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COMMITTEE PRINT NO. 19

WATER RESOURCES ACTIVITIES IN THE UNITED STATES

WATER RESOURCES OF ALASKA

SELECT COMMITTEE ON NATIONAL WATER RESOURCES
UNITED STATES SENATE

PURSUANT TO

S. Res. 48

EIGHTY-SIXTH CONGRESS

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SELECT COMMITTEE ON NATIONAL WATER RESOURCES

(Pursuant to S. Res. 48, 86th Cong.)

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STATEMENT BY THE CHAIRMAN

January 12, 1960.

To the Members of the Select Committee on National Water Resources:

At a meeting of our committee held on June 11, 1959, it was agreed that in its consideration of water problems under the provisions of Senate Resolution 48, separate and specific attention should be given to the water resource problems of Alaska and Hawaii, since in many respects these problems are far different than those in the contiguous States of the United States. In addition, the new States have not had the benefit of all of the longstanding water resources programs which have been carried out in the contiguous States.

In view of the interest and responsibility of the Department of the Interior in the affairs and problems of Alaska during the long period of years before it achieved statehood, it was decided to ask the Secretary of the Interior for a report containing an analysis of present developments and of potential future water resources development and the part it may play in stimulating the growth of the economy through 1980. It was suggested that special attention be given to hydroelectric potential as related to industrial growth, inland navigation and the improvement of forest and mineral accessibility, fisheries, and recreational pursuits.

The Department's report on Alaska has now been received. The report points out that the four major problems which will hinder development of good water supplies in Alaska relate to freezing conditions and the presence of permafrost north of the Alaska Range; quality of water as related to the presence of iron and glacial flour; the presence of impervious consolidated rocks limiting the availability of ground water; and difficulties of waste disposal during winter months. Irrigation in the State of Alaska is still in its infancy but the report suggests that eventually some 50,000 acres may be irrigated. Water power potential is enormous and constitutes one of the valuable resources of the State. It is estimated that the prime power potential at 168 sites is somewhat over 13 million kilowatts. This is a very large percentage of the total hydroelectric power resources of the United States, and affords possibly our only opportunity for developments of the magnitude of some of the multimillion kilowatt plants now under construction in the Soviet Union thus appearing to offer great potentiality as a basis for economic development of Alaska. The wildlife resource of Alaska—fur animals, game birds, game animals, and, above all, commercial and game fishes—represent a greater per capita wealth than the wildlife resources of any other State. But probably the most significant conclusion that can be drawn from the report is that we know very little indeed of the extent and magnitude of the magnificent water and water related resources of Alaska.

The facts referred to above and many others given in this report will be of interest to Senators and others interested in the water problems of Alaska, and I am having it printed as one of our series of committee prints. The Governors of both Alaska and Hawaii have also submitted reports at my request and these are being published together with reports of the other States discussing their water problems in Committee Print No. 6.

Rob't S. Kerr, *Chairman.*

COMMUNICATIONS

JUNE 18, 1959.

Hon. FRED A. SEATON,
Secretary of the Interior, Department of the Interior,
Washington, D. C.

MY DEAR MR. SECRETARY: Further reference is made to my letter dated June 15, 1959, concerning the work of the Select Committee on National Water Resources. The committee at a meeting held June 11, agreed that in its consideration of water problems, it should give separate and specific attention to the problems of Alaska and Hawaii, since in many respects these problems may be somewhat different from those of the continental United States.

Because of the long interest of the Department of the Interior in the affairs and problems of both Alaska and Hawaii, it seems but natural that the committee should look to your Department for a large part of this information. We are also writing directly to the Governors of both States, soliciting their views as to their water problems, even though we recognize that the new State government of Hawaii is just in the process of being formed. We expect also that we may receive information from their Federal agencies concerned with development of water and related resources in the two new States.

In the absence of knowledge of just what information may be available in the Department of the Interior concerning available water supplies, present demands, and related problems in Alaska and Hawaii, the following requests are set forth in general terms only. They may be modified following consultation with members of your staff. It is requested that the committee be furnished with reports containing information along the following general lines:

A. ALASKA

An analysis of present developments and of potentialities of future water resource development, and the part it may play in stimulating the growth of the Alaskan economy through 1980, keeping in mind needs which may be felt through the remainder of the 20th century. Among the specific purposes of development which should be given attention are—

1. Hydroelectric potential as related to feasible industrial growth. Cost estimates would be useful.
2. Inland navigation and the improvement of forest and mineral accessibility.
3. Fisheries.
4. Recreational pursuits.

B. HAWAII

An analysis of facts presently known about the water resources of the Hawaiian Islands and their development potentialities, including data on present uses and estimates of expected uses in 1980 and looking even further into the future to the end of the century. Among other things the report should present—

1. An appraisal of the future supply-demand situation resulting from urban and military requirements.
2. Potentialities for future irrigation and electric power development.
3. Water development which could benefit the recreational industry.

We would like this information to be made available in a summary report of not more than about 10,000 words for each of the two States, with whatever tables, charts, appendixes, and graphic illustrations as may be considered necessary. It would be most helpful if this information could be furnished the committee by about October 1, 1959.

The committee staff will be glad to discuss any problems which may arise in the preparation of these reports with members of your staff who are assigned the task of preparing these reports.

Sincerely yours,

Rob't S. Kerr, *Chairman.*

U.S. Department of the Interior,
Office of the Secretary,
Washington, D.C., December 16, 1959.

Hon. Robert S. Kerr,
Chairman, Select Committee on National Water Resources,
U.S. Senate, Washington, D.C.

Dear Senator Kerr: Pursuant to your request of June 18 the Department is pleased to submit to the Senate Select Committee on National Water Resources the enclosed report entitled "Water Resources of Alaska." Twenty copies are enclosed.

The report on water resources in Hawaii, requested in the same letter, is nearing completion and will be submitted to the committee in the near future.

Sincerely yours,

Elmer F. Bennett,
Under Secretary of the Interior.

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WATER RESOURCES OF ALASKA

Basic Physical Data

CLIMATE

The climate of Alaska is variable with respect to time and location. The southeastern part of the 49th State has a climate milder than that of the northern Great Plains. The great interior of Alaska has a general climate comparable to that of Montana and the Dakotas. North of the Brooks Range the climate is arctic.

The part of the State adjacent to the Gulf of Alaska has a maritime climate much affected by the Japan current. Southeastern Alaska—that portion east of the 141st meridian—has a climate like Seattle, Wash. In this region, stretching from Ketchikan to Juneau and beyond, annual precipitation is heavy. At elevations near sea level most of it falls as rain. At medium and high altitudes much precipitation occurs as snow. Summer precipitation is light—June and July rainfall drops well below the amounts occurring during the other months.

The coastal area south of the Alaska Range has a climate not greatly different from that of the southeastern region. Precipitation is heavy and the monthly distribution is similar to that of the southeastern region. Back from the seacoast the warming effect of the ocean is absent and much of the precipitation occurs as snow. The frost-free season decreases with distance away from the seacoast, restricting the types of farm crops that can be grown.

The great interior region of Alaska north of the Alaska Range and south of the Brooks Range has a climate similar to North Dakota and Montana. Annual precipitation ranges from 5 to 20 inches. Monthly distribution is such that growing season precipitation is normally adquate for agriculture. The frost-free season in the interior varies from 63 to 90 days. The shortness of the growing season is compensated for by the great duration of sunlight.

The region north of the Brooks Range has an arctic climate. The average frost-free season at Point Barrow is 17 days. Annual precipitation is less than 5 inches along much of the arctic coast.

In the country north of the Alaska Range the long duration of below freezing weather produces a great thickness of ice cover on lakes and streams. Even the major rivers of the interior region are frozen over from early November to early May. The long periods of freezing conditions have a great effect on the hydrology of the region.

GLACIERS

During the ice ages great portions of Alaska were covered by glaciers. One, in the north, centered on the Brooks Range, extended from the Mackenzie River almost to Kotzebue Sound. Another covered all of coastal Alaska from British Columbia to the Aleutian chain. At present there are many separate glaciers in the areas once occupied by the giant ice sheets. The largest modern Alaskan glacier is in the southeastern region. Glaciers have a great effect on the water resources. Melt water from the glaciers provides a dependable supply not related locally to the occurrence of precipitation. However, almost all glacier melt is charged with rock flour which detracts from the quality.

LAKES

Alaska has many lakes large enough to have a significant effect on the hydrology of the regions where they abound. Even in the hard rock southeastern region there are sufficient lakes so that a few municipal supplies are taken from them. In the rest of Alaska concentrations of lakes are found in all regions. Some of the large lakes found at the base of the Alaska Peninsula are Iliamna, Clark, Naknek, Becharof, and Ugashik. Iliamna has a surface area of 1,226 square miles. The firm power possibilities in the rivers flowing from many large lakes are tremendous. The delta country

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Regional Map of Alaska

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C. 1954

ALASKA, MAP C

FOR SALE BY U. S. GEOLOGICAL SURVEY, FEDERAL CENTER, DENVER, COLORADO OR WASHINGTON 25, D. C.

between the mouths of the Kuskokwim and Yukon Rivers is dotted with lakes. Lakes abound in the arctic drainage north of the Brooks Range.

PERMAFROST

Permafrost is defined by Muller as "a thickness of soil or other surficial deposit or even of bedrock, at a variable depth beneath the surface of the earth in which a temperature below freezing has existed continuously for a long time (from two to tens of thousands of years)." In Alaska permafrost is a result of both the present climate and of colder climates that occurred intermittently during the past hundred thousand years. The transition from the permafrost-free terrain of southern Alaska to the continuous permafrost of northern Alaska reflects the present and past variation of climate. Locally, permafrost varies in thickness depending on subsurface drainage and surface insulation.

Permafrost limits supplies of ground water in central and northern Alaska. North of the Brooks Range the prevalence of permafrost makes the development of wells improbable except in the alluvium of major rivers such as the Colville, in material beneath deep, wide lakes, and in proximity to hot springs. Between the Alaska Range and the Brooks Range ground water may be developed in the flood plains of major rivers, in unfrozen channels within permafrost, in unfrozen sediments overlain by permafrost, and in areas entirely free of permafrost.

The distribution of water supplies through pipes and the collection of wastes through sewers is a difficult and costly undertaking in permafrost zones. Water mains and sewers can't be protected from freezing by entrenching them, but must be placed in enclosing insulated conduits on top of the ground to protect from freezing.

RELATION OF GEOLOGY TO WATER SUPPLIES

Southeastern region (east of 141°)

The rocks in this region are generally hard, relatively impervious masses of volcanic or dense sedimentary rock. The chances of developing large ground-water supplies are meager. The impervious nature of the rocks, slight or absent soil cover to absorb precipitation, and the steep relief account for the high ratio of stream runoff to precipitation.

Coastal region south of Alaska Range

The hydrologic pattern here is quite different from that of the southeastern part. Ground water is available from the wide glacial deposits filling the major valleys. These deposits are readily recharged by local precipitation and probably, to some extent, by runoff from glaciers in the higher more impervious volcanic peaks and ranges. Overland flow and streamflow are tempered by the low grades of the glacial valleys. Near the coast the land often is so flat that muskeg bogs are common.

The hydrology of the Copper River system is peculiar in that near its mouth the river cuts through a rock slot. In this respect the basin is somewhat like a teapot—it can hold a large volume of water below the spill point. Perhaps this phenomenon accounts for the high salt content of the ground water. Near the ocean, precipitation may carry appreciable quantities of sea salts. If, during its history, the Copper River had trouble cutting through the hard rock in the lower reaches, some of the valley might have been flooded and the salts concentrated in the remaining water by evaporation.

Interior region

In this region broad stream valleys have been gouged out of hard rock by glaciers and later filled with debris as the glaciers melted and retreated. These intermontane valleys contain large quantities of ground water. In wide areas of the Tanana, Yukon, and Kuskokwim valleys, the glacial alluvium has very little clay and till; hence, the permeability is high. The nonglaciated areas probably have less ground-water potential, but much of this area is too swampy or otherwise unattractive to be of immediate concern.

Streams, many of which rise from glaciers, are recharged by ground-water inflow from the permeable valley fill. This lends stability of low flow in the streams. The glacial streams are fouled with glacial flour, which is discussed in the section on quality of water.

Arctic region

North of the Brooks Range, geology has little effect on water supplies. Permafrost is present to the exclusion of true ground water except in the alluvium of Colville River. During the winter, shallow lakes and small streams are frozen, but in summer it is possible to develop a little ground water from the thin skin of permafrost melt.

OCCURRENCE OF WATER

Climate and geology profoundly affect the occurrence of water in Alaska. In general, there is an abundance of water, but during parts of each year it may become almost unavailable. The reason for the temporary shortage varies with location. In the southeastern region where streamflow is the only feasible source of water supply, a short drought may result in the drying up of streams not receiving lake outflows because there is such a lack of alluvium for natural storage. In the interior during the long, cold winters small streams and shallow lakes freeze solid, and water is made available only by melting snow or ice. The availability of water is discussed region by region in the paragraphs that follow:

Southeastern region

In the southeastern region east of the 141st meridian, runoff is unique in magnitude and dependability. Streamflow measured at 41 gaging stations in this region shows that annual runoff varies from about 50 to more than 300 inches depending on the mean elevation and exposure of the drainage area. Because the official rain gages are located near sea level, the recorded annual precipitation is frequently less than the annual runoff measured on a nearby drainage.

Streamgaging in Alaska thus far has been adequate to define some generalities. Because of the difficulties of travel and the limited personnel for streamgaging, only two areas in the southeastern region have been thoroughly studied. These are Revillagigedo Island and the Juneau area. The records show that average annual runoff on Revillagigedo Island varies from 250-plus inches for drainages with good windward exposures at high altitude to 130-plus inches for drainages not well situated with respect to interception. Lakes are so prevalent on the island that all of the gaged streams are lake outflows. Average annual runoff in the Juneau area varies from 60-plus to 230-plus inches. Again, the variability of annual runoff with location is related to geology, windward exposure, and elevation of the drainage basin.

In addition to the beneficial effect of much natural storage in lakes, southeastern Alaska's streamflow is made more dependable by the contributions of glacier melt. Significant melt runoff occurs during the period from May to September. The Alaska-Canada boundary line along the southeastern region is amply supplied with glaciers.

The variation of streamflow during the year for streams draining the southeastern region follows a fixed pattern. Although mean winter temperatures recorded near sea level are only slightly below freezing, the temperatures at higher elevations are such that significant snow storage occurs from November through April. Runoff decreases rapidly from October or November to a low usually occurring during March. The spring thaw produces noticeable pickup in runoff during April but the peak rates occur during May or June. The peak spring-summer flow generally occurs during May in the vicinity of Ketchikan, during June near Juneau and Sitka. Runoff declines during July and August from the peak of May or June and then picks up again with the heavy fall precipitation during September-October.

Although streamflow in southeastern streams is low from November to April and high from April to August, the dependability of yield of southeastern streams is good. A variability index used to compare dependability of flows in the U.S. ranges from 0.2 near Ketchikan to 0.4-plus near Juneau. The lower the index the more dependable the flow. The average variability index of streams in the United States is 0.57.

Geologic conditions in southeastern Alaska make the occurrence of ground water a rarity. The country is generally a series of partially submerged mountain ranges so that many alluvial deposits which were formed in the past now lie submerged beneath the sea. The portion above sea level is "hard rock" and there is practically no ground water in it. At a few places, such as near Juneau, enough unconsolidated material exists so that a producing well has been developed. The abundance of surface supplies has not encouraged an interest in well supplies although from a public health standpoint the well water would be better.

Coastal region

Annual precipitation in the coastal region, which lies west of longitude 141° between the Alaska Range and the Gulf of Alaska, is less than precipitation in the southeastern region. Because the portion of the year with temperatures below freezing is longer and more severe than the like period in the southeastern region, the decline in streamflow during the winter and the increase in flow during the period of melt runoff makes a wider variation in surface-water supplies. Contributions to streamflow from glacial melt are sizable; some icefields and glaciers considered as a single unit cover 2,500 to 5,000 square miles.

Average annual runoff gaged on only a few streams in the coastal region shows variation from about 15 to about 170 inches. The high figure represents runoff from a glacial area. The seasonal pattern of variation of streamflow is such that little streamflow occurs from December 1 to May 1 and peak runoff occurs in July or August. About 70 to 80 percent of the total annual volume of streamflow occurs during the 4 months June, July, August, and September. There are some large lakes in the region; these can be converted to excellent reservoirs for stabilization of flow by constructing regulating works at the outlet.

Ground-water supplies are fair to good in the coastal region. Unconsolidated deposits from glaciers and streams are common. Municipal supplies from wells have been developed at Valdez, Moose Pass, Homer, Kenai, and Anchorage. More than 300 wells have been developed in the Matanuska Valley agricultural area. These generally yield adequate water for domestic use. Possibilities for development of ground-water supplies in alluvial and glacial deposits appear good.

Interior region

This great region, which extends from Yukon territory to the Bering Sea and from the Alaska Range to the Brooks Range, has typical runoff conditions dictated by the climate. Most of the annual runoff is concentrated in the period May to September with low flows during the frozen part of the year. Two great rivers—the Yukon and the Kuskokwim—drain the interior region. Although annual precipitation is low, annual runoff varies from 8 to 40-plus inches. The variability of streamflow on Yukon River is about equal to the national average in continental United States.

Ground-water supplies may prove to be an excellent source of water in the interior region, but so far conditions are known only fairly well for the Fairbanks area. Permafrost is a factor to contend with throughout the region but especially so north of the Yukon. In the alluvium of the large streams permafrost is generally absent, and chances of developing ground water should be excellent. Wells have been developed at Nenana, McGrath, Farewell, Aniak, Tanana, and Nome in addition to the Fairbanks area.

Arctic region

Little information is available on the Arctic region, the country north of the Brooks Range. Water is supplied during the fall, winter, and spring in small quantities by melting snow or ice over a fire. During the short summer season water is abundant everywhere in the region.

QUALITY OF WATER IN ALASKA

The quality of surface waters in Alaska is generally good. To the extent the streams have been examined, the dissolved solids of most at the time of maximum concentration is less than 200 parts per million (p.p.m.). The waters are the calcium-magnesium bicarbonate type. Generally, chloride concentrations are less that 10 p.p.m., but reach 20 to 40 p.p.m. in the Susitna and Copper River Basins. Hardness of the water for some streams will not exceed 100 p.p.m., and for most it will not exceed 150 p.p.m. A relatively few streams carry noticeable quantities of iron.

In general, the factors affecting the sediment concentration and load of the streams are about the same in Alaska as elsewhere, but Alaska has one added element, glaciers. In many parts of the State, the nature of the terrain, the forest cover, and the lack of manmade disturbances are not conducive to intense sediment yields. However, glacial action contributes appreciable quantities of sediment, a part of which is glacial flour. This is a very fine sediment produced by the grinding action of glaciers. The sediment discharge of glacial streams is quite variable. For example, the suspended sediment concentration of the Gulkana River at Gulkana ranged from 1 p.p.m. on January 8, 1954, to 9,460 p.p.m. on August 3, 1954. This amounted to sediment discharged in tons per day of from less than 0.5 ton to 198,000 tons. Not all streams receive glacial water, for it is not unusual to see a clear nonglacial stream discharging into a turbid glacial stream.

Glacial flour is so fine that clarification of water for domestic and some industrial uses is very costly. It also forms a relatively impervious seal in streambeds and valley fill that restricts the movement of water from the stream to adjacent ground-water aquifers.

Iron is the most universally troublesome chemical constituent of ground water. Without treatment, iron-bearing water is objectionable for domestic and many industrial uses. Fortunately, iron does not hinder the use of water for irrigation. Crops are irrigated in the Tanana and Matanuska Valleys. In many places in the Tanana Valley the ground water is high in iron or organic matter, or both. Most of the shallow wells around Anchorage also yield water with high iron content.

Alaska has many springs, 32 of which were sampled for chemical analysis prior to 1917 (Water-Supply Paper 418). The major portion had a high iron content, but otherwise the waters are suitable for many uses. A few contained more than 1,000 p.p.m. bicarbonate.

The southeastern part of the Copper River Basin is a specific area of poor quality ground water. The areal extent of this hard and highly saline water has not been fully defined, but poor quality water occurs in the general area covering Gulkana on the north, Copper Center on the south, and extending at least 15 to 20 miles to the east and west of the Copper River. The difficulty of obtaining ground water of suitable quality in this area is pronounced. Limited quantities have been developed that receive water primarily from seepage or surface drainage. This water is subject to contamination from sewage, cesspools, and other sources. Water from deeper wells (100 to more than 400 feet) is also poor. Dissolved solids range from 1,000 to 24,000 p.p.m. Chloride is high and hardness may exceed 6,000 p.p.m.

Cool temperature is an often sought after trait of water, but in Alaska it can be detrimental. Where water is used for irrigation, too cold a water "shocks" the plants, and farmers frequently must wait for the rivers to warm before they apply water to their fields. Typical river temperatures are shown on figure 1.

Stream and ground-water pollution is another serious problem related to temperature. With the ground and rivers frozen during the winter, animal and human waste accumulates. Not only is there the problem of where to put the waste, but also the normal bacterial decomposition processes almost cease at the low temperatures. In spring, runoff and ground-water recharge is accompanied by rapidly putrifying wastes.

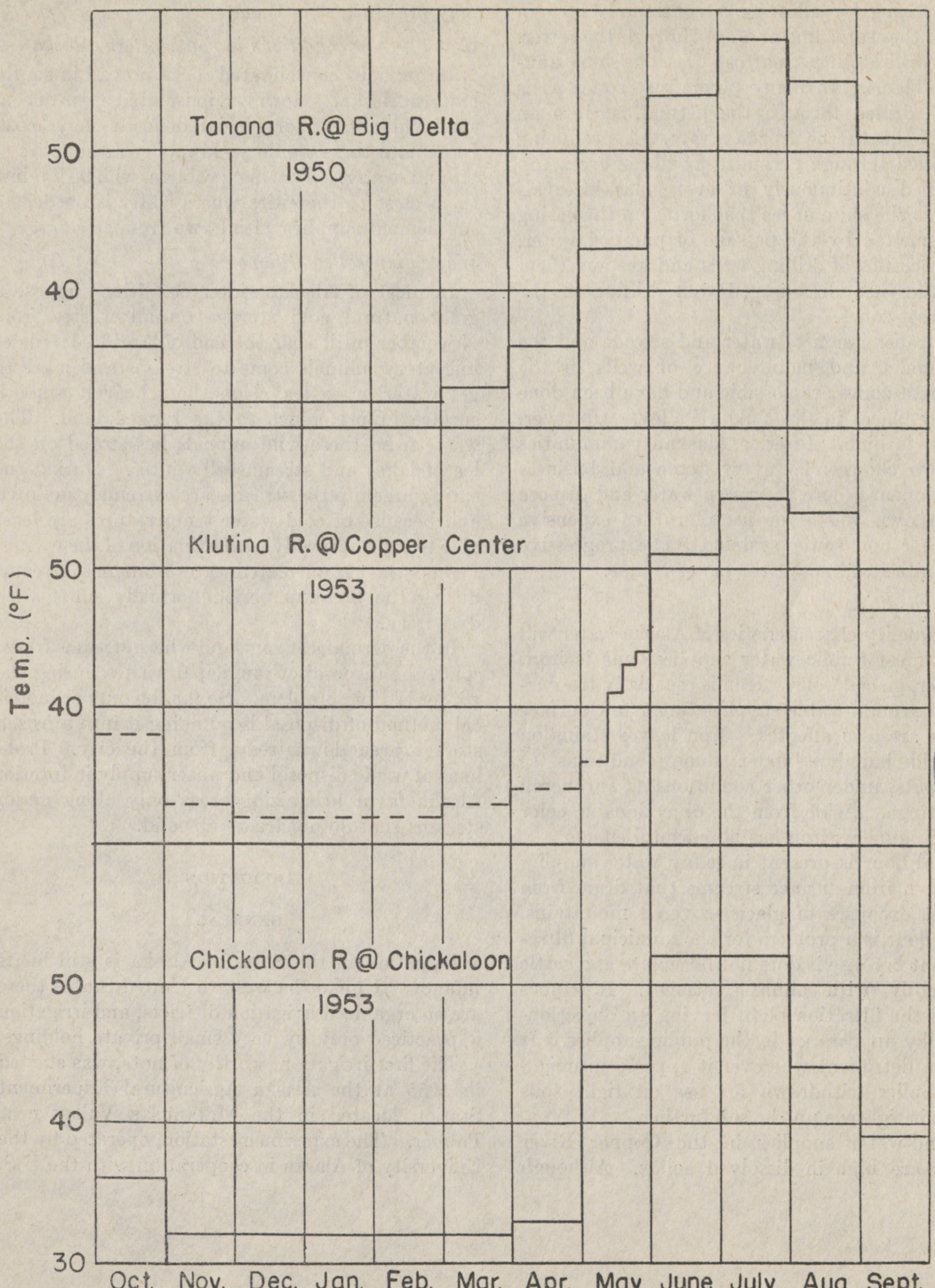
SPECIAL PROBLEMS

Water for communities in Alaska will be supplied only by surmounting several problems that are characteristic of the different regions of the State. All of the problems are natural with the exception of a small part of the pollution problem. Four major problems will hinder development of good water supplies: (*a*) Freezing conditions, (*b*) quality conditions, (*c*) ground-water conditions in southeast Alaska, and (*d*) winter pollution. These are discussed in detail.

Freezing conditions

Throughout the State water-supply systems to be troublefree must be designed to operate under extreme cold. The design problems for areas free of permafrost are no more severe than the same problems in the northern tier of States in continental United States. However, north of the Alaska Range where permafrost conditions prevail, the protection of water transmission systems by entrenching in earth is impossible. Permafrost may be several hundred feet thick, so that the idea of installing water mains beneath the permafrost is impracticable. All water transmission lines in the permafrost areas must be laid on the ground surface and given adequate protection from cold. In some cities and military installations the water and sewer mains are enclosed in an insulated box. Needed warmth can be furnished by maintaining sufficient flow of warmed water or by laying a

Figure 1--Water Temperature Alaska



steampipe with the sewer and water mains. Household lines from the mains are protected from freezing by allowing a continuous flow in through the water line and out through the sewer.

Well drilling in permafrost presents some unusual problems. In many permafrost zones wells may be drilled through the permafrost into an aquifer beneath the frozen strata. A producing well drilled through permafrost will not freeze up if pumped continuously or at regular intervals spaced so the skim of ice that forms on the casing can be melted by the passage of pumped water. The difficulties of drilling wells and keeping them productive has discouraged well drilling in the permafrost zones.

The transmission of water and sewage and the development and maintenance of wells in the permafrost zones are possible and have been done at many places in the Yukon Valley. However, the cost is high. Interior Alaskan communities have two choices: let every home and business establishment secure their own water and dispose of their own wastes or install rather expensive city water and sewer systems. The progressive communities will adopt the latter course.

Quality conditions

Two quality characteristics of Alaska water will trouble most public water supplies: one is iron; the other, glacial flour. Iron is especially troublesome in ground-water supplies but a few surface supplies are also affected. Iron leaves stains on household laundry—under some conditions as black spots, under other conditions as an overall yellow tinge. Aside from the objectionable color effect on laundry, iron has no harmful effects.

Glacial flour is present in many water supplies withdrawn from surface streams that drain from the vast expanses of glacier-covered mountains. Glacial flour is a problem for the municipal filtration plant because it does not flocculate and settle out readily with alum treatment. It comes through the filtration plant leaving an objectionable milky appearance in the public supplies. It will be a detriment wherever it appears in irrigation supplies withdrawn for use on tight soils because it tightens up the soil further.

Ground-water supplies in the Copper River country are high in dissolved solids. Although ground-water supplies might be preferred over surface-water supplies, the high dissolved solids may prevent use of them.

Ground-water conditions in southeastern Alaska

Impervious consolidated rocks prevail in southeastern Alaska. However, in isolated areas unconsolidated alluvial or glacial deposits may exist. In general these would yield moderate supplies of ground water. The big problem will be finding them close to the cities where water is needed to supplement supplies withdrawn from streams.

Waste disposal conditions

In most of Alaska winter conditions impose a great natural cold storage on all wastes from November until near the end of April. Herds of migratory animals come to streams and lakes to get water or to travel on the relatively smooth surface in preference to the rugged land. The waste from these wild animals lies stored on the ice of lakes and streams all winter. During the spring breakup the streams are extremely polluted and because of cold water temperatures are least able to cope naturally with oxidation of the wastes. People who use untreated water from most streams during the breakup period normally suffer with dysentery.

In the permafrost zone and where streams freeze solid, the disposal of municipal wastes during the winter is a big problem. So far the only economical method of disposal is pumping it into a frozen storage area downstream from the city. Problems of waste disposal and water supply in interior Alaska favor urbanizing areas only along major streams that do not freeze up solid.

Irrigation

GENERAL

Irrigation in the State of Alaska is still in its infancy. Unlike the western United States there are no organized irrigation districts, and irrigation is practiced only by very small private holdings.

The first irrigation, worthy of note, was started in 1955 at the Alaska Agricultural Experiment Station located in the Matanuska Valley near Palmer. The experiment station, operated by the University of Alaska in cooperation with the U.S.

Department of Agriculture, has conducted sprinkler irrigation studies through each summer to date, in cooperation with the Soil Conservation Service and the U.S. Bureau of Reclamation.

The topography of the arable lands in Alaska, as well as the soil types, favor the method of applying water by sprinkler for irrigation. Nearly all lands in Alaska require clearing or drainage, or both, to convert them to agricultural uses. Both coniferous- and deciduous-type trees grow in abundance, and high land-clearing costs encourage farmers to make intensive use of their limited fields.

A large percentage of the agricultural land has a shallow soil. North of the Alaska Range permafrost or permanently frozen ground lies within 3 feet of the surface over large areas. On cultivated land where peimafrost exists the permafrost level is gradually lowered, but subsurface soils remain relatively cool. Large canals constructed through permafrost areas would be costly to maintain, and canal structure foundations would remain unstable for many years. Thus, for any large-scale irrigation undertaking in Alaska a closed-pipe distribution system and a controlled application of irrigation water by overhead sprinklers is recommended.

EXISTING DEVELOPMENT

The Alaska Agricultural Experiment Station in the Matanuska Valley reports that only 358 acres were irrigated in the State during the 1959 season. A brief summary of the present farm irrigation by areas is shown on table I–1.

TABLE I–1.—*Irrigated farmland in Alaska, 1959*

	Matanuska Valley	Tanana Valley	Kenai Peninsula	Total
Number of systems in 1959	13	5	1	19
Number of acres covered	270	80	8	358
Acre-inches applied	4	5	2	4

Significant crop benefits through use of sprinkler irrigation have been demonstrated on plot studies in the Matanuska Valley. Irrigation has in general been found to be beneficial during the first part of the growing season, usually May, June and early July. Rainfall is nearly adequate for crop production for the remaining growing season.

In 1958 there were only 21,515 acres of active cropland in the State. The land utilization in 1958 by areas is shown in table I–2.

TABLE I–2.—*Land utilization by areas, 1958*

Area	Total Cropland	Acres Cleared	Acres Irrigated	Acre-inches of water
Tanana Valley	4, 294	910	80	4
Matanuska Valley	13, 556	1, 500	270	5
Anchorage area	1, 126	203	----------	----------
Kenai Peninsula	1, 801	261	8	2
Kodiak and other	315	30	----------	----------
Southeast Alaska	423	3	----------	----------
Total	21, 515	2, 907	358	4

FUTURE REQUIREMENTS

The physical geography and climate of the State of Alaska limit its agricultural potential. Even so, there are probably 3 million acres that could be converted into productive cropland. With increased advances in science and the development of more efficient methods of preparing and using the land, many areas will become economical to develop, and the cultivated area will rapidly increase. The now sparsely settled State can be expected to absorb more inhabitants. This factor alone will increase the demand for locally produced foods.

Irrigation agriculture will supply some of these demands, and it is estimated that by the end of the next half century at least 50,000 acres will be under irrigation. The general location and estimated amount of the probable irrigated acreage for the years 1980 and 2000 are shown in table I–3.

TABLE I–3.—*Present and future irrigation*

Area	Acres irrigated, 1959	Estimated acres of future irrigation	
		1980	2000
Tanana River Valley	80	2, 000	5, 000
Matanuska Valley	270	5, 000	15, 000
Anchorage area	----------	1, 000	2, 000
Kenai Peninsula	8	2, 000	5, 000
Susitna River Valley	----------	5, 000	20, 000
Copper River Valley	----------	----------	1, 000
Kuskokwim Valley	----------	----------	1, 000
Southeast Alaska	----------	----------	1, 000
Total	358	15, 000	50, 000

PROGRAM FOR DEVELOPMENT

The military and civilian population in the Anchorage and Fairbanks areas is the principal consumer of Alaska agricultural products. As this population increases and marketing methods improve, the demand for local produce will increase substantially. The Matanuska Valley near Anchorage and the Tanana Valley near Fairbanks will probably become the first to see irrigation farming on a larger scale.

Annual irrigation requirement will probably vary from one-half to three-fourths of an acre-foot per acre. In some areas the maximum monthly requirement may be 50 percent of the seasonal requirement.

Expanding development of the major existing and potential farming areas (particularly the Susitna and Tanana River Valleys) can also be expected to take place.

The present costs of converting new land into a producing irrigable area in Alaska are from 1½ to 2 times similar costs in the Western United States.

PROBLEMS OF DEVELOPMENT

The major obstacles to agricultural development in Alaska today are land clearing and markets. Establishing local food processing plants would do much to alleviate the latter problem as locally grown foods could then be marketed year around. Specialized land clearing equipment could reduce clearing costs and the practice of irrigation would enable farmers to regulate better the timing of their harvests and insure a dependable source of produce.

Irrigation is presently being practiced by private landowners who have financed their own installations. To provide an irrigation system adequate to serve an overall local need would probably require Federal financing because of the high construction and maintenance costs involved.

In some parts of Alaska permafrost conditions will make agriculture rather difficult because of land settlement. However, sufficient permafrost-free land should be available to cover the agricultural needs of Alaska far into the future.

Hydroelectric Power

The greatest stride in water resource development in Alaska in the last 40 years was the completion of the 30,000-kilowatt Eklutna plant by the Bureau of Reclamation in 1955. This single plant, small as it is, more than doubled the firm installed hydroelectric capacity of the State.

PRESENT USE

Hydroelectric sources presently supply central station power in seven general areas served by electric utilities. Table II–1 lists these areas along with hydroplant installed capacity and firm capacity.

Table II–1.—*Existing usable hydroelectric capacity available for central station power*

General area	Project or development	Capacity-kilowatts		Remarks
		Nameplate	Firm	
Ketchikan	Ketchikan Lakes	4,200	4,200	
	Beaver Falls	6,400	4,000	
Metlakatla	Chester Lake	405	0	Standby only.
	Purple Lake	2,000	2,000	
Petersburg		1,600	1,600	
Juneau	Salmon Creek No. 1	1,600	1,600	
	Salmon Creek No. 2	2,800	2,800	
	Annex Creek	2,800	2,800	
	Gold Creek	1,600	0	Seasonal operation.
Skagway		290	0	Do.
Anchorage-Palmer.	Eklutna	30,000	30,000	USBR project.
Fairbanks	Chatanika	5,625	0	Seasonal operation.
Total		59,320	49,000	

In five of the areas listed in table II–1, hydropower supplied the majority of the utility load. This is illustrated in table II–2.

Table II–2.—*Electric utility service areas where hydropower constitutes major source of supply*

Utility area	1958 utility load kilowatt-hours	Supplied from hydro source	
		Kilowatt-hours	Percent of total
Metlaktla	3,887,000	3,887,000	100.0
Ketchikan	35,871,000	35,871,000	100.0
Petersburg	(1)	(2)	100.0
Juneau	24,402,000	23,501,000	96.3
Anchorage-Palmer	[3] 167,246,000	[3] 149,368,000	89.3

[1] Unknown.
[2] Total.
[3] Does not include military loads. The Eklutna project supplied an additional 17,584,000 kilowatt-hours of nonfirm energy to the 2 military bases in 1958. In 1955 the military had 63,136 kilowatts installed capacity in steam and diesel units.

Numerous small developments supply many of the isolated fish canneries, cold storage plants, mining operations, and lodges and individual homes throughout the State. Most of these plants fall within the range of 2 to 500 kilowatts. In nearly all cases they are not available to supply general utility loads. Quite generally, the actual output capability differs markedly from installed nameplate rating. Furthermore, many are river-run plants designed to supply only seasonal operations. This is especially true in the case of fish canneries. There are no statistics available which would indicate the aggregate capacity of all of these small plants. It is probably true, however, that their total firm year-round capability and use are quite small.

PROGRAM FOR DEVELOPMENT

Normally, programs for meeting power requirements are based on projections of future power usage. However, in this case, there is considerable justification for reversing this procedure because of the change of status of the former territorial frontier to statehood.

It is generally believed that the development of a large block of low-cost power at this time would do more than any other program to encourage the needed industrial growth of the State. The most likely source of low-cost power is hydroelectric.

The Chugach Electric Association, Inc., of Anchorage, has under construction a 15,000-kilowatt Cooper Lake project on the Kenai Peninsula. The project energy will be transmitted to the city of Seward, the Homer Electric Association, and to Anchorage. A second hydroproject presently under construction is Blue Lake. This 6,000-kilowatt project is being built by the city of Sitka. Its ultimate capacity is 9,000 kilowatts. Both Cooper Lake and Blue Lake are scheduled for completion in 1961.

Studies are currently (and continuously) underway by most of the utility systems to determine the best method of meeting power requirements of the immediate future. The city of Ketchikan plans to increase the usable capacity of its Beaver Falls hydroplant by 2,000 kilowatts. Engineering studies are being made for several of the public utilities to determine the feasibility of building small steamplants. Several envision adding new diesel generating capacity.

All of these proposals will provide relatively high cost power. None will provide sufficient incentive to encourage new uses because of the rates charged for this costly power.

A workable Federal development program could be initiated. For the past decade the Bureau of Reclamation has been conducting studies of individual power projects in the State. The often lengthy comprehensive investigation of project feasibility has already been accomplished or is well along in a few instances. Construction of one or more projects could be undertaken at an early date.

Table II–3 provides cost information for four such investigated projects believed to merit consideration for development.

TABLE II–3.—*Potential power projects investigated by the Bureau of Reclamation and estimated costs*

		Capacity (kilowatts)	Year of estimate	Estimated—	
				Construction cost	Firm rate (mills)
Devil Canyon [1]	Entire rail belt.[2]	500,000	1958	$360,000,000	5.0–6.0
Snettisham (Long-Crater Lakes division).[3]	Juneau	48,000	1959	38,400,000	6.3
Lake Dorothy [4]	do	26,000	1955	15,667,000	7.2
Swan Lake [5]	Ketchikan	15,000	1958	16,360,000	11.8–15.4
Total		589,000		430,427,000	

[1] Devil Canyon project (includes Devil Canyon and Denali Dams): Field investigations will be completed in calendar year 1959. Feasibility report programed for March 1960. The 5- to 6-mill rate neglects power market pattern as utilization study has not been completed.

[2] Rail belt: All areas served by the Alaska Railroad.

[3] Preliminary feasibility report completed in July 1959. Power rate of 6.3 mills is based upon power market pattern, which includes construction of a newsprint mill in the area.

[4] Original reconnaissance report completed in 1949. Revised and updated report completed in 1955. Mill rate included power market pattern. Power rate marginal for newsprint mill operation and project too small to supply 30,000-kilowatt newsprint load. Would be a good development to supplement Crater-Long Lakes power.

[5] Original feasibility report completed in 1951. Revised and updated in 1959. The 11.8-mill rate assumes an immediate market for all project power. The 15.4-mill rate develops from assuming power market pattern similar to past and present load growth.

The Devil Canyon project is envisioned as the initial step in the utilization of the Susitna River Basin to supply power to the entire rail belt. Two additional power dams (Vee and Watana) could be built above Devil Canyon Dam, adding more than 500,000 kilowatts of firm capacity to the system. It is believed that this four-dam development of the upper Susitna River should be developed in stages as required load growth is indicated and ultimately more than 1 million kilowatts of power would be installed and marketed at a rate of between 4 and 5 mills.

The Bureau of Reclamation has scheduled initiation of feasibility investigations of the Vee Dam site in fiscal year 1961. Concurrently, an investigation of the Chakachamma project (200,000 kilowatts) will be made.

ESTIMATED NEEDS

There is no precedent within Alaska which would demonstrate what use of large blocks of low-cost power would be made when available.

However, a few indications have appeared from time to time.

In 1952 the Aluminum Co. of America proposed to spend $400 million on construction of an aluminum plant and the initial development of the Yukon-Taiya hydroelectric project near Skagway, Alaska. The location was selected because of the large power potential (presently estimated to exceed 2,500,000 kilowatts of prime power) and its low unit power rate (estimated at about 2 to 3 mills per kilowatt-hour). The plan to divert Yukon River headwaters in Canada for this project was subsequently rejected by the Canadian Government.

Harvey Aluminum Co. has expressed an interest in using a block of the 1,500,000-kilowatt potential of Wood Canyon project on the Copper River. This power has been estimated to cost about 3 mills.

The Georgia Pacific Alaska Co. recently expressed a definite satisfaction with the estimated 6.3 mill cost of power from the potential Snettisham project near Juneau. The company had previously indicated a need for 30,000 kilowatts of firm power for newsprint mill operations. Power costs in excess of 7 mills are generally felt to be too high for such an operation.

Interest has recently been indicated in possible sources of 80,000 kilowatts of low-cost power for processing iron ore deposits at Klukwan near Haines and Port Snettisham near Juneau.

An ammonium nitrate plant to produce fertilizers was at one time considered for location on the Kenai Peninsula. Its low-cost power requirement was estimated at between 10,000 and 20,000 kilowatts.

In connection with its project investigations the Bureau of Reclamation has made recent forecasts for the Ketchikan and Juneau areas. Both assume the availability of project power.

The forecast for Juneau assumes the construction of a newsprint mill in the area and the Snettisham power project (Crater-Long Lakes division) in operation by 1964. Under these assumptions the 1958 area energy requirements of 30,174,000 kilowatt-hours will have increased to an estimated 336,550,000 kilowatt-hours by 1975. Of this total, 230 million kilowatt-hours will be required for industrial use. The peakload in 1975 would probably exceed 53,000 kilowatts.

The forecast for Ketchikan assumes the project would be supplying power by 1964. Under normal load growth conditions and in consideration of the low-cost output of existing generating facilities, a 22-year utilization period is shown for project power. For the area, the 1958 requirement of 36,550,000 kilowatt-hours is expected to increase to about 88 million kilowatt-hours by 1980. The peakload in 1980 would probably exceed 18,000 kilowatts.

It appears probable that the 6,000-kilowatt Blue Lake development by the city of Sitka will be fully loaded shortly after its completion. This will necessitate initiation of work on the city's proposed additional 3,000-kilowatt ultimate development at an early date.

A power-use study is presently underway by the Bureau of Reclamation for the rail-belt area. This projection is being made for the feasibility investigation of the 500,000-kilowatt Devil Canyon project. It will assume that power from the project will cost from 5 to 6 mills.

If Devil Canyon project power could be placed on the line by 1968, utility power requirements increasing at the present rate of 8.2 percent annually would total approximately 117,000 kilowatts. If the cost of Devil Canyon power is between 5 and 6 mills it would be the lowest cost power available, firm or nonfirm. It appears reasonable to assume that at least 60 percent of this total load, which would temporarily be served from high-cost sources, would be transferred to Devil Canyon.

The peak military power requirements by 1968 (based on a percentage of present and proposed installed capacity) are estimated at 80,000 kilowatts. Possibly as much as 25 percent of this could be supplied by the much lower cost hydrocapacity.

The utility requirements of 1980 (excluding military and large industrial) might be expected to exceed 360,000 kilowatts. By supplying a percentage of military requirements and a very minor industrial load, public utility requirements would probably exceed 400,000 kilowatts.

If Devil Canyon project power could be made available for 5 mills in 1968, it is believed that some major industrialization will follow. This added to the above 400,000 kilowatts suggests that the loads of 1980 will require additional major sources of supply, which can be provided by construction of Vee and Watana Dams on the Susitna River.

WATERPOWER POTENTIAL

The potential waterpower in the numerous streams and lakes constitutes one of the valuable natural resources of the State of Alaska. The waterpower sites vary in size from only a few hundred kilowatts to what is considered the largest site on the North American Continent, the Rampart site on the Yukon River which has an estimated potential capacity double that of the Grand Coulee Dam in the State of Washington. Although it is generally known that there are many potential waterpower sites in Alaska, basic or specific data to evaluate them are available for only a comparative few. At present the potential of most of the sites is based on estimates using whatever data and general information are available. In order to evaluate accurately the waterpower potential of a stream, the following information is required:

(1) Data on streamflow and its variation through the year as well as from year to year;

(2) Available fall or head through which the water can be utilized;

(3) Storage possibilities that can be used to equalize the streamflow to conform with the power demands; and

(4) The geologic conditions at the sites of of the various structures required for development such as dam sites, reservoir sites, tunnel routes, and powerhouse sites.

Information on item (1)—streamflow—must be collected over a period of years in order to arrive at reliable estimates of the amounts that can be depended on in making plans for power development.

Information on items (2) and (3) require topographic surveys which can be made within a comparatively short time.

Item (4), geologic examinations, can also be made in a comparatively short time and preferably should follow the topographic surveys so that a base map will be available on which to show the geologic features.

Streamflow records are being obtained at a number of gaging stations throughout the State. There are, however, many streams on which records are not being obtained and in many cases where records are being obtained the location of the gaging station is far removed from the potential waterpower sites. The actual streamflow at specific sites must, therefore, frequently be based on estimated values. Practically all of the streams in Alaska have a very pronounced seasonal variation. On many streams as much as from 80 to 90 percent of the total annual flow occurs within the 5-month period of May through September. For several months during the winter period the flow in most streams is very low. Storage to equalize the streamflow is a requisite for any feasible power development. There are few, if any, streams in Alaska on which a run-of-river installation would be satisfactory.

Information on items (2) and (3) mentioned above require topographic maps of the areas under consideration. All of Alaska is now covered with topographic quadrangles on a scale of 1:250,000, or about 1 inch equals 4 miles. These are general maps and not too helpful in power site studies. Many additional areas are covered by quadrangle maps on a scale of 1 inch equals 1 mile, usually with a 100-foot contour interval. Although these are very useful general purpose maps they do not show sufficient detail to fully evaluate the power potential of a stream. Detailed supplemental surveys of limited areas along the streams are necessary to show the location and characteristics of prospective dam sites and reservoir sites, stream gradients, conduit routes, and powerhouse sites. A program of surveys of this kind, designated as river surveys, has been in progress on a moderate scale in Alaska since 1947.

The Geological Survey's role in the investigations of potential waterpower of Alaska is derived from its responsibility to classify the public lands for minerals and waterpower. The modest appropriation for this activity requires that its program be rigidly selective. For this reason the Survey's program has as its first objective the investigation of sites whose suspected character and location promise earliest development. The wisdom of this studied discrimination is evidenced by the fact that two of the most recent hydroelectric developments in Alaska, the Eklutna project of the Bureau of Reclamation and the Cooper Lake project of Chugach Electric Association, occupy sites for which the pioneering investigations were made and mapping was done by the Survey early in the present program.

The program of the Survey has further placed emphasis on investigation of small sites which could be utilized as power source by single industries such as pulp and paper or lumber mills or municipalities.

Geologic examinations of prospective damsites and reservoir sites are normally made after the topographic surveys have been completed. These are made to determine the feasibility of the sites, from the geologic viewpoint, for the contemplated development. Geologic examination of damsites and reservoir sites is a very necessary part of the investigational program for the evaluation of waterpower. It frequently happens that what appears to be a favorable damsite from topographic conditions is not feasible due to adverse geologic conditions.

As already stated the values for potential power given for Alaska are for the most part estimates rather than determinations from basic data. Until more basic data are obtained these estimates are, of course, the only figures that are available. There are three main sources of information on power estimates for Alaska, viz:

1. "Water Powers, Southeast Alaska," Federal Power Commission and Forest Service, 1947.
2. "Reconnaissance Report on the Potential Development of Water Resources in the Territory of Alaska, Bureau of Reclamation, 1952" (H. Doc. 197, 82d Cong., 1st sess.).
3. Corps of Engineers "308" reports.

The latter are similar to the reports prepared for other sections of the United States.

The estimated potential power according to the main geographic subdivisions of Alaska as summarized from these reports is listed below:

Estimated potential waterpower in Alaska by regions [1]

Region	Number of sites	Prime power (kilowatts)
Southeastern Alaska	83	400, 000
Cook Inlet and tributaries	21	1, 020, 000
Copper River and gulf coast	17	2, 100, 000
Tanana River Basin	15	290, 000
Southwestern Alaska	16	376, 000
Northwestern Alaska	8	370, 000
Yukon and Kuskokwim River Basins	8	8, 600, 000
Total	168	13, 156, 000

[1] Summarized from data prepared for distribution at the Alaska Chamber of Commerce Convention, Oct. 23–25, 1958.

Most of the information available on potential power is based on estimates rather than on actual surveys and basic data. The Geological Survey has since 1947 been carrying on a modest program of field surveys and investigations of various streams and lakes in order to accurately evaluate the waterpower potential of Alaska. The objective of this program is to arrive at a complete inventory or catalog of all of the waterpower sites in Alaska with pertinent information relating thereto. The Geological Survey, however, does not prepare actual designs or cost estimates as that is beyond the scope of its responsibility. Its responsibility is rather to point out the existence of prospective power sites and obtain the basic physical information that will be needed by those that will actually prepare the plans and carry out the development.

The field surveys have consisted of topographic surveys to obtain information not adequately shown on other available maps. Geologic investigations have been made at a number of damsites and reservoir sites in order to evaluate their geologic feasibility for power development. Following the topographic surveys and geologic investigations reports have been prepared showing the potential waterpower and the conditions that would be encountered in actual development.

The maps and reports resulting from the investigational program started in 1947 are listed below. The maps have been published in accordance with standard Survey procedure. The reports, with three exceptions, have not been formally published but have been placed in open file and are thus made available for the use of the public.

RIVER, RESERVOIR, AND DAMSITE MAPS

Eklutna Lake.
Little Susitna River, Cottonwood Creek, Wasilla, Cottonwood and Finger Lakes.
Eagle River.
Ship Creek.
Grant Creek and Grant Lake near Seward.
Ptarmigan Lake near Seward.
Cooper Lake near Seward.
Crescent Lake near Seward.
Seldovia River and Seldovia Lake near Seldovia.
Power Creek near Cordova.
Sheep Creek and Carlson near Juneau.

Long Lake, Crater Lake and vicinity near Juneau.
Scenery Creek and Scenery Lake near Petersburg.
Cascade Creek and vicinity near Petersburg.
Lost Lakes near Seward.
Bradley River and Bradley Lake near Homer.
Kenai River, Skilak Lake to Kenai Lake.
Kenai River, Moose River to Skilak Lake.
Kasilof River, Mouth to Tustumena Lake.
Juneau Lake and vicinity near Seward, Alaska.
Snow River on Kenai Peninsula near Seward.
Kasnyku Lake, Baranof Island.
Takatz Lake, Baranof Island.
Baranof Lake and Carbon Lake, Baranof Island.
Lowe River, mile 12 to mile 21, near Valdez.
Duck River and Silver Lake near Valdez.
Chilkoot Lake near Haines.
Miscellaneous damsites (Tanana River, Chickaloon River, and Carter Lake).

Reports on potential waterpower and geology of powersites

The following reports on waterpower resources and geology of powersites have been prepared and placed in open file:

Preliminary report on waterpower resources of Eklutna Creek, Alaska, by Arthur Johnson, 1947.

Preliminary report on the geology along the route of a proposed tunnel to develop hydroelectric power from Eklutna Lake, Alaska, by F. F. Barnes, 1947.

Reconnaissance report on geology of Eklutna Lake damsite and conduit route near Anchorage, Alaska, by A. F. Bateman, Jr., 1947.

Preliminary report on waterpower resources of Little Susitna River and Cottonwood Creek, Alaska, by F. F. Lawrence, 1949.

Reconnaissance report on geology of lower Eagle River Valley, Alaska, by A. F. Bateman, Jr., 1948.

Report on water utilization, Ship Creek near Anchorage, Alaska, by J. L. Colbert, 1950.

The potential waterpower of Grant, Ptarmigan, Cooper, and Crescent Lakes near Seward, Alaska, by Arthur Johnson, 1955.

Geologic investigations of proposed powersites at Cooper, Grant, Ptarmigan, and Crescent Lakes, Alaska, by George Plafker, 1954 (published as Geological Survey Bulletin 1031-A).

Preliminary report on the waterpower possibilities of the Seldovia River, Alaska, by F. A. Johnson, 1954.

Preliminary report on waterpower resources of Power Creek near Cordova, Alaska, by Arthur Johnson, 1949.

Geology at the site of a proposed dam and reservoir on Power Creek near Cordova, Alaska, by D. J. Miller, 1951 (published as Geological Survey Circular 136).

Waterpower resources of Scenery Creek near Petersburg, Alaska, by F. F. Lawrence, 1950.

Waterpower resources of Cascade Creek, Scenery Creek, and Delta Creek near Petersburg, Alaska, by J. L. Colbert, 1955.

Geology of waterpower sites on Cascade Creek, Scenery Creek, and Delta Creek near Petersburg, Alaska, by J. C. Miller, 1955.

Geology of proposed Blue Lake damsite and tunnel near Sitka, Alaska, by W. S. Twenhofel, 1950 (published as Geological Survey Circular 147).

Preliminary report, waterpower possibilities of Bradley Lake, Alaska, by F. A. Johnson (with chapter on "Tentative Geologic Conclusions on Bradley Lake Powersite" by Kenneth S. Soward), 1956.

Waterpower possibilities of Sheep Creek, Carlson Creek, Lake Dorothy, and Turner Lake near Juneau, Alaska, by F. A. Johnson, 1957.

Waterpower possibilities of Crater Lake, Long Lake, and Speel River near Juneau, Alaska, by F. A. Johnson, 1955.

Geology of waterpower sites on Crater Lake, Long Lake, and Speel River near Juneau, Alaksa, by J. C. Miller, 1956.

Geologic investigations of proposed Sheep Creek, Carlson Creek, and Turner Lake power sites, by George Plafker, 1956.

As stated above, the potential waterpower projects in Alaska vary in size from a few hundred kilowatts to hundreds of thousands with several over 1 million kilowatts. Although the large ones are the most spectacular and challenging to the imagination, their development must be accompanied by the establishment of some industrial enterprise that requires large blocks of power. In most instances the potential power sites are not near existing communities or areas that would be susceptible to industrial development. The power must therefore be brought from the point of generation to the point of use. The distances involved, in general, are not particularly long when compared with transmission distances within the 48 contiguous States. However, construction costs in Alaska are high and the financing of high voltage transmission has not been justified in the past. Also in many areas waterways or fiords must be crossed, requiring submarine cable installations, and in other areas steep mountainsides cannot be avoided in the location of transmission line routes. Only after initiation of construction of sizable power plants can major transmission be justified.

The subject of the possible locations of industrial sites at which fairly large blocks of power could be used is discussed for an area in southeastern Alaska in Geological Survey Circular 280, "Potential Industrial Sites in the Lynn Canal Area, Alaska."

Industrial and Municipal Water

PRESENT USES

Existing municipal and industrial use of Alaska's water resources are very insignificant against available water resources. The major population centers are located within the Ketchikan, Juneau, Anchorage and Fairbanks areas. Their present municipal use approximates 13.3 million gallons per day. Municipal use for the balance of Alaska would not approach this amount.

A pulp mill located at Ketchikan, Alaska, is presently the chief user of water for industrial purposes. Its water requirement is about 75 cubic feet per second. A second pulp mill is presently under construction at Sitka and is scheduled to go into operation in 1960. Other important industrial uses of water are for steam generating plants, placer mining, and salmon canneries. These uses are very indeterminate.

FUTURE USES

With statehood and the increased interest in oil exploration, mining, timber, agriculture, hydroelectric development, and the allied industries associated with these resources, it is expected there will be a significant increase in water use in future years. The water requirements for industrial purposes will expand more rapidly than for municipal use.

With the numerous lakes, streams and rivers throughout the State, stream depletion is not expected to become the problem that exists in other states. By the year 2000 water supply should pose no problem.

The demand for water for added industrial and municipal purposes in Alaska will develop slowly in the next few years and then will gain momentum. It is estimated that by 1980 the requirements will be double the present requirements and by the year 2000 it will be quadrupled. Thus, excluding irrigation water requirements, the water use for 1980 for industrial and municipal purposes would amount to only 500,000 acre-feet, and for the year 2000 the water use would be about 1 million acre-feet. This is a very small percentage of Alaska's surface water runoff.

Fish and Wildlife in Relation to Water-Resource Development in Alaska

IMPORTANCE OF FISH AND WILDLIFE

The wildlife resources of Alaska—fur animals, game birds, game animals and, above all, commercial and game fishes—represent a greater per capita wealth than is the case with any one of its sister States. Since its purchase by the United States in 1867, fur trading and commercial fishing have been—and still remain—Alaska's principal industries. In addition to being of commercial significance, these resources are of national interest in that Alaska is the last preserve for many valuable species of game animals still remaining under the American flag.

In Alaska today, the fish and wildlife resources still provide food and clothing for aboriginal populations along the Bering and Arctic seacoasts as well as along the interior rivers of Alaska such as the Yukon and Kuskokwim. It has been estimated that between 700,000 and 1 million salmon are taken from the Yukon River by Eskimos and Indians for human food as well as dog food. Items of clothing such as parkas, boots, and gloves are made from the hides and pelts of various wildlife species. Trapping and the selling of furs is often the only source of cash income for many of the native peoples.

In terms of income to the State and Nation, the commercial fisheries and fur resources are of primary importance. The most significant cash contribution comes annually from the commercial species of fish such as salmon, halibut, herring, and shellfish. Of these species, salmon is most valuable in sustaining the industry. During 1956 the wholesale value of these resources was $95 million. During this same year, 26,000 individuals were employed in this basic industry of the State. A further contribution in terms of direct cash income to the State and Nation is found in the production of fur-seal pelts from the Pribilof Islands. As an example of this species' worth, in 1956, 53,907 pelts were sold for $5,235,000. Although of less importance in recent years, the land furs of Alaska are of significant value. In 1952, almost $2 million worth of raw furs were trapped in Alaska.

The recreational value of sport hunting and fishing may best be demonstrated by the fact that, in 1958, more than 59,000 licensed hunters and fishermen spent an estimated 993,000 man-days hunting and fishing. In terms of money, these 59,000 licensees spent more than $16 million in pursuit of fish and game. In the urban areas such as Juneau, Ketchikan, Fairbanks, and Anchorage, large portions of the white residents supplement or rely on big-game animals for their annual meat supply. In 1954, it was computed that over 1,800,000 pounds of moose, caribou, and deer were consumed by white residents of Alaska.

IMPACT OF EXISTING WATER DEVELOPMENTS ON FISH AND WILDLIFE

To date, water development projects in Alaska have been small in size and few in number and the overall impact on the fish and wildlife resources has been negligible.

A few small power projects licensed under the Federal Power Commission have been developed within the State. These projects have generally been located in areas of low fish and wildlife populations. Their effect, therefore, on fish and wildlife has generally been negligible. Provisions of minimum flows downstream from the dams have usually helped to minimize losses to both sport and commercial fisheries involved.

The only Federal hydroelectric development in the State is the Eklutna project located between the towns of Anchorage and Palmer. This project, completed in the early 1950's, is located in an area almost devoid of fish and wildlife. Therefore, no effect was sustained by fish and wildlife resources.

In addition to power projects, other water development projects throughout Alaska have included the construction of small boat harbors and the dredging of channels. These projects have usually resulted in no adverse effect on the fish and wildlife species of the area. An indirect, although significant, benefit of these projects has been the development of safe facilities to the advantage of the commercial and sport fishermen who utilize harbors and channels.

A few flood control projects of a minor nature have also been constructed throughout Alaska and their overall effect on fish and wildlife populations has been insignificant.

FISH AND WILDLIFE RESOURCES AND FUTURE WATER DEVELOPMENT

In recent months, plans for exploration and development of Alaska's timber and mineral wealth have been greatly accelerated; concurrently, interest in the development of the water power potential and other water developments in general has soared. Inevitably, the alteration of natural flow patterns will produce conflicts, the disposition of which will vitally affect the future of wildlife and fish in Alaska.

An example of how immense the proposed projects and their associated problems may be is found in the Corps of Engineers proposed plan of development for the vast Yukon and Kuskokwim River Basins. This plan proposes construction of dams at eight sites in the Yukon and one site on the Kuskokwim. The total area of the resulting impoundments would exceed 22,500 square miles, a significant portion of Alaska's total land area of 586,400 square miles. Rampart Canyon impoundment alone would surpass Lake Erie in surface area.

The impact of the Rampart Canyon project upon the fish and wildlife resources would be tremendous. Facilities to permit the passage of salmon and other migratory species over the proposed 500-foot dam would be extremely expensive. Since the problems of passage of fish at high dams have not been solved, it is expected that a significant portion of the Yukon salmon runs would be destroyed.

Aside from the anadromous fish, resident species, such as sheefish, whitefish, grayling, northern pike, and burbot would be affected through loss of stream habitat, particularly spawning and rearing areas. Resultant habitat changes might permit less desirable fish species to flourish and overwhelm the natural populations now present. The native people living in the small villages of the Yukon Basin depend heavily for food upon these resident fish populations, as well as upon the salmon runs.

Of the big game, bands of the nomadic caribou, numbering up to 45,000 animals, have been observed to cross the Rampart impoundment area repeatedly within the course of a single year. The disruption of their historic migration routes might constitute a mortal blow to their vast herds. Critical wintering grounds for moose—the birch willow stands of the stream courses—would be lost through inundation. Inevitably, populations of moose would decline. The grizzly and black bear of the area would also suffer loss of habitat.

Fur bearers—mink, marten, muskrat, beaver, and lynx—as well as small game animals, would be virtually eliminated through inundation.

One of the most productive waterfowl breeding grounds of this hemisphere—the Fort Yukon Flats—would be destroyed. Total annual production of this extensive marsh-pond area is estimated at 540,000 ducks and geese. Scaup banded on the Fort Yukon breeding grounds have been recovered in the Mississippi and Atlantic flyways. White-fronted geese migrate from the Yukon chiefly down the Central flyway, while the puddle ducks and Canada geese travel through the Pacific flyway. Loss of nesting and rearing habitat in the Rampart Canyon impoundment area would sharply affect the success of American waterfowl hunters, particularly those of the Pacific coast.

Two plans of international interest have been advanced for harnessing the hydroelectric potential of the upper Yukon in Canada involving the large lake system. The Taiya project, formulated by the Bureau of Reclamation, would raise the level of the headwater lakes by impounding additional water. Flows of 2,800 cubic feet per second would be diverted to a tidewater powerhouse at Taiya Inlet near Skagway. A second plan proposed by Canadian interests is similar except that the flows would be diverted through Sloko Lake, thence, to a powerhouse at Tahi Creek in the Taku River Basin. Other developments of international concern are located on the Unuk and Iskut Rivers. As in the upper Yukon developments, the primary fish and wildlife interest of this country would be the maintenance of adequate flows downstream to permit for anadromous fish runs harvested by American fishermen.

The Bureau of Reclamation's proposed plan for the Susitna River Basin involves 12 major sites. Present information indicates that anadromuso fish do not migrate upstream beyond Devil Canyon, the site proposed for earliest development. However, downstream effects on these fishery resources would require consideration; perhaps suitable water releases might be prescribed. Although the Devil Canyon impoundment would not inundate a significant area, additional storage would be required to permit full utilization of the flows available. This would require development of an additional site upstream from Devil Canyon—the Denali Reservoir. As in the large Yukon reservoirs, a large block of wildlife habitat and some resident stream fish habitat would be flooded. Because of the access provided by the Denali Highway running from Paxson to Mount McKinley Park, hunting pressure for moose and caribou is substantial, although present information dealing specifically with the impoundment area is scant. Reduction of the available moose habitat and disruption of the caribou migration route probably would lead to eventual reduction in the herds themselves. Waterfowl nesting and rearing habitat would also be adversely affected.

The Central Alaska Power Association currently holds a preliminary permit from Federal Power Commission for the proposed Wood Canyon hydroelectric development on the Copper River. The project would consist of a dam 560 feet high and a reservoir extending 51 miles up the Copper River and 55 miles up the Chitina River. Considerable amounts of habitat for moose, black and grizzly bear and bison would be lost through inundation. The Copper River delta, which is one of the finest waterfowl-producing areas in Alaska, may be affected by the proposed development. The Copper River is one of the most important salmon producing streams in Alaska. From 1951 through 1955 the average annual value of the total salmon pack was $2,617,000. Since most of the salmon spawn above the proposed dam site, this important resource is in jeopardy.

There are more than 200 power sites of southeastern Alaska, and several similar projects in westward Alaska. These sites are small when compared with projects such as those proposed for the Yukon and Copper Basins. These smaller drainages typically include a glacially formed valley with steep, bare-rock sides and a good dam site on the outlet stream of an existing lake. In general, the area inundated would be relatively small—on the order of several hundred acres; thus, reductions in wildlife habitat produced by development would not be extensive. Some of the lakes, particularly those over 1,500 feet in elevation and possessing cascades in their outlet streams, are impassable for fish. Where a resident fish population is present, or where conditions make stocking feasible, maintenance of a population under project operation may require periodic stocking since project operations may preclude natural reproduction.

In nearly all smaller projects, Dolly Varden trout and pink and chum salmon utilize the lower reaches of the outlet stream. Dewatering of the stream may follow project development, making mandatory a water release of proper temperature for fish maintenance. Whereas losses incurred by a single project might appear negligible in some cases, several such projects might comprise a significant portion of the total salmon resource.

Several types of nonhydroelectric developments also will affect the fish and wildlife resources. The logging of southeastern Alaska's overaged stands of spruce, hemlock and cedar will require such facilities as roads, camp grounds and gravel sources. Roads constructed by the State highway department will also require gravels for fill and topping. In many cases, the only gravel sources available involve streams, most of which sustain runs of pink and chum salmon or trout. Care must be taken in the construction of bridges and culverts to assure that they will not impede runs of these migratory fish.

Water requirements for pulp mill operation will also provide fishery problems for the future.

PRESERVATION AND ENHANCEMENT

The prospects for mitigating or enhancing fish and wildlife resources in the face of many of the large projects proposed to date are not promising. In certain cases, access will be improved due to roadbuilding activities associated with the project. Fundamentally, however, these large project developments will constitute an exchange of extensive game habitat, waterfowl breeding grounds, excellent sport fish streams, and salmon spawning areas for a large reservoir which may offer some sport fishing and, perhaps, some commercial fishing. Such an exchange can in no way be construed as benefiting aesthetic recreational or commercial fish and wildlife values; further, no means for adequately mitigating resultant losses may be foreseen.

At the present time, in a State where nearly the entire land area is virgin wilderness, the need for reserving streams and other water areas for fish and wildlife is difficult to discern. Certainly, such a reservation wherein water development would be prohibited, and management would be aimed entirely toward the fish and game resources, would not mitigate losses which might occur if the large hydroelectric projects proposed to date are constructed.

On the smaller projects, losses are generally simpler to compensate by such stipulations as those for water releases, fish stocking, and free public access. Future techniques, including the creation of artificial spawning channels, may improve mitigation possibilities on these smaller projects.

The U.S. Fish and Wildlife Service will continue to study and report on Federal and federally-licensed water-use projects in the interest of conserving and, where feasible, enhancing fish and wildlife resources. This work will be carried on under authority of the Fish and Wildlife Coordination Act in cooperation with the Alaska Department of Fish and Game.

Recreation

GENERAL

Today one of the biggest challenges Alaska has is the education of her people to the realization that their destiny lies in the prudent use of her fish and game, minerals, agricultural lands, forests, and waters, and her enormous and compelling recreation resources. Nowhere else in our Nation is there such a vast wilderness region left and in many respects the superlative scenic attractions are unique in the Nation or perhaps in the world. The recreation resources of Alaska have demonstrated their attractiveness. Already they are the basis of a business worth nearly $19 million annually to the State.

Tourist recreation ranks third or fourth among the sources of new production dollars annually. According to a study made of all Alaska travel between June 1, 1952, and May 31, 1953, there were 22,500 tourist visitors during that time who spent over 7 million new dollars in Alaska.

Recreation resource utilization is a realistic need, not only in aid of Alaska's economy in the tourist industry, but also in gaining further social stability and security among her citizens.

The population of Alaska in 1950 was 128,643, only 22.5 persons per 100 square miles and 26.6 percent of them lived in the six urban places having over 2,500 population. This sparse and unevenly distributed population calls for provision of recreation facilities in and near the urban centers where residents of the State may meet for healthful and companionable recreation. Beyond the immediate vicinity of the urban areas, the recreation objective should be to provide opportunities for tourists and residents to enjoy the natural recreation resources of the State.

The hundreds of natural lakes in Alaska have great recreational potentialities. This is particularly true in the southeast and southwestern regions where the scenic attractions are greatest and where the future population increase is likely to occur.

EFFECTS OF WATER RESOURCE DEVELOPMENT

The harnessing of Alaska's water resources for power production may create some impoundments that would receive recreation use and construction of roads would open heretofore inaccessible regions to exploitation for recreation purposes such as hunting and fishing. However, it appears that many of the potential reservoir sites are too far removed from population centers to justify developments for recreation and most reservoirs would be competing recreationally with the numerous natural lakes.

PRESENT USE AND FUTURE NEEDS

The development of recreation resources requires the provision of public use areas. Water supplies will be needed in such areas for domestic, sanitary and fire protection purposes and possibly small hydroelectric developments.

The National Park Service administers the following four areas in Alaska:

Name	Location	Gross acreage	1958 attendance
Glacier Bay National Monument	Coastal	2,274,595	5,130
Katmai National Monument	do	2,697,590	727
Mount McKinley National Park	Inland	1,939,493	25,906
Sitka National Monument	Coastal	54.33	12,796

Unfortunately, travel figures for Glacier Bay and Sitka National Monuments are only available for 1956 and later, and records of the other two areas do not provide conclusive trends because of the strong influences of the economic cycles, recent transportation improvements, and increased public accommodations which are now being provided. However, the trend at Mount McKinley National Park since 1930, at Sitka National Monument since 1943, and the brief records at the other two monuments all suggest that there will probably be at least 100,000 visitors per year at all the areas by the year 2000.

Present water supplies and development programs are only based on the probable needs between 1966 and 1975, when only a small part of the increased demand will materialize. However, no water shortages are anticipated although several wells of individual small yield will doubtless be needed for one water system in some areas. Several water systems must be operated throughout the year, with resulting problems of frostproofing, but most water systems are only needed and used during the summer travel season.

Sitka National Monument is supplied from the adjacent town of Sitka, which now has adequate water of good quality.

Present water supplies at Glacier Bay are from streams. The major development at Bartlet Cove is supplied with water from Alder Creek whose samples occasionally show bacterial contamination of unknown origin. Well supplies are being considered for this and other developed areas if the ample surface waters are found unsuitable. Development plans are still in a formative stage.

There is now only one Federal water system in Katmai National Monument, and an offshore fish cannery maintains another. Additional supplies will be obtained from both streams and wells. Existing wells suggest that the headquarters area can be supplied throughout the year by a number of wells, each of which have individual yields of about 500 to 700 gallons per hour from depths of 110 to 140 feet, and necessary storage. More wells and storage can be provided as needed.

There are now two all-year water systems, and three summer systems at Mount McKinley, and four additional summer systems are proposed. The all-year supplies for the hotel and headquarters areas are now supplied from streams, and reduced winter flows and frozen pipes cause winter problems, and heated conduits are proposed. Other supplies from springs and streams will be for summer use and the systems are drained in the winter. Where well supplies are, or will be provided, the well depths and yields are limited because of permafrost at a depth of 8 or 10 feet. Some stream supplies show bacterial contamination and require treatment.