, in view of already identified projects.

Of the total of 234,000 labor force, it is estimated that about 27,000 may be classified as operatives, a figure nearly 7% below the national average, reflecting the low degree of industrialization of the area. It is estimated that about 20,000 may be classified as craftsmen, almost 3% below the national average. Because of these conditions and the high degree of employment, it may be expected that difficulty in recruitment of labor from this area will be encountered.

PERATIONAL COSTS

There is no appreciable difference in the operating wage scale between the two sites, the proximity of the two states having resulted in a considerable interchange of labor especially among those workers who are seasonally employed, who constitute about one quarter of the labor force.

ECONOMIC ADVANTAGE OR DISADVANTAGE ACCRUING TO EITHER SITE BY REASON OF AREA-LOGICAL FACTORS.

Any project with isolation requirements such as presented by the subject project must bear an excess cost burden that would not be present if the isolation requirements were removed. Not only are excess costs suffered in acquiring and transporting materials to the site, but a burden of direct or indirect excess cost on behalf of the constructing and operating labor for the project results.

Extreme housing shortage results in higher rental or purchase charges while the same conditions that cause the housing shortage are creating a demand market for foodstuffs, and the other necessaries.

The rapid accrual of 25,000 additional persons in an area where not more than 10,000 had resided previously cannot but set up a competitive price condition, especially in view of the still generally short supply of goods and the difficulty of obtaining increases in either wholesale or retail allotments. Such a condition would prevail at the Fort Peck Site where access to either wholesale or retail markets is not of the best.

At the Pocatello Site a concentration of cities and towns along the American Falls Reservoir and the Snake River provides a housing and population concentration which, within a radius of about 55 miles from the site, amounts to about 125,000 persons. Obviously the assimilation of 25,000 additional people into this area is capable of accomplishment with far less economic dislocation than would be the case at Fort Peck, especially in view of the far better wholesale and retail market access. It is expected that from this area a considerable number of workers could be drawn, diminishing the problem by that number.

A direct comparable situation existed and to the same degree in the area around the Hanford works, where in less than two years time something on the order of a 600% population increase was added to towns developed by the project owners, with controlled rentals. Still within the area the cost of living rose 20%, a rise that was reflected in direct wage cost to the owners or in indirect cost through the turnover of personnel. Such experience is not uncommon and it is believed that at least a 10% construction and operating cost penalty would be incurred with the selection of the Fort Peck Site.

WATER RIGHTS

In common with most western states, the States of Montana and Idaho follow the "use right rule" under which water may be appropriated for use, providing only that such appropriation does not damage a prior "use right" holder. Both States have provided in their laws for water appropriation by the United States Government through the Secretary for the Interior, subject to the same general requirements that apply to appropriation by private individuals.

Water may be diverted and used and returned to the source upon which a prior use right exists providing that such water is returned unchanged or in such condition and quantity as will not damage the prior "use right" holder. Local legal advice should be sought upon questions of specific nature upon specific waters.

GRAZING RIGHTS

Much of the land in both site areas, especially that which is publicly owned, is subject to grazing leases. Most such leases contain provisions covering the right to sell and assure possession, are subject to the right of eminent domain and in the majority of cases require only advance rental payments for the immediate year of use. Local legal advice should be sought with regard to specific parcels or areas of land.

Craters of the Moon National Monument is about 45 miles from the center of the Pocatello Site area, it is 20 miles distant from Arco to the park entrance on U.S. Highway No. 20, and about 20 miles from the Naval Proving Ground.

Accommodations at the Craters are limited to about three double tourist cabins and a camp site, a cafe and gasoline station in addition to a registration booth and headquarters building.

The majority of visitors to the Craters area are of transient character and no sizable number will be found there at any given time, the next nearest overnight accommodations being at Crater Inn, 17 miles west of Arco and which provides only 7 tourist units.

REVISED REPORT

EARTHQUAKE RISK AT FORT PECK, MONTANA AND ARCO, IDAHO SITES

by

J. STEWART WILLIAMS

Consulting Geologist

Logan, Utah

February 1, 1949

EARTHQUAKE RISK AT A SITE NEAR FORT PECK, MONTANA

Revised Report

by

J. Stewart Williams

PURPOSE OF REPORT

This report is written at the request of Smith, Hinchman and Grylls, Inc., of 243 West Congress Street, Detroit, Michigan.

SCOPE OF REPORT

This report is an evaluation of the risk of earthquake damage to an industrial structure that might be built at a designated site near Fort Peck, Montana. Elements considered in evaluating the risk are:

1. Nature of the terrane as it might affect the transmission of earth vibrations.
2. Earthquake history of the site.
3. Position of the site with respect to active earthquake centers.
4. Position of the site with respect to faults which may become active.

SOURCES OF INFORMATION

Geological information has been taken from the published reports on the area, particularly those of the U. S. Geological Survey. Earthquake information has been taken from the published reports of the U. S. Coast & Geodetic Survey.

DEFINITION OF SITE

Township 26 N., R. 36½ E., Valley County, Montana, is the site. This township is approximately 20 miles southwest of Glasgow and 30 miles west of Fort Peck dam, at latitude 48.0 north, longitude 107.0 west.

GEOLOGY OF THE SITE

The site and the area that surrounds it is underlain everywhere by the Bearpaw shale of Late Cretaceous age. The Bearpaw is a dark-gray clay shale 800 to 1,000 feet thick. The Milk River to the north and the Missouri River to the south have cut shallow valleys in the shale and deposited alluvial material--gravel, sand and clay--in the form of floodplains, along these valleys. Lesser streams in the area, such as Willow Creek, which flows near the site, have probably produced small floodplains in the lower parts of their valleys. These smaller floodplains probably are composed largely of sand, silt and clay.

The site is on higher ground, probably several hundred feet above the principal streams. Bearpaw shale is the bedrock everywhere at the site. The mantle (loose material lying on the bedrock) must consist principally of weathered Bearpaw shale, but in places there may be patches of gravel left by the Missouri and Milk rivers when they flowed at higher levels. The mantle will be thicker (perhaps tens of feet thick) in the bottoms of the small valleys, but absent from the steeper slopes on the valley sides. Generally speaking, the mantle will be so thin that it can be removed completely and the foundations for all structures placed in the undisturbed bedrock (Bearpaw shale).

At the site the water table is probably well below the surface of the ground (30-50 feet, or more).

Absence of a thick mantle, which will permit placing of foundations in undisturbed bedrock, and good drainage, should make this site entirely satisfactory, as far as geology at the site affects earthquake risk.

EARTHQUAKE HISTORY

Intensity scales. Prior to 1931, the Rossi-Forel Scale of earthquake intensity was used for rating earthquakes. Beginning with the year 1931, the U. S. Coast & Geodetic Survey adapted a new scale, known as the Modified Mercalli Intensity Scale of 1931. Intensities for recorded earthquakes prior to 1931 belong to the Rossi-Forel Scale; those for earthquakes subsequent to 1930 to the Modified Mercalli Scale.

In this report, in general discussion, reference is to the Modified Mercalli Scale, a copy of which is appended.

Equivalence of the scales is as follows

Rossi-Forel	Modified Mercalli
I	I
I-II	II
III	III
IV-V	IV
V-VI	V
VI-VII	VI
VIII	VII
VIII+-IX	VIII
IX+	IX
X	X
	XI
	XII

<u>Earthquakes felt at Glasgow</u>. Seismological investigations for the U. S. Government were assigned to the Coast & Geodetic Survey in 1925. This bureau has compiled an earthquake history of the United States prior to that year from various catalogues, scientific journals and the records of the U. S. Weather Bureau. This history lists all earthquakes of intensity V or greater. It lists no earthquake felt at Glasgow.

An earthquake on 15 May, 1909, which originated in Canada probably was felt at Glasgow, because it was reported felt at Havre. This earthquake was felt from Winnipeg, Manitoba, on the east to Swift Current, Saskatchewan, on the west. It probably originated near latitude 51, longitude 103. The following newspaper clipping from the Washington (D.C.) Post indicates that the intensity near the epicenter did not greatly exceed V. Intensity at the site was not greater than II or III.

"EARTHQUAKE IN MONTANA

Tremor Strong Enough to Break Glass Felt in Several Towns.

Great Falls, Mont., May 15.--A distinct earthquake shock was felt here tonight at 9:15 o'clock, and it was also felt at Chotau, Havre, Wagner, and other points, showing that it prevailed generally over northern Montana.

While no serious damage was done, the shock was sufficient to spill articles from shelves in stores, and there was some breakage of glassware.

Winnipeg, Manitoba, May 15.--An earthquake shock, lasting from 30 to 40 seconds, was felt here this evening. Reports from as far west as Swift Current, Sask., show it was felt there. Laningan, Reg., and several other points also reported a shock.

Reports from Weyburn and Moose Jaw state that the tremor was sufficient to shake articles off mantlepieces. It was not felt at Calgary, in the foothills of the mountains, or any distance east of Winnipeg. It seems to have been felt between Moose Jaw and this city as far north as the Saskatchewan River ...."

On 27 June, 1925, an earthquake originated near Logan, 280 miles west southwest of Glasgow. The intensity at Glasgow was III.

Since 1925 a complete record of felt earthquakes has been kept by the U. S. Coast & Geodetic Survey. It reveals one earthquake felt at Glasgow.

Earthquakes in western Montana. Thousands of felt earthquakes have been recorded for western Montana. Almost all of these have originated in a rather narrow belt along the east base of the Rocky Mountains stretching northward from Yellowstone National Park through Bozeman, Logan and Helena. Well over 3,000 shocks have been recorded at Helena since 1935.

The major shocks that have originated in this belt are as follows:

Date	Place	Intensity	Lat.	Long.
1872 Dec. 10	Near Helena	VII-VIII	46.4	112.5
1925 June 27	Near Menard	IX	46.0	111.2
1935 Oct. 12	Near Helena	VIII	46.6	112.0
1935 Oct. 18	Near Helena	VIII-IX	46.6	112.0
1935 Oct. 31	Near Helena	VIII	46.6	112.0

Of these major shocks, that of 1925 produced intensity III at Glasgow, while that of 18 October, 1935, produced intensity IV.

Summary. Strong earthquakes in western Montana have produced intensities of III and IV at Glasgow. The Canadian earthquake probably produced intensity III. There are no other records of felt earthquakes at Glascow.

POSITION RELATIVE TO POTENTIALLY ACTIVE FAULTS

The latest generation of faults in the Western Mountain Region of the United States are the so-called Basin and Range faults. These are responsible for the basins of the Great Basin area and for the basins of western Montana. Most of these faults are still active and they are responsible for the earthquakes of the Western Mountain Region. No fault of this type appears to exist in Montana east of the 111th meridian, which is the west boundary of Yellowstone Park. This is approximately 200 miles west of the meridian of the site in question.

The site is at least 200 miles from potentially active faults.

SEISMIC PROBABILITY MAP OF THE UNITED STATES

This map (copy attached), prepared by a group of experts for the U. S. Coast & Geodetic Survey, shows four categories of seismic probability and the corresponding damage expectable as follows:

Zone 0 - no damage
Zone 1 - minor damage
Zone 2 - moderate damage
Zone 3 - major damage.

The site in question falls in Zone 1, but it is near the boundary of Zone 0. This means that the danger of even minor damage at the site is small.

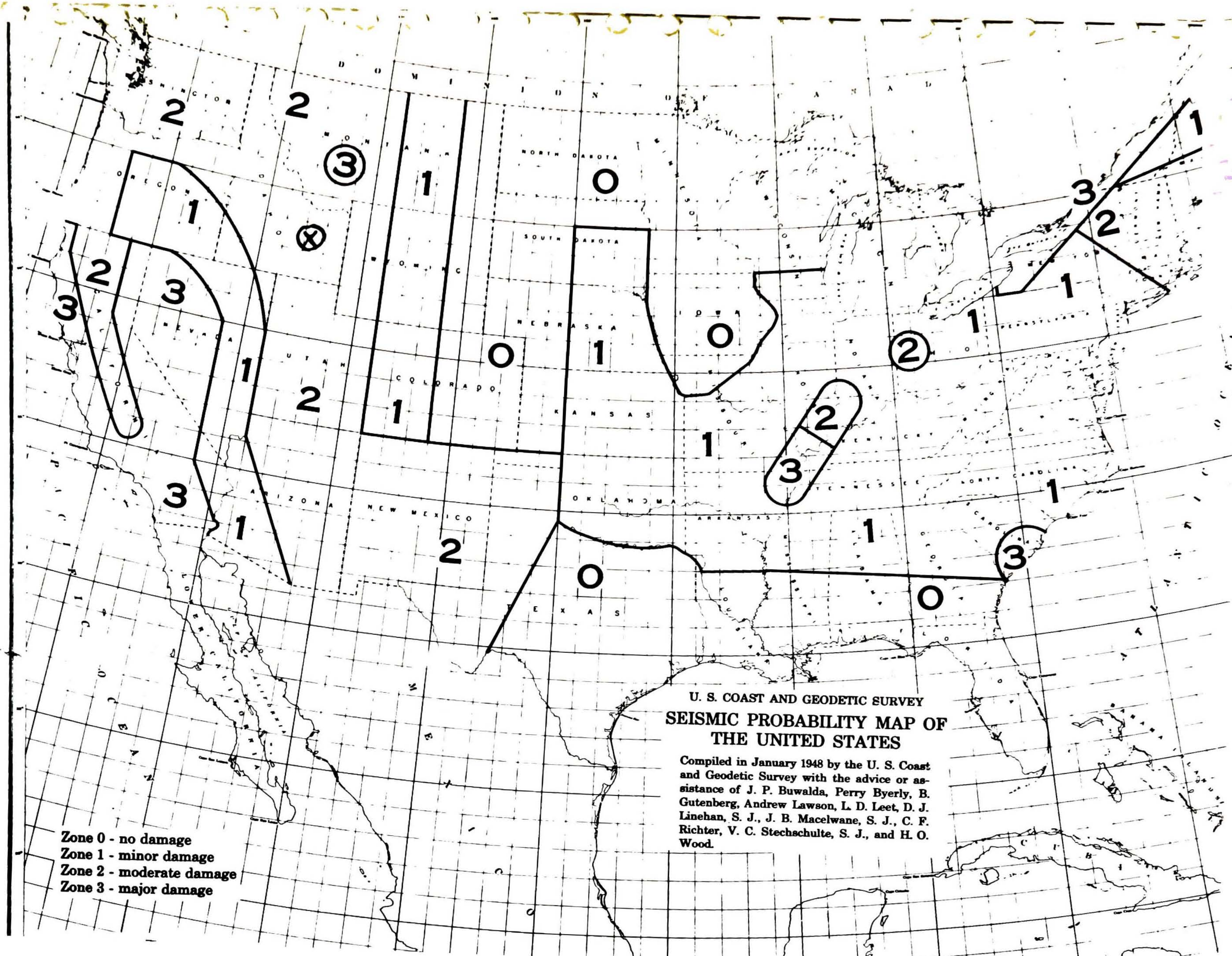
CONCLUSION

Earthquake risk at this site is small. No earthquake is known to have originated within several hundred miles of the site. Known potentially active faults are 200 miles away. No earthquake intensity greater than IV is recorded for Glasgow, town nearest the site. The terrane at the site is such that foundations can sit in dry undisturbed bedrock.

Any well-built structure could be considered safe from earthquake damage at this site. Heavy reinforced concrete structures designed to withstand the strong horizontal stresses produced in earthquakes, could be considered as safe from earthquake damage at this site as at any place in the United States.

J. Stewart Williams,
Consulting Geologist

JSW:mlt



U. S. COAST AND GEODETIC SURVEY

SEISMIC PROBABILITY MAP OF THE UNITED STATES

Compiled in January 1948 by the U. S. Coast and Geodetic Survey with the advice or assistance of J. P. Buwalda, Perry Byerly, B. Gutenberg, Andrew Lawson, L. D. Leet, D. J. Linehan, S. J., J. B. Macelwane, S. J., C. F. Richter, V. C. Stechschulte, S. J., and H. O. Wood.

Zone 0 - no damage
Zone 1 - minor damage
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EARTHQUAKE RISK AT A SITE NEAR ARCO, IDAHO

Revised Report

by

J. Stewart Williams

PURPOSE OF REPORT

This report is written at the request of Smith, Hinchman and Grylls, Inc., of 243 West Congress Street, Detroit, Michigan.

SCOPE OF REPORT

This report is an evaluation of the risk of earthquake damage to an industrial structure that might be built at a designated site near Arco, Idaho. Elements considered in evaluating the risk are:

1. Nature of the terrane as it might affect the transmission of earth vibrations.
2. Earthquake history of the site.
3. Position of the site with respect to active earthquake centers.
4. Position of the site with respect to faults which may become active.

SOURCES OF INFORMATION

Geological information has been taken from the published reports on the area, particularly those of the U. S. Geological Survey. Earthquake information has been taken from the published reports of the U. S. Coast & Geodetic Survey.

DEFINITION OF SITE

The station of Cerro Grande, on the Union Pacific Railroad line between Blackfoot and Arco, is taken as the site. It is about 25 miles east of the Craters of the Moon National Monument and 60 miles northwest of Pocatello, Idaho, at latitude 43.4 N., longitude 112.9 W.

GEOLOGY OF THE SITE

The site is near the center of the Snake River lava plain. This plain is underlain by flows of black lava (basalt) to a depth of hundreds if not thousands of feet. The basalt at the surface is of Pleistocene or Recent age and is generally little weathered. It is covered in many places with a thin veneer of wind-blown silt (loess) or with a thin layer of stream-borne sand and gravel. At other places the lava is bare. At the naval rifle range, near the site, there is enough loose material on the lava to provide earth for banking igloos and other similar structures.

The depth to the water table at Cerro Grande is estimated at 200 feet or more.

Any structures erected at this site would have foundations on the basalt bedrock. There should be no magnification of earth movement in this bedrock, such as is produced in saturated alluvium.

EARTHQUAKE HISTORY

Intensity scales. Prior to 1931, the Rossi-Forel Scale of earthquake intensity was used for rating earthquakes. Beginning with the year 1931, the U. S. Coast & Geodetic Survey adapted a new scale, known as the Modified Mercalli Intensity Scale of 1931. Intensities for recorded earthquakes prior to 1931 belong to the Rossi-Forel Scale; those for earthquakes subsequent to 1930 to the Modified Mercalli Scale.

In this report, in general discussion, reference is to the Modified Mercalli Scale, a copy of which is appended.

Equivalence of the scales is as follows:

Rossi-Forel	Modified Mercalli
I	I
I-II	II
III	III
IV-V	IV
V-VI	V
VI-VII	VI
VIII	VII
VIII+-IX	VIII
IX+	IX
X	X
	XI
	XII

Earthquakes probably felt at Cerro Grande. There is one record of an earthquake felt at Cerro Grande, but probably many have been felt there.

... is a list of earthquakes, originating in the areas about the Snake River lava plain, that probably were felt, or could have been felt, at Cerro Grande.

Date	Place of Origin	Intensity	Lat.	Long.
1894 Dec. 24	Boise	VI	44.8	117.0
1897 Nov. 4	Dillon, Montana	VI	45.0	113.0
1905 Nov. 11	Shoshone	VII	42.9	114.5
1906 Oct. 18	Paris	V	42.5	111.5
1909 Feb. 19	Near Idaho Falls	II-III	43.5	112.1
1909 Oct. 6	Pocatello	II-III	42.9	112.5
1909 Oct. 26	Idaho City	II-III	43.8	116.0
1915 Oct. 2	Pleasant Valley, Nevada	VIII	40.3	117.6
1916 May 12	Boise	VII	44.8	117.0
1916 May 25	Idaho City	V-VI	43.8	116.0
1916 Sept. 9	Hailey	V	43.5	114.3
1917 Dec. 12	Near Wayan	V	43.0	111.3
1922 Feb. 19	Near Wayan	IV	43.0	111.3
1924 Nov. 25	Near Nounan	V	42.5	111.5
1927 Aug. 7	Arco	Not Given	43.6	113.3
1932 Dec. 21	Twin Falls	II-III	42.5	114.5
1934 Mar. 15	Twin Falls	IV	42.5	114.5
1934 Apr. 12	Burley	II-III	42.5	113.8
1940 Mar. 28	Pocatello	II-III	42.9	112.5

On the basis of this record it is highly probable that Cerro Grande has been shaken by several earthquakes. Shocks have been reported from Idaho Falls, Pocatello, Burley, Twin Falls, Shoshone and Arco, all the larger towns that surround the Snake River lava plain. These shocks, however, have all been of moderate intensity, and it seems equally probable that no intensity greater than V has been experienced at Cerro Grande.

It is possible that some of these shocks may have originated beneath the lava plain and close to Cerro Grande. Slight earthquakes have been reported from the Craters of the Moon National Monument only 25 miles from the site. But no major earthquake has originated beneath the lava plain since records have been kept.

Earthquake activity of adjacent areas. There are several areas of rather pronounced earthquake activity around the Snake River lava plain. These have produced numerous earthquakes of moderate intensity, many of which were probably felt at Cerro Grande, and several of great intensity that were almost certainly felt there.

The Hansel Valley earthquake center lies at the north end of Great Salt Lake, latitude 41.7, longitude 112.8, 120 miles south of Cerro Grande. The following major earthquakes have originated there:

Date	Intensity	Felt Area
1909 October 5	VII	30,000 sq.mi.
1934 March 12	IX	170,000 sq.mi.
1934 April 14	VII	30,000 sq.mi.

The earthquake of 1934 April 14 was reported felt at Burley and Pocatello, and so was probably felt at Cerro Grande. Such being the case, all three of the earthquakes were probably felt there. That of 1934 March 12 produced an intensity of III or IV at Cerro Grande.

Another area of rather pronounced activity lies to the west of the site, about 160 miles, in the vicinity of Boise, and extends northward into the Idaho panhandle. The principal earthquakes that have originated there are:

Date	Place	Intensity	Felt Area	Lat.	Long.
1894 Dec. 24	Boise	VI		44.8	117.0
1905 Nov. 11	Shoshone	VII		42.9	114.5
1916 May 12	Boise	VII	50,000 sq.mi.	44.8	117.0

These have all been of moderate to strong intensity, but they denote continuing activity in the area.

A third area of activity lies north of the Snake River lava plain in southwestern Montana, roughly 100 miles north northeast of the site, and extends thence northward toward Butte, Montana. Principal earthquakes originating here are:

Date	Place	Intensity	Lat.	Long.
1897 Nov. 4	Dillon	VI	45.0	113.0
1908 Dec. 20	Virginia City	VII	45.2	111.8
1933 Nov. 29	Virginia City	IV-V	45.2	111.8
1941 Feb. 27	Monida	V	44.6	112.2

The Montana earthquake of 27 June, 1925, was felt as far southwest as Boise, Idaho, and as far southeast as Casper, Wyoming, but was not felt at Idaho Falls, Blackfoot or Hailey. Pardee, who reported this earthquake (U.S.G.S. Professional Paper 147) suggested that the isoseismals bent around the Snake River plain because the lava flows and interlayered gravel beds, "loosely aggregated masses," were able to "break up and check the rather feeble vibrations that reached them." The Helena earthquake of 18 October, 1935, was likewise felt at Boise, but not felt at Arco or Idaho Falls, showing a similar bending of the isoseismals around the north side of the lava plain. However, the isoseismals drawn for the Utah earthquake of 12 March, 1934, sweep as widely across the lava plain as in any other direction. It would be unsafe to assume that the lava plains will not transmit earthquakes.

Summary. As far as the recorded earthquake history of Cerro Grande goes, there is record of only one earthquake having been felt there, the Utah earthquake of 12 March, 1934, which reached intensity IV at the site. It is probable that several of the stronger shocks in surrounding areas in years preceding 1925, before more careful records were kept and isoseismal maps regularly drawn, could have been felt at Cerro Grande.

According to an interpretation (Bulletin Geological Society of America, Vol. 49, Pl. 2, 1938) by N. H. Heck, for many years the leading seismologist of the U. S. Coast & Geodetic Survey, the area of principal seismic activity in this part of the Western Mountain Region forms a great Y which includes the Snake River lava field and Cerro Grande between its forks. The bottom of the Y is along the front of the Wasatch Mountains in north-central Utah. One arm of the Y bears slightly eastward along the Idaho-Wyoming boundary, through Yellowstone Park and thence northward to include the active belt of western Montana. The other arm bears westward to include the Hansel Valley earthquake center, thence northwestward to include the Boise area and part of the Idaho panhandle.

POSITION RELATIVE TO POTENTIALLY ACTIVE FAULTS

The Snake River lava plain lies across an area characterized by the presence of geologically young faults. To the south of the plain these faults have produced the characteristic basins and ranges of the Great Basin area. To the north of the plain they have produced many of the valleys and ranges of western Montana. Presumably such faults lie beneath the Snake River plain. The earthquake history of the Western Mountain region shows that many of the faults have produced earthquakes in the last 100 years. Any one of them may be considered potentially active.

SEISMIC PROBABILITY MAP OF THE UNITED STATES

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Zone 3 - major damage

The site in question falls in the center of a belt which is part of Zone 2. It is 200 miles south of the Helena area in Montana which is part of Zone 3.

CONCLUSION

Earthquake risk at this site is appreciable, but not great. Since isoseismal maps for principal earthquakes have been drawn, beginning in 1925, the isoseismals of only one earthquake reach Cerro Grande. Prior to this time several earthquakes recorded for surrounding areas may have been felt at Cerro Grande. There is no record of a major earthquake originating close to Cerro Grande.

However, Cerro Grande is surrounded by areas of comparatively high seismic activity. Furthermore, it lies in a region of geologically young faults, any one of which must be considered potentially active. For these reasons earthquake risk at this site should not be dismissed from consideration in planning an industrial plant to be built at the site.

Cerro Grande is situated within one hundred and fifty miles of several areas of pronounced earthquake activity. Any one of these might produce a shock stronger than it has yet produced with a correspondingly greater intensity at Cerro Grande. The earthquake history of one hundred years for this area is very short, from the geological point of view. An earthquake might occur any day that would alter substantially our ideas of the distribution of seismic activity in the area about the Snake River plains.

Earthquake risk in any area is relative to the type of structures to be built. Reinforced concrete buildings well constructed in every way with high factors of safety and incorporating features recommended by engineers acquainted with earthquake-proof design, stand less risk of being damaged. Such buildings, set on the lava bedrock at Cerro Grande, certainly would be reasonably safe from earthquake damage.

Considering the earthquake history of the surrounding area, and its geologic structure, any industrial plant involving large capital investment or any government plant important to the general welfare should be constructed to resist intensities of eight or nine. The cost of meeting this requirement would not be great, and it would offer practically complete assurance against earthquake damage.

Viewed from another angle, certain types of structures are of such design as to be essentially earthquake-proof. For such structures earthquake risk in any area would not be great. For such structures at Cerro Grande it would be practically nil.

No traces of recent faults are known by the writer to cross the Snake River plains. The chances, then, of displacement in the ground that would cut water supplies are small, small enough to be eliminated from consideration.

J. Stewart Williams,
Consulting Geologist

JSW:mlt

RCALLI INTENSITY SCALE OF 1931
(Abridged)

I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale)

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale)

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing truck. Duration estimated. (III Rossi-Forel Scale)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. (IV to V Rossi-Forel Scale)

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc. broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VII Rossi-Forel Scale)

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale)

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars. (VIII Rossi-Forel Scale)

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbed persons driving motor cars. (VIII+ to IX Rossi-Forel Scale)

IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale)

X. Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable

(Continued next page)

from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale)

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.