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Alaska. Department of Community and Regional Affairs

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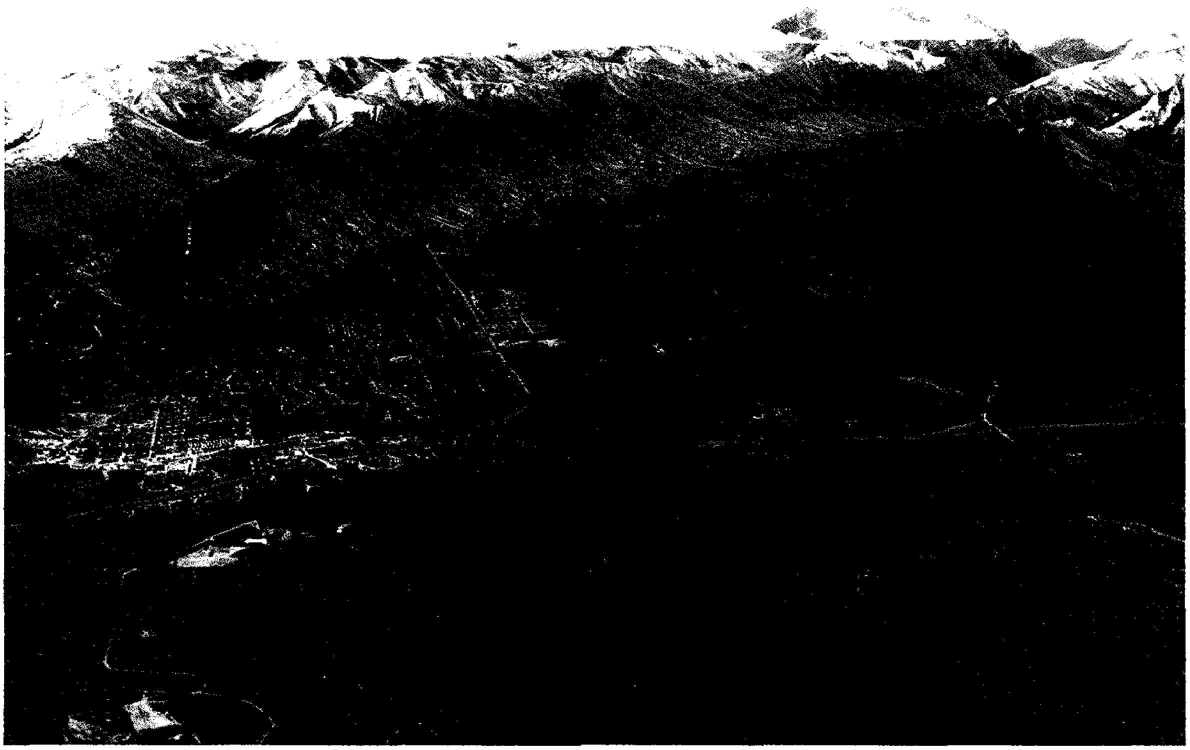
EXECUTIVE SUMMARY

Eagle River Water Resource Study



Municipality of Anchorage
Water and Sewer Utilities

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CH2M HILL

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PREFACE

In 1980 the Municipality of Anchorage retained CH2M HILL to investigate the potential of the Eagle River Valley to provide 70 million gallons per day (mgd) of water necessary to meet demands projected through the year 2025. This projection was based on the 1979 U.S. Army Corps of Engineers Metropolitan Anchorage Urban Study (MAUS), which indicated the need for an additional 70 mgd by 2012 and 81.5 mgd by 2025. Combined with planned increases in supply from within the Anchorage Bowl, the additional Eagle River source would meet these demands.

Initially, the study comprised four tasks:

- Task 1. A well-drilling program to study the feasibility of developing the Eagle River Valley as a groundwater source.

- Task 2. A preliminary damsite investigation to determine the feasibility of developing the Eagle River as a surface water source.

- Task 3. A study to determine if glacial rock flour--material entering the water through glacial melting in the Eagle River--could be easily removed.

- Task 4. A preliminary design of a pipeline to transport groundwater or surface water from the Eagle River Valley to Anchorage.

During the execution of these tasks, serious concerns developed regarding the use of Eagle River as a water source for the Municipality of Anchorage. As a result, another task was added:

- Task 5. An investigation of Eklutna Lake as an alternative water source for the Municipality.

This executive summary is a concise presentation of the work done in the study, the conclusions reached, and the recommendations developed as a result. Detailed descriptions and discussions of each task will be found in the five separately bound appendixes to this summary. The preliminary plans and specifications developed in Task 4 are included in Appendix IV.

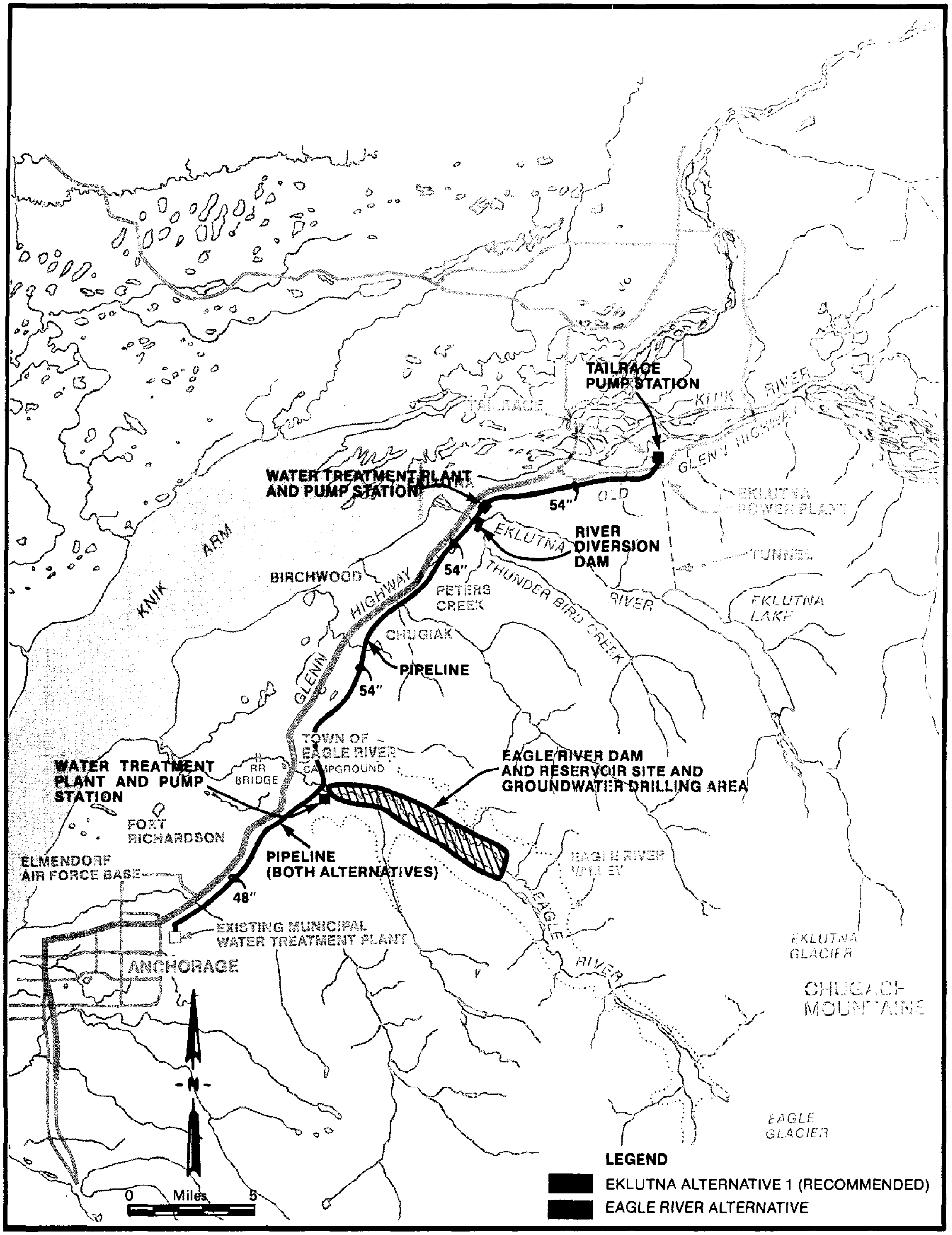

Figure 1
Area Map

SUMMARY

Three potential sources of water to meet the Municipality of Anchorage's projected future needs were investigated in this study: Eagle River Valley groundwater, the Eagle River itself, and Eklutna Lake. The results of the study indicate that the anticipated groundwater source does not exist. Further, while it is technically feasible to construct the proposed dam and reservoir concept, its difficult location and the array of uncertainties and unknowns that will have to be addressed would almost certainly incur sharp additional costs and significantly extend the construction schedule. Because of these considerations, and as the discussion that follows will detail, the Eagle River Valley should not be considered the most viable water source for the Municipality of Anchorage. On the other hand, the Eklutna Lake alternative presents fewer problems and its development should be pursued by the Municipality.

Both the initially proposed Eagle River project elements and the recommended Eklutna Lake concept are shown in Figure 1.

EAGLE RIVER GROUNDWATER

The Eagle River Valley is located approximately 18 miles northeast of Anchorage in the Chugach Mountain Range. Eagle River groundwater was identified by the Municipality of Anchorage as the preferred source, rather than surface water, because its development would have much less environmental impact. It was also expected to require substantially less treatment. To obtain a quantitative estimate of the availability of groundwater, CH2M HILL conducted a well-drilling and testing program in an area identified by the U.S. Geological Survey 4 miles upstream of the confluence of the Eagle River and its South Fork.

Five wells, ranging from 130 to 765 feet in depth, were drilled in this area. Two additional wells were drilled in search of deep aquifers near the proposed damsite 2 miles downstream of the mouth of the South Fork. An eighth well was drilled near the mouth of the South Fork to evaluate the potential there for a shallow groundwater collection system.

The investigation established that low-permeability silts and clays make up most of the middle Eagle River Valley, and although some shallow groundwater potential does exist, the low winter flows of the Eagle River could not recharge shallow aquifers. These aquifers therefore could not sustain year-round demand.

As indicated by the well-drilling program results summarized in Table 1, no aquifers were discovered that could produce enough water to meet the projected Municipality of Anchorage demands.

Table 1
TEST WELL DATA

Well No.	Location	Depth of Well (ft)	Depth of Bedrock (ft)	Aquifers
1	Upstream Study Area	314[a]		Poor or None Found
2	Upstream Study Area	765	750	Poor or None Found
3	Upstream Study Area	350		Poor or None Found
4	Upstream Study Area	130		Poor or None Found
5	Upstream Study Area	305		Poor or None Found
6	Downstream Study Area	160	130	Poor or None Found
7	South Fork Study Area	50		Poor or None Found
8	Downstream Study Area	88	74	Fair

[a]Depth at which glacial till boulder was encountered.

EAGLE RIVER WATER STORAGE

To meet the projected Municipality of Anchorage water demand through 2025, the proposed Eagle River dam and reservoir complex would have to store a sufficient quantity of water during late summer and fall to provide a constant supply of 70 mgd to a treatment plant.

A study was conducted to determine which of two suggested damsites, both located between the Eagle River Campground and the South Fork, would best meet this requirement. As well as establishing and analyzing major design considerations, the effort included hydrologic and hydraulic analyses, geological studies including field exploration and examination of subsurface conditions, a survey of potential environmental concerns, and examination of construction considerations including preliminary costs and permit requirements, and an analysis of operational and maintenance considerations for the entire complex.

Preliminary damsite investigations were conducted for each site to size dams that would form reservoirs capable of meeting a constant diversion of 73 cfs (47 mgd) and 108 cfs (70 mgd). These investigations led to the selection of the lower damsite, located 1-1/2 miles east of the Glenn Highway bridges. The analysis also indicated that it would be more practical to construct at the outset a dam that would provide the ultimately desired water supply; staged construction would not substantially decrease the cost of the dam. To provide 70 mgd, the dam would need to be only 6 feet higher (approximately 80 feet total height) than would be required to provide 47 mgd. The proposed dam and reservoir (shown in Figure 2) would be constructed of compacted earth fill and would have a crest length of about 800 feet. The embankment would have a nominal crest elevation of 350 feet National Geodetic Vertical Datum (NGVD). The normal pool surface would be at elevation 338 feet, with a reservoir surface area of 2,530 acres and a total storage volume of approximately 56,000 acre-feet. The maximum pool surface, achieved only under the most critical flood conditions, would be at about elevation 344.5 feet, with a reservoir area of approximately 2,840 acres and a total storage volume of 72,000 acre-feet.

The spillway structure would be a relatively complex reinforced concrete chute with a horizontal apron stilling basin. Spillway discharges would be controlled by three 30-foot-square movable radial gates. Two 10-foot-square low-level outlet conduits would be provided for reservoir drainage and summer sediment bypassing, and a 3-foot-diameter outlet pipe would provide water for minimum streamflow and fish facilities.

To minimize sedimentation, careful regulation of the reservoir would be required. The low-level outlet gates would be open during the summer and the reservoir would be nearly empty to

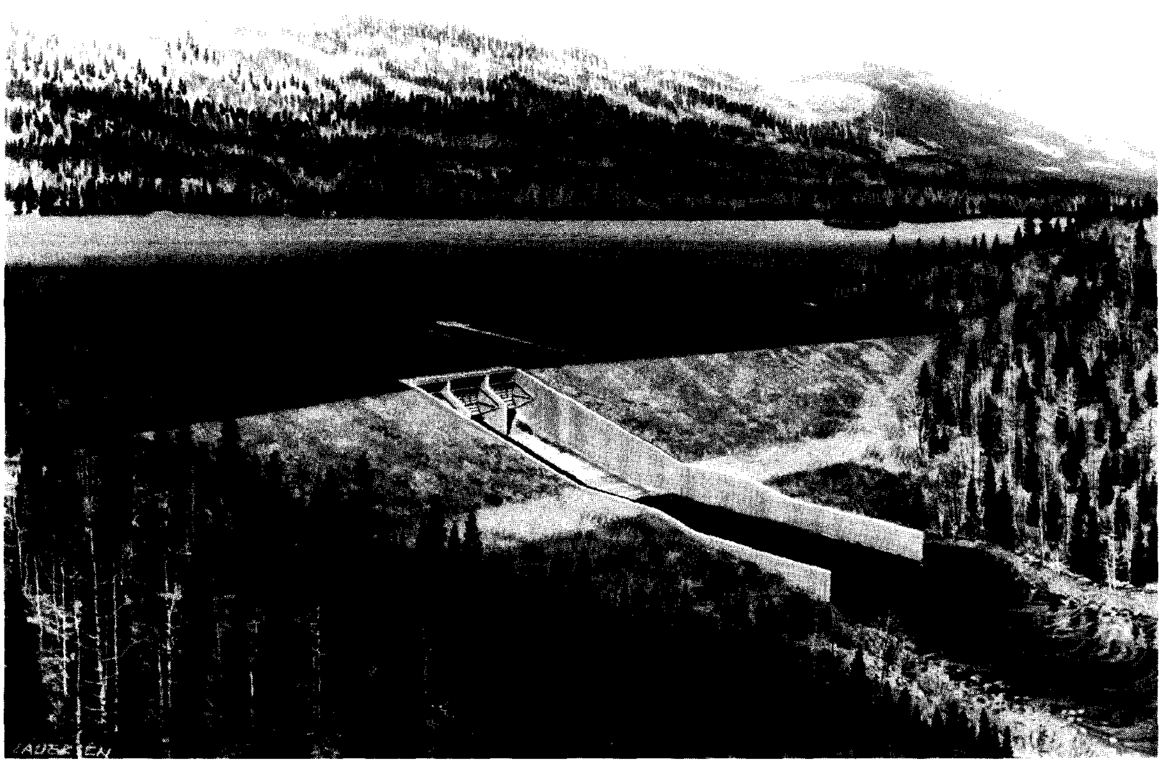
Proposed Eagle River Dam and Reservoir

Figure 2
Proposed Eagle River Dam and Reservoir

allow passage of the high-sediment-laden flows. During late August the low-level outlets would be closed to begin storing water for later use. The minimum downstream releases would be met at all times.

The reservoir would normally fill by mid-October and would be drawn down as needed to meet the water demand during the winter and spring. On about May 1, when river flows are sufficient, the low-level outlets would be opened and the reservoir almost totally drained. This would return the river to a nearly natural condition. If the reservoir were not lowered, the dam would have to be constructed higher to provide more dead storage for sediment.

This storage facility could provide the required water supply if there were no major deviations from the following assumptions used in the study:

- 31 cfs (20 mgd) is adequate for minimum downstream fish flows

- Mitigation for fisheries impact can be achieved to the satisfaction of the controlling agencies

- Other environmental considerations do not block construction or the withdrawal of water from the river

- Sediment deposition in the reservoir does not occur at a rate that will make the dam unfeasible

- All permits and licenses can be obtained from the appropriate agencies in a timely manner

WATER TREATABILITY

Water drawn from sources such as the Eagle River or Eklutna Lake is characterized, especially during the summer, by glacial rock flour. This is material produced by glacial action and entering the water during the glacial melt periods. For water to be potable, this turbidity must be removed.

Field and laboratory testing indicated that the turbidity caused by glacial flour in Eagle River is removable. Two different seasonal processes that can be provided in a single treatment plant would be required. The transition between processes would occur in June and September, correlating with the melting cycle of the glaciers.

The treatment processes for removal of glacial flour are (1) flocculation, sedimentation, high-rate filtration, and disinfection for the high-turbidity glacial melt period and (2) coagulation, high-rate filtration, and disinfection for the low-turbidity period during the colder months. A typical treatment plant flow is shown in Figure 3.

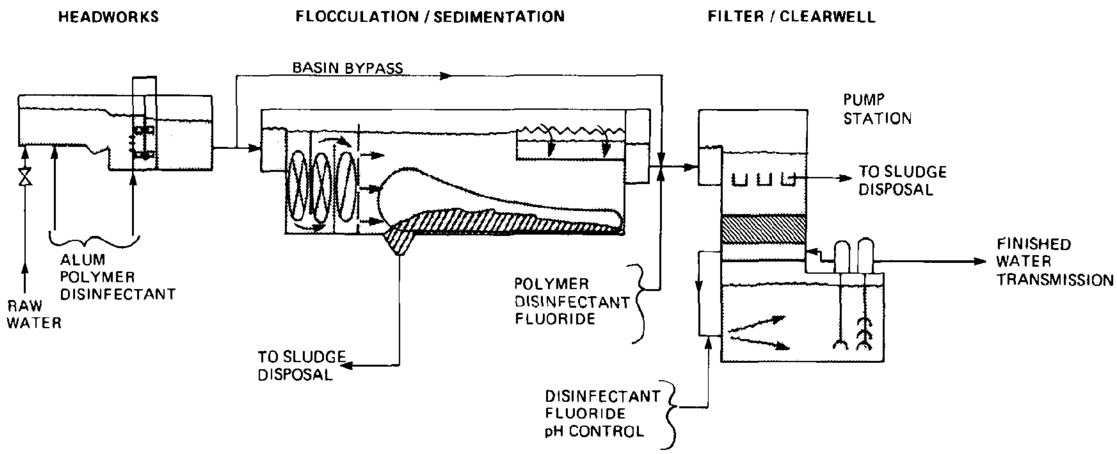

Figure 3
Typical Treatment Plant Flow Schematic

Eklutna Lake water quality is similar to that of Eagle River. Bench-scale testing indicated that the same treatment would be required. Any sludge disposal would be directly to the Knik Arm of Cook Inlet. Much less sludge would be produced by the proposed Eklutna treatment plant than by the Eagle River treatment plant, since the lake water is less turbid than the river water.

Additional field and laboratory testing of various inorganic, organic, bacteriological, and radioactive parameters was done. The test results indicated that the water can be treated to meet current state drinking water standards.

TRANSMISSION MAIN DESIGN

A preliminary design was prepared for the approximately 8 miles of water transmission main from the site of the proposed Eagle River storage facility to the existing Municipal Water Treatment Plant. This pipeline would also serve as a section of the Eklutna Lake alternative water supply concept.*

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*No geotechnical investigation or corrosion survey was made on the Eklutna water supply alternative pipeline route north from Eagle River to the Eklutna hydroelectric facility. This will need to be done during future study and design. For cost-estimating purposes, it was assumed that this section would require an impressed-current cathodic protection system.

Three potential alignments were formulated and evaluated: One paralleling Glenn Highway for the majority of the route; one following the Eklutna powerline right-of-way to Glenn Highway, then paralleling the highway to the water treatment plant; and one paralleling the Alaska Railroad south to the existing treatment plant.

The Alaska Railroad route was eliminated during initial screening because of high construction costs, environmental constaints, and potential difficulties associated with its implementation. Following a more detailed review, the Glenn Highway alignment was selected as the most cost-effective, the easiest to implement from the standpoint of obtaining permits and rights-of-way, and the least constrained by environmental considerations. It will require about 41,000 linear feet of 48-inch-diameter pipe and 1,200 feet of 30-inch-diameter pipe to convey the water from Eagle River to the existing Municipal Water Treatment Plant. The connection to the existing treatment plant would be only for times of low flow from Eagle River or for emergency operation; normally, treatment would be accomplished at a site near the diversion. The selected alignment will involve one stream crossing as well as encroachments into existing easements and rights-of-way.

During preliminary design, several Federal, state, and municipal agencies and Eklutna, Inc., reviewed the selected alignment.

Commonly accepted standards for the design of large-diameter pipelines located in cold climates were used in the preliminary design. These standards served as a basis for formulating the three alternative alignments and for preparing cost estimates. Table 2 lists the representative criteria.

The soils along the selected alignment were tested at the depths at which pipe would be laid to measure their corrosive potential on the three types of pipe material that appear most practical for the project: ductile iron, concrete cylinder, and welded steel. The soils were found to be relatively noncorrosive to metallic pipe materials, and cathodic protection would probably be unnecessary for pipe coated with material such as coal tar epoxy, coal tar enamel, cement mortar, or concrete.

Fifteen test pits along the selected pipeline alignment were excavated with a backhoe. The soils were visually classified, and pocket penetrometer tests were made on selected strata in the test pit side walls. In addition to field testing, the geotechnical study included an analysis of seismic-induced loading and displacement effects on the pipeline, dewatering requirements, and sloping and temporary shoring requirements for the excavated trench wall.

Table 2
TRANSMISSION LINE DESIGN CRITERIA

Design Capacity	57.8 mgd[a]
Pipe Size	48-inch-diameter
External Loads	
Depth of Cover	7 feet for most areas
Backfill	Determined by "Marston Load Theory"
Live Loads	Standard H-20 wheel load except where greater loads are anticipated
Thrust Restraint	Thrust blocks or restraining joints
Rights-of-Way	
Construction (temporary)	Approximately 100 feet
Operation and Maintenance (permanent)	Approximately 20 to 25 feet

[a]A total of 70 mgd would be diverted from Eagle River; 12.2 mgd for the pipeline that will divert flows north to the Chugiak-Eagle River area and 57.8 mgd for the pipeline diverting to the Anchorage Bowl. The 12.2-mgd pipeline has not been designed.

EKLUTNA ALTERNATIVES

Because of the negative results of the Eagle River Valley groundwater investigation and serious potential cost, schedule, and operational problems associated with the proposed Eagle River water storage facilities, an investigation was undertaken to identify feasible concepts utilizing alternative water sources in the Eklutna watershed.

Eklutna Lake is a high-altitude glacially formed lake 30 miles northeast of downtown Anchorage and 16 miles northeast of Eagle River. The lake waters have historically flowed down the 10-mile-long Eklutna River to the Knik Arm of Cook Inlet. The annual inflow to Eklutna Lake averages over 200 mgd and the average elevation of the lake is above 840 feet. Essentially all of this flow is diverted through a tunnel for the generation of electrical energy by the 30 MW Eklutna power plant.

Any water supply project drawing on Lake Eklutna must take into consideration this hydroelectric facility, whose turbines extract about 800 feet of head from the lake water and normally control the lake. The facility includes a 9-foot-diameter, 4-1/2-mile-long pressurized concrete-lined tunnel, a tailrace channel near sea level, and a dam with a 30-inch by 30-inch gate at elevation 852 and an uncontrolled spillway at elevation 871. There is also a 1,395-foot penstock between the tunnel and the power plant; however, it was not considered in any of the supply development alternatives because of the potential serious impacts of increased hydraulic losses on hydroelectric generation.

Diversion of Eklutna Lake water upstream of the turbines would reduce the hydroelectric energy output. Any project diverting water below the turbines would require large amounts of energy for pumping. The alternatives considered reflect tradeoffs between these two constraints.

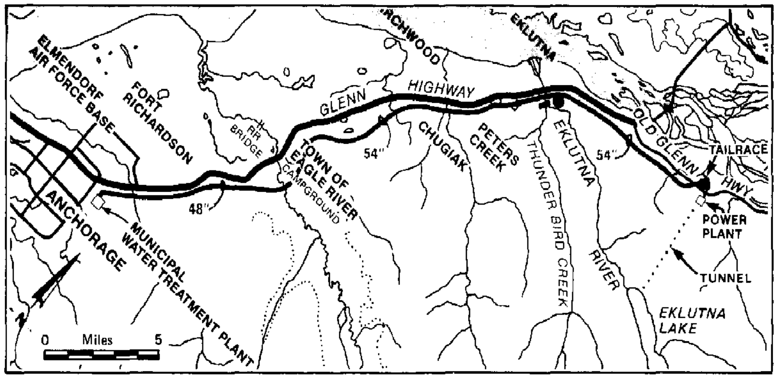
Three conceptual alternatives were developed (Figure 4). Each could meet the projected demand of the Anchorage area that cannot be met by local sources. This assumes that the existing Municipal Water Treatment Plant near Ship Creek is expanded, additional Anchorage Bowl water wells are constructed, and other sources within the bowl are explored to meet intermediate or peak demands.

Alternative 1: Tailrace and River Diversion

This alternative draws water from the power plant tailrace and from the Eklutna River at a point near the Old Glenn Highway bridge. At the beginning of the project, a large percentage of the summer demand would be provided by the river flows. Most of the winter low flows in the river would be required for minimum streamflow maintenance downstream of the diversion structure near Old Glenn Highway. The water would be pumped from the tailrace to meet demand not met by the river diversion. As total demand increases over the years, tailrace withdrawal and river diversion would also increase. Tailrace and river water would be treated near the village of Eklutna and pumped to Anchorage through a 54- to 48-inch pipeline. Treated water would be available to communities along the line.

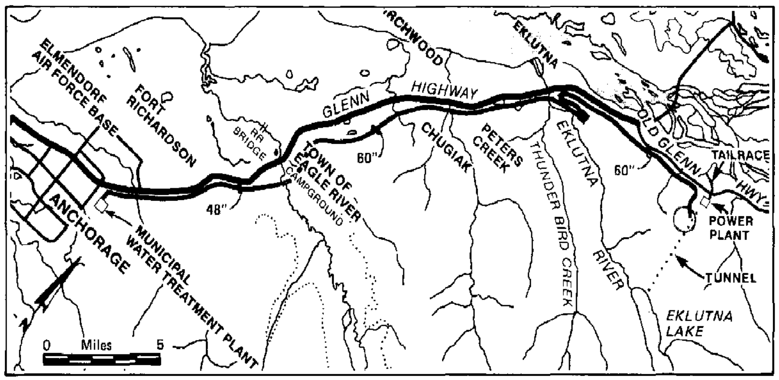
Alternative 2: Tunnel Diversion

In this alternative, water would be taken by tapping the pressurized hydroelectric tunnel at the adit near the surge tank. This would divert water upstream of the turbines. All of the 70-mgd



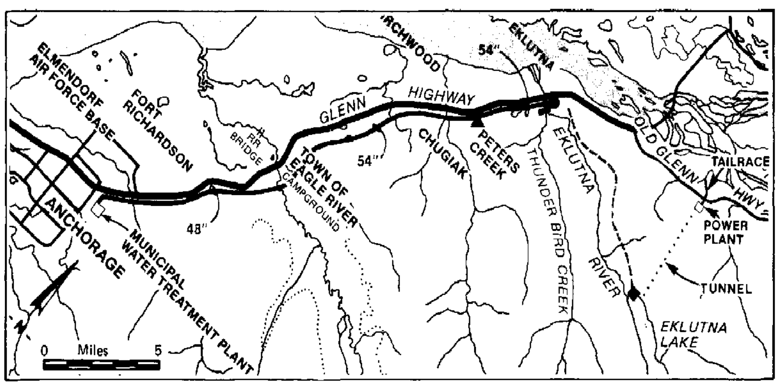
ALTERNATIVE 1
(TAILRACE AND RIVER DIVERSION)

LEGEND
PROPOSED FACILITIES:
- TAILRACE PUMP STATION
- EKLUTNA RIVER DIVERSION DAM
- TREATMENT PLANT AND PUMP STATION
- PIPELINE



ALTERNATIVE 2
(TUNNEL DIVERSION)

LEGEND
PROPOSED FACILITIES:
- WATER TREATMENT PLANT
- TUNNEL DIVERSION
- PIPELINE



ALTERNATIVE 3
(EKLUTNA LAKE AND RIVER DIVERSION)

LEGEND
PROPOSED FACILITIES:
- ▲ MIRROR LAKE BOOSTER PUMP STATION
- ■ EKLUTNA LAKE PUMP STATION
- --- POWER LINE TO PUMP STATION
- EKLUTNA RIVER DIVERSION DAM
- WATER TREATMENT PLANT AND PUMP STATION
- PIPELINE

Figure 4
Eklutna Alternatives

demand would be provided from this location. The water would be treated at a high-altitude treatment plant and would flow by gravity to Anchorage through a 60- to 48-inch pipeline. Communities along the pipeline would take water through pressure-reducing valves.

Alternative 3: Eklutna Lake and River Diversion

This alternative would take water directly from Eklutna Lake and the Eklutna River. Early in the life of the project, a large percentage of the summer demand would be provided by the river flows. Minimum winter flows in the river would be required for streamflow maintenance downstream of the diversion structure near the Old Glenn Highway. To meet demands not met by the river, water would be diverted from the lake into the river by opening the 30-inch by 30-inch gate in the existing Eklutna Lake Dam. When the lake level is too low, the lake water would be pumped to the gate by a low-head pump station. The lake water would then flow down the river to the diversion structure near the Old Glenn Highway. The lake and river water would be treated near the village of Eklutna and pumped to Anchorage through a 54- to 48-inch pipeline. Treated water would be available to communities along the pipeline. As demand approaches 70 mgd, more lake water would be diverted, decreasing the amount of water available for hydroelectric generation.

Alternative 1 Preferred

All three Eklutna alternatives appear feasible, and none incurs cost, scheduling, construction, and environmental problems of the magnitude that the Eagle River dam and reservoir project must address. Alternative 1, drawing water from the tailrace, incurs energy costs for pumping; however, it does not significantly impact the operation of the Eklutna hydroelectric power plant, whose energy losses would have to be reconciled. Further, Alternative 1 is technically simpler to accomplish. For these reasons, it is recommended that it be pursued as a solution to the Municipality of Anchorage's projected water needs through the year 2025.

ENERGY IMPACTS

The energy impacts of the alternatives and the Eagle River dam and reservoir project are shown in Table 3. These impacts include the replacement energy for lost hydroelectric generation, energy for pumping and treatment, and capacity to provide the needed energy. The tunnel diversion (Alternative 2), requires much less energy than the other alternatives, but uses much more than the Eagle River project. The cost of pumping and replacement energy is assumed to be 8.66¢ per kWh, the expected cost (1981 dollars) of new thermal generation.

Table 3
ANNUAL ENERGY AND CAPACITY IMPACTS

	Eklutna Alternative 1	Eklutna Alternative 2	Eklutna Alternative 3	Eagle River
Total Energy Impact (MWh)				
14 mgd	11,869	12,150	15,671	6,850
45 mgd	49,496	43,900	68,945	23,400
70 mgd	88,003	67,737	121,680	38,808
Total Capacity Impact (kW)				
14 mgd	1,500	150	1,490	1,150
45 mgd	6,500	500	5,720	3,500
70 mgd	12,025	775	10,005	6,175
Annual Cost of Impacts (x $1,000)				
14 mgd	1,136	1,056	1,464	676
45 mgd	4,754	3,838	6,383	2,278
70 mgd	8,486	5,922	11,257	3,221

NOTE: Without additional sources developed in the Anchorage Bowl, 14 mgd is needed by 1985, 45 mgd is needed by 2000, and 70 mgd is needed by 2012 (MAUS, 1979). Development of Anchorage Bowl water sources will delay the need for these volumes of water from a source outside of the Anchorage Bowl.

CAPITAL COSTS

The capital costs for the four identified projects (1981 dollars) are:

Alternative 1 (Tailrace and River Diversion): $149 million
Alternative 2 (Tunnel Diversion): $151 million
Alternative 3 (Lake and River Diversion): $131 million
Eagle River Dam and Reservoir: $122 million

The Eagle River project costs are not complete nor directly comparable to the costs of the Eklutna alternatives. In Figure 5, the three Eklutna alternatives and the Eagle River project are rated in terms of the potential impact of a number of important considerations. The chart suggests that costs are higher for the Eklutna alternatives. However, this does not include reservoir land acquisition, fish facility, and other unknown Eagle River costs. Additionally, the development of a water supply project at Eklutna will have considerably less environmental impact than the Eagle River project. Potential delays of the Eagle River project for land acquisition, environmental studies, and old Eagle River dump mitigation lead to the conclusion that the Eklutna project can be implemented in a more timely manner. The cost impacts of these considerations range over many millions of dollars. Additionally, the inflation effects of such delays could severely impact final construction costs of the Eagle River project.

The total annual cost for supplying 14 mgd, 45 mgd, and 70 mgd from each of the alternative projects is shown in Table 4.

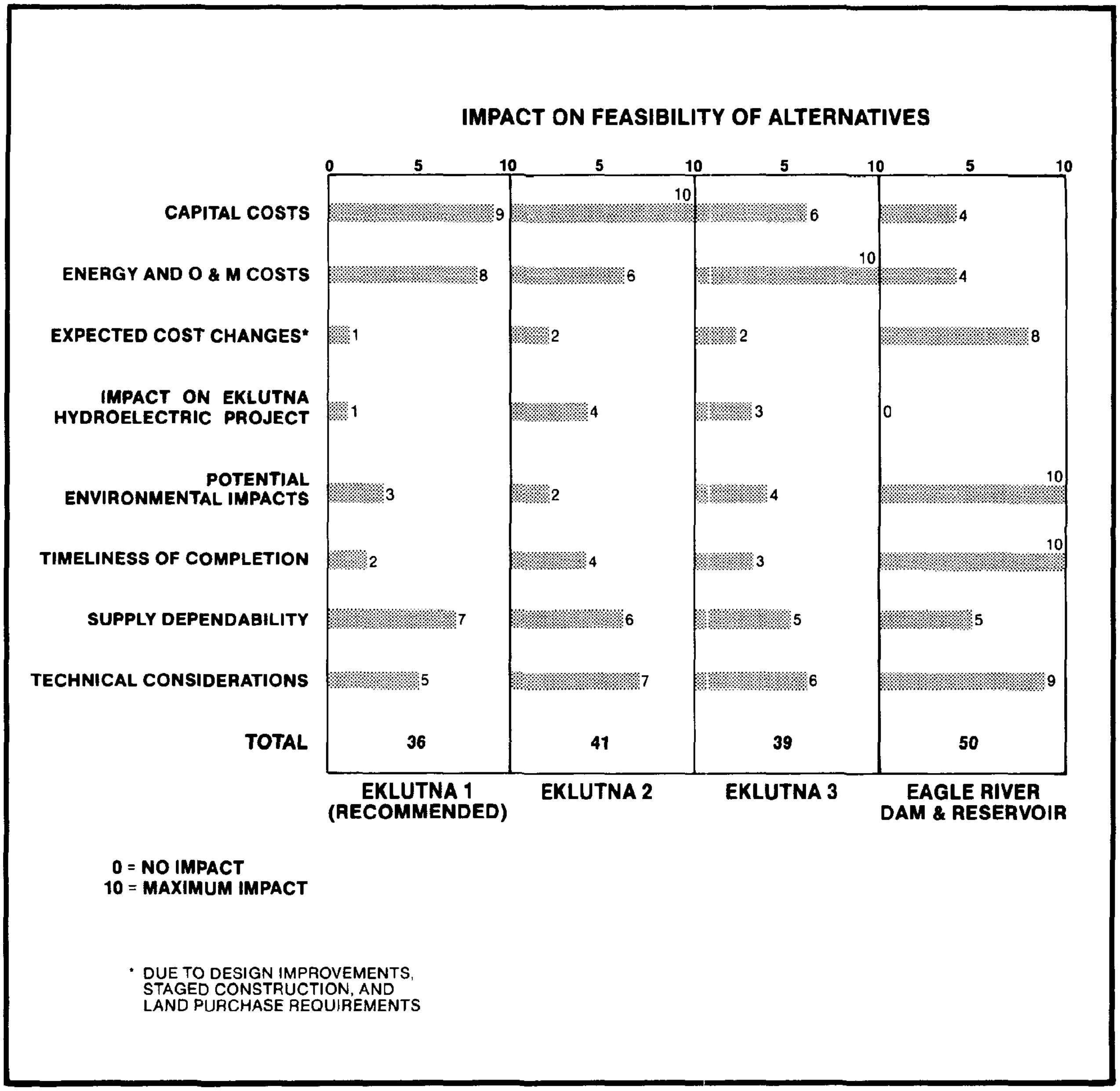


Figure 5
Comparison of Water Supply Alternatives

Table 4
ANNUAL COST SUMMARY

Alternative	Annual Cost ($)		
	14 mgd	45 mgd	70 mgd
ALTERNATIVE 1			
(Capital Cost = $148,580,000)			
Annual Capital Cost (50 years @ 8%)	12,111,000	12,111,000	12,111,000
Power Costs	1,136,000	4,754,000	8,486,000
O&M (excluding power)	641,000	1,581,000	2,353,000
Total	13,888,000	18,446,000	22,950,000
$/1,000 gallons	2.63	1.12	0.90
ALTERNATIVE 2			
(Capital Cost = $151,140,000)			
Annual Capital Cost (50 years @ 8%)	12,320,000	12,320,000	12,320,000
Power Costs	1,056,000	3,838,000	5,922,000
O&M (excluding power)	614,000	1,464,000	2,144,000
Total	13,990,000	17,622,000	20,386,000
$/1,000 gallons	2.65	1.07	0.80
ALTERNATIVE 3			
(Capital Cost = $131,360,000)			
Annual Capital Cost (50 years @ 8%)	10,708,000	10,708,000	10,708,000
Power Costs	1,464,000	6,383,000	11,257,000
O&M (excluding power)	633,000	1,578,000	2,350,000
Total	12,805,000	18,669,000	24,315,000
$/1,000 gallons	2.43	1.14	0.95
EAGLE RIVER[a]			
(Capital Cost = $122,060,000)			
Annual Capital Cost (50 years @ 8%)	9,949,000	9,949,000	9,949,000
Power Costs	676,000	2,278,000	3,221,000
O&M (excluding power)	691,000	1,631,000	2,393,000
Total	11,316,000	13,858,000	15,563,000
$/1,000 gallons	2.14	0.85	0.61

Note: All costs are in 1981 dollars.

[a]Does not include major items such as reservoir land acquisition, fish facilities, and special requirements.

ENVIRONMENTAL CONCERNS

Numerous agencies were contacted regarding environmental concerns for the Eagle River and Eklutna projects. The environmental concerns relating to natural resources are less for the three Eklutna alternatives than for a dam and reservoir at Eagle River. Potential fisheries and animal habitat impacts are also much less. While there might be slightly greater fisheries impacts from Eklutna Alternatives 1 and 3 than from Alternative 2, they are not expected to be significant. The environmental effects of the four projects are summarized in Table 5.

Table 5
MAGNITUDE OF ENVIRONMENTAL EFFECTS

Impact	Eagle River	Eklutna Alt. 1	Eklutna Alt. 2	Eklutna Alt. 3
Fisheries				
Loss of Habitat	H	L	0	L
Fish Passage Facilities	H	0	0	0
Minimum Flow Requirements	H	L	0	L
Sediment (from reservoir flushing)	H	0	0	0
Requirement for Mitigation of Losses	H	L	0	L
Changes in Microclimate (including downstream temperature)	L	0	0	0
Wildlife				
Loss of Habitat for Big Game Species	H	0	0	0
Loss of Habitat for Nongame Species	H	L	L	L
Management of Pipeline Right-of-Way	H	H	H	H
Groundwater				
Shallow Aquifers Near Eagle River	L	0	0	0
Water Quality				
Leachate from Dump	H	0	0	0
Septic Systems in Drainage Area	H	L	0	L
Recreational Use of Watershed	H	H	0	H
Dilution of Existing Sewage Outfalls	L	0	0	0
Power Production				
Effect on Eklutna Hydroelectric Facility	0	L	H	H
Energy Requirements	H	H	0	H
Land Use				
Effects on Land Use Options	H	H	H	H
Location of Treatment Plant	L	L	L	L
Powerlines	L	0	0	L
Dam Safety	H	0	0	0
Aesthetic Effects				
Historic and Archaelogical Sites	L	L	L	L
Visual Impacts	H	0	0	L
Rights-of-Way and Difficulty of Reservoir Land Acquisition	H	L	L	L

L = Low
H = High
0 = None

CONCLUSIONS

- No significant groundwater is available within the Eagle River Valley for development. Investigations have been sufficiently extensive to eliminate this as a possible source of any significant supply.

- It is technically feasible to design, build, and operate at the proposed damsite 1-1/2 miles east of the Glenn Highway bridges a dam and reservoir complex that will yield the desired 70 mgd.

- There are many uncertainties associated with the full implementation of the proposed Eagle River storage project. These are the cause of grave concerns as to the final cost and viability of the undertaking. These uncertainties include:

    - The extreme complexity of the dam and appurtenances, which must be built at a remote site with difficult foundation conditions, and with a critical construction sequencing in extreme weather conditions.

    - The practicality and efficacy of the proposed reservoir operational procedures required to meet water demand and to cope with anticipated inflow variations and the sediment loads.

    - Seismicity conditions.

    - The anticipated high cost of reservoir land acquisition.

    - Presently undetermined costs associated with mitigating the potential effects of the old Eagle River dump on reservoir water quality.

    - Substantial unknown costs for fishery maintenance and mitigation facilities and for their operation. These costs could not be meaningfully estimated in this study because of the lack of information relating to the magnitude of fisheries involved.

    - The possibility of serious cost impacts resulting from delays in construction required to resolve fish and wildlife impact questions, the time required to acquire land, and the time consumed in addressing any organized opposition that develops on general environmental grounds.

- The estimated capital cost of the Eagle River storage project is $122 million. However, there will likely be significant added costs associated with the unknowns and uncertainties identified above.

- It is possible that the resolution of these uncertainties could easily delay the project beyond the point of need, escalating costs far beyond those of the Eklutna alternative.

- Eagle River and Eklutna River water is similar in quality and can be treated to state drinking water standards with currently available technology.

- A firm supply of water is readily available from the Eklutna alternative at a variety of diversion points.

- Eklutna Alternative 1 incurs negligible environmental consequences and avoids the Eagle River dam and reservoir development problems.

- The Anchorage Bowl area needs additional water within the next 10 years and the Eagle River-Chugiak-Eklutna area is in need of a new source of water now.

- Only the Eklutna water supply source can be developed in a sufficiently timely fashion to meet Anchorage Bowl needs.

- The Eklutna alternative offers several opportunities for staging and possible conjunctive operations with the existing Anchorage Bowl groundwater and Ship Creek facilities.

- The estimated total capital cost of Eklutna Alternative 1 is $149 million in 1981 unit prices.

- Taking into consideration all of the environmental costs, considerations relating to project implementation, and technical aspects, Eklutna Alternative 1 designs should be refined and implemented without delay.

RECOMMENDATIONS

To meet the water supply demands of the next decade and beyond, an aggressive development program must be undertaken by the Municipality of Anchorage. Immediate steps should be taken to ensure timely implementation of the Eklutna Lake water supply project.

- Develop a schedule, work plan, and budget estimates for the required studies, designs, right-of-way and permit acquisitions, and project construction.

- Optimize the tailrace and river diversion alternative concept by considering features of other alternatives for possible incorporation. Development of staging possibilities should be examined and, where feasible, implemented.

- Investigate energy conservation opportunities. Pipe size selection should be based on a comparison of capital and O&M costs. The possibility of reducing friction length or static pumping head by means of alternative alignments should be considered.

- Refine the Municipality of Anchorage water demand projections. New projections should be included in future design work to ensure that the facilities are properly designed. Seasonal variations in demand must be considered in establishing peak demands.

- Integrate the Ship Creek treatment plant expansion and new water well plans with the Eklutna project. This will provide a more accurate schedule of future water needs, and will make it possible to identify construction staging and facility needs.

- Determine methods of minimizing the impact on the system of frazil and other ice-related problems.

- Gather field data and conduct tests sufficiently early that preliminary design can address the complex geological conditions that exist at the pump station and treatment plant site, and along pipeline routes.

- Conduct pilot water treatment plant tests for a full year, using at least 1-mgd plant design criteria. This testing program should address iron, color, and turbidity removal; chemical dosages required over the range of raw water conditions; filtration rates and media selection; and the effectiveness of the recommended treatment process.

- While the data identified above are being gathered, begin preliminary design of all facilities. Preliminary plans and specifications should be prepared for the pipeline, pump stations, diversion structures, and treatment plant. A detailed cost estimate should be developed.

All of these recommendations can be performed independently. Each provides data important to the development of a reliable, timely water supply system to make the best use of available sources.

Additionally, Anchorage Bowl water sources should be developed to their feasible capacity to meet intermediate demands until the Eklutna project is developed. These will be more reliable and should use much less energy than the Eklutna source, since they are closer to the source area. They should also be sufficient in the long term to accommodate peak demands that cannot efficiently be met by the distant Eklutna source.