Gastineau Channel   Juneau, Alaska

Feasibility Report

CHANNEL DEEPENING
FOR
NAVIGATION

ALASKA DISTRICT

CORPS OF ENGINEERS
NOVEMBER 1977

FEASIBILITY REPORT

APPENDIX A - ECONOMICS

GASTINEAU CHANNEL, ALASKA

PRESENT AND FUTURE ECONOMIC CONDITIONS

Natural and human resources and developmental trends of the study area are presented to provide a general understanding of their relation to the problems and needs of the area and to establish a "most probable future" for the purpose of benefit and impact analysis.

Of particular importance is the role waterways play in the social and economic well-being of the community. All waterborne traffic to and from Juneau must use Gastineau Channel. The channel southeast of Juneau is navigable by all classes of vessels, but the northern portion from Juneau-Douglas bridge to Fritz Cove is navigable only by shallow-draft vessels at selected tide levels. A shoaled reach, south of Juneau Airport, is navigable only at high tide and even then, only with current knowledge of channel conditions. These restrictions cause the majority of traffic to take the longer route around Douglas Island, resulting in increased operating time and costs, a reduction in the navigation season due to adverse weather conditions, and the added risk of life and property because of the longer voyage through unprotected waters.

TRIBUTARY AREA

Gastineau Channel, a narrow strait about 16 miles long that separates Douglas Island from the mainland of southeastern Alaska, connects Stephens Passage on the east with Fritz Cove on the west. Although much of Southeast Alaska is a general tributary area, the Juneau-Douglas area is the principal contributor. Juneau is located on the mainland side of Gastineau Channel at about its midpoint. Southeast of Juneau, the channel is fairly uniform with the width varying from 4,000 to 6,000 feet. A naturally deep channel with controlling depth of about -45 feet mean lower low water (MLLW) exists in this portion. Northwest of Juneau the width varies from 2,000 to 10,000 feet with the western 5.5-mile reach shoaled up to +9 feet (MLLW) in the existing 75-foot-wide dredged channel. An additional confinement on the northwest reach is vertical clearance at the existing Juneau-Douglas highway bridge of +49.5 feet above mean high water (MHW) for a clear width of 215 feet. Because Juneau has no direct land connection with other mainland ports, it is mainly dependent upon waterborne transportation, all of which utilizes a portion of Gastineau Channel. In addition to sealanes, important tributary fishing grounds are broadly described as waters west and north of Douglas Island and Lynn Canal as far north as Haines.

GOVERNMENT

Juneau, first settled by gold miners in 1881, quickly became the mining center of Southeast Alaska. In later years it boasted the Alaska-Juneau Mill, at one time the largest low grade gold mine in the world. Douglas Island was the location of the famous Treadwell Mine, almost as large as the Alaska-Juneau. In 1906, Juneau replaced Sitka as capital of the Territory of Alaska. With the coming of statehood on 3 January 1958, Juneau became the State capital. On 18 February 1970, the citizens of the Juneau area approved a charter forming a single governmental entity in place of the former municipalities of the city of Juneau, the city of Douglas, and the Greater Juneau Borough. Unification brought forth into one municipality, the City and Borough of Juneau, all surrounding properties and undeveloped areas which make an accumulated total of 3,108 square miles.

POPULATION AND EMPLOYMENT

The 1977 population of the City and Borough of Juneau is estimated at 19,200. About 45 percent of the residents are located within the central urban areas of Juneau and Douglas, but the centroid of population has been moving and is expected to continue to move to the northwest suburban areas. Population growth is summarized as follows:

CITY AND BOROUGH OF JUNEAU BOUNDARIES POPULATION 1/

Year	Population
1900	4,881
1910	6,125
1920	6,088
1930	6,174
1940	8,563
1950	8,758
1960	9,745
1965	12,415
1970	13,556
1971	14,564
1972	15,079
1973	16,593
1974	17,195
1975	18,400
1976	19,193
1977	19,200

1/ Source: U.S. Census Bureau, Capital City Economic Base Study, and Supplement entitled State and Federal Employment in Juneau.

In the early years, the economy of the Juneau area depended almost entirely on mining, fishing, and government. In 1941 the Alaska-Juneau mine reduced operations and then closed down in 1944. The economy remained fairly stable during the next 15 years, deriving much of its support from the tourist industry. Since statehood in 1959 there has been a steady growth in population and economic activity derived from increased tourism, logging, both sport and commercial fishing, and most of all from government. Historically, Juneau has had the lowest unemployment rates of any region of Alaska, but the gap narrowed in 1976 when Juneau had a rate for insured unemployed of 8.6 percent as compared to 8.8. percent statewide. Trends in employment and the importance of the government sector are evident in the following labor force summary:

NONAGRICULTURAL WAGE AND SALARY EMPLOYMENT

	1965		1970		1975	
	Number	Percent	Number	Percent	Number	Percent
Construction	354	7%	297	5%	381	4%
Manufacturing	131	3	84	1	147	2
Transportation, Communications, Public Utilities	536	10	524	8	656	7
Trade	610	12	816	13	1,275	14
Finance, Insurance, Real Estate	143	3	154	2	355	4
Service, Miscellaneous	423	8	545	9	1,100	12
Government	2,910	57	3,951	62	5,234	57
Federal	(1,042)	(20)	(1,189)	(19)	(991)	(11)
State and Local	(1,868)	(37)	(2,762)	(43)	(4,243)	(46)
Total	5,107	100	6,371	100	9,148	100

TRANSPORTATION

From its founding as a mining center, Juneau has become a trading and service center to surrounding communities accessible only by water or air. Transportation modes in the Juneau area include:

Air - Modern airport facilities, including a 9,468-foot paved runway, provide service for interstate and local commercial carriers as well as scheduled service with Canada. Seaplane facilities and air taxi services are also available.

Highway - The Alaska State Highway extends north 42 miles to Berners Bay, south 5 miles, and across a bridge to the Douglas Island community.

Trucks utilizing the Alaska State Ferry System provide a minimum of triweekly service interstate and intrastate service connecting other communities on the ferry route. Scheduled and charter busses utilize the local highway system. Regular limousine service is also available to and from the airport.

Water - Juneau is served on regular schedules by the Alaska Marine Highway (ferry system) and by seagoing tug and barge operations. Shallow-draft pleasure, charter, and commercial fishing craft number near 2,100 in the Juneau area. Additionally, there are over 100 cruise ship arrivals at Juneau annually.

HARBOR FACILITIES

Gastineau Channel south of Juneau is navigable by all classes of vessels to 45 feet in draft and provides access to deep-draft docks maintained by the City and Borough of Juneau, Foss Alaska Line, Northland Marine Lines, Standard Oil, and Union Oil. In addition to the ferry terminal at Juneau, a ferry terminal is maintained at Auke Bay to provide Juneau access via highway for vessels traveling the Sitka to Haines route. Auke Bay also has two U.S. Government docks used by the Bureau of Commercial Fisheries and Park Service. Six shallow-draft facilities, three in Juneau and the others at Douglas, Auke Bay, and Tee Harbor serve the near 2,100 small craft. The majority, 1,400, are permanently berthed in public and private small boat harbors at Juneau, Douglas, Auke Bay, and Tee Harbor. Approximately 350 are trailered or stored at private locations. Some 325 transient vessels, mostly seiners, gill netters, and trollers also operate out of Juneau during the fishing season. Privately-owned marine ways capable of hauling ships up to 500 gross tons, a machine shop, a carpenter shop, and a retail machinery and marine sales outlet are located on Gastineau Channel near the small boat basins.

GROWTH POTENTIAL

Impacts associated with navigation improvements will tend to become more pronounced as population grows and economic activity increases within the City and Borough of Juneau. Two very different population forecasts are possible for the Juneau area depending upon relocation of the State capital to southcentral Alaska. Without the capital move, the outlook for the Juneau area is for sustained growth with government remaining the prime mover of the economy. City and Borough of Juneau planners expect the spinoff from oil and gas pipeline construction and increased petroleum revenue to continue the expansion of State government employment. The natural resource based industries on the other hand, are not expected to be major influences in the near future. Timber resources exist for operation of a pulp mill in the area, but timber industry development has been stymied by environmental suits. Fisheries have traditionally played a significant part in the Juneau economy, but only limited growth, resulting from a combination of increased salmon stocks induced by State fish hatchery investments and the harvesting of new species, is forecast. Mining offers substantial potential, but no significant development is expected to occur until after 1995.

Continued growth is projected for the tourism and recreation industries, with construction activity expected to continue at a moderate pace primarily in response to State government expansion. All transportation systems and facilities will expand to meet the growing area population as well as the increasing number of visitors expected.

The effects of the Alaska Native Claims Settlement Act will be experienced during the study period and provide a stimulus to the local economy because of the direct cash injection, and in later years by the return on investment made by the regional and village corporations as well as by the individual recipients.

On the basis of these assumptions, and utilizing an economic base analysis, local planners forecast an area population of 21,500 in 1980. After 1980, population projections are based on the cumulative growth effects of all economic influence expected to impact on the Juneau area. Between 1980 and 1995, population is forecast to increase at an annual rate of 3.7 percent. 1/

This population increase, along with resource potential and moorage facilities, will in turn be key determinants in future vessel traffic in the Juneau area. Commercial fishing vessel traffic, both local and transient, is expected to rise only slightly, restrained by depressed fishery stocks. A nominal growth rate of one percent is assumed, based on the possibility of moderate success in planned salmon rehabilitation programs and on the possibility of utilization of alternative species. The number of recreation craft could be expected to grow in proportion to population, but the number of moorage spaces has been and will continue to be the single most important restriction to the growth of boating activity in the channel. Planned enlargement of harbor facilities in the immediate Juneau area is confined to expansion of the Douglas Boat Harbor to accommodate an additional 125 to 150 boats. An additional 500 new mooring spaces are forecast, but most of that growth is likely to occur in the Auke Bay area, which substantially diminishes the average number of trips per boat through the channel. Additional and improved launching ramps at several locations will encourage increased trailering

1/ Source: Capital City Economic Base Study, City and Borough of Juneau, Alaska, 1974, pp 33-52.

of vessels allowing access to new areas and a decreased use of the channel for these craft also. Based on planned and projected moorage space and its location, sport vessel traffic through the channel is expected to grow at a rate of two percent annually. Tug operations and charter boat activity are assumed to grow at a rate comparable to population increase, while Coast Guard and National Marine Fisheries Service vessel traffic will reflect the specific plans of these organizations.

A very different future for Juneau is probable when the site of the State capital is relocated to southcentral Alaska. State government employment, the main catalyst for growth, would be severely diminished with far-reaching implications for the local economy. It has been estimated that about 2,350 State and Federal Government jobs would be lost to the Juneau area with a resulting decrease in population of approximately 10,000 persons. 1/ From this reduced base, growth would depend on employment increases in regional offices of State and Federal Government and expansion of wood products and mining industries. The associated vessel traffic utilizing Gastineau Channel would decrease as compared to the activity forecast without capital relocation. Commercial fishing traffic would not be affected since the fishery resource is the controlling factor, while tug operations and charter activity would reflect the new population levels. Recreation use of the channel would decrease, but not as precipitously as population, because the number of moorage spaces rather than the demand for boating has been the limiting determinant in channel use.

1/ Source: State and Federal Employment in Juneau (A Supplement to The Economic Base Study), December 1975.

BENEFIT ANALYSIS

BENEFITS RELATED TO REDUCED NAVIGATION DISTANCES

Improved channel depths would allow boats to travel north-south without traveling the additional 20 miles around Douglas Island. Fishermen using Lynn Canal and Icy Straits located to the north of Juneau utilize the city's services and cold storage facilities. The channel trip would result in substantial annual savings to this fleet that reaches approximately 425 vessels during the salmon and halibut season. Tug boats that serve the Juneau area would also realize substantial savings from the proposed improvement as would the other types of boats that operate in the area. It is estimated that one-half of the sport and dual-purpose boats--approximately three-fourths of the boats harbored in the area--would use the channel on a regular basis and all other craft on an intermittent basis.

An improved passage would allow small boats to avoid the rigors of Stephens Passage on the west side of Douglas Island. These benefits are difficult to measure, but can be expressed in terms of time and money saved by rescue operations.

The primary benefit of dredging the channel is associated with the difference in the amount of time required to make a round trip from Juneau to a common point north of Douglas Island via the channel as compared to the same trip made around Douglas Island. The difference in such a round trip is some 40 miles; the trip by way of Douglas Island is approximately 62 miles while the same trip via the channel is only 22 miles. The proportionate savings in time is less than the associated distance saving, however, because reduced speeds would generally be required in negotiating the dredged portion of the channel. Information regarding the number of trips to be made through the channel, operating costs per hour, draft (which includes 1-foot of channel clearance) and average cruising speed by boat class was developed by consulting with boat operators, the harbormaster of the two Juneau harbors, the Alaska Department of Fish and Game, the Coast Guard, the Fisheries Research Laboratory at Auke Bay, and the Division of Water and Harbors, Alaska Department of Public Works.

Operating costs include the cost of fuel and maintenance of the boat, although the latter prove insignificant in this analysis and are, therefore, disregarded. Also, except for boats used for recreation, a charge for labor is included. With regard to most of the boat classes, the cost of labor is incurred on an hourly basis and so needs no explanation for being included as part of operating costs. However, this is not the case where commercial fishing operations are concerned as most of these boat owners and operators pay the additional labor a fixed share of the catch rather than an hourly wage. In spite of this method of payment to labor and in order to make the operating costs of boats in this class comparable to those in the other classes, a charge of $5.50/hr for labor has been included.

On certain tide stages in Gastineau Channel, boat owners are unable to traverse the channel. The tide in the area has a diurnal range of 16.4 feet. The Juneau harbormaster reports that on the basis of fathometer measurements the channel is shoaled to approximately +9 feet MLLW. This means that at MHHW, there is a minimum depth in the channel of approximately 7 feet. However, at any given time, weather conditions can cause deviation of from 2 to 3 feet. In spite of this, under present conditions some use of the channel is possible by most of the boats presently harbored in the Juneau area. Under present conditions, however, passage of the deeper draft boats is restricted, and at lower tide stages passage is impossible for all waterborne traffic. The owners of the smaller boats normally prefer to wait for satisfactory tide conditions rather than make the trip around Douglas Island, which would expose them to open water and the potential hazards involved when the weather is bad. The larger boats, however, usually travel around Douglas Island and the use of the channel by them is quite limited in its present condition.

BOAT SURVEY - CITY AND BOROUGH OF JUNEAU

The following is an estimate of boats harbored in the area as of 1976. Estimates were provided by the Juneau Harbormaster and by the Division of Water and Harbor, Alaska Department of Public Works.

Total Boats Harbored in Area (excludes about 350 trailered craft):	
Local	1,438
Transient	325
Total	1,763

Number of Boats by Class:		
Commercial:	Local	100
	Transient	325
Sports Only		900
Dual Purpose, Sports and Commercial		400
Work Boats (includes charter, tug, and pilot)		31
Fisheries Research		3
Coast Guard		4

Currently a shortage of moorage space exists, resulting in approximately 350 pleasure craft being trailered within the City and Borough of Juneau.

BENEFIT COMPUTATION

In presenting and analyzing present and potential benefits to the proposed channel improvement project, craft using the channel are divided into seven categories, and the benefits to each category are computed. In addition, benefits resulting from reduced search and rescue efforts are estimated. The benefit categories include the following:

a. Commercial fishing vessels, both local and transient

b. Dual-purpose boats used both for commercial fishing and recreation

c. Sport boats which are used primarily for recreational purposes

d. Tug operations

e. Coast Guard activity

f. Charter boats

g. Fisheries research boat

h. Search and rescue, which includes an estimated amount of annual damage to vessels that go around Douglas Island as well as time spent by the Juneau search and rescue mission in search of lost vessels.

For purposes of this discussion, the term "trip" refers to a round trip unless otherwise indicated.

Commercial Fishing Boats: The fishing grounds for the Juneau area are broadly described as west and north of Douglas Island and Lynn Canal as far north as Haines. The greatest amount of activity by recorded movement is in the Auke Bay-Tee Harbor area in direct line with the proposed channel improvements. The salmon season for the districts involved, as described by the Alaska Board of Fish and Game, varies, but is generally from April through September, and involves, to varying degrees, purse-seiners, gill netters, and trolling vessels. In addition, a few boats are involved in the herring catch. In the early part of the season, fishing occurs both north and south of Juneau, but from June on, the majority of fishing is to the north and west. The season in the north is four months. The fleet harbored in Juneau numbers 100 vessels, but during the fishing season, transients increase this number to roughly 425, although transient use is intermittent. In order to get to the fishing area north of Juneau, boats harbored in the Juneau area must travel around Douglas Island--a distance of roughly 31 miles one way. If Gastineau Channel were improved, this distance would be reduced to about 11 miles, a one-way saving of some 20 miles. Use of the channel, then, would result in a round trip of about 40 miles less than that around Douglas Island. At an estimated cruising speed of 10 miles per hour and an average channel speed of 7.5 miles per hour, use of the channel would save an average of 3-3/4 hours per trip. 1/ Also, it is estimated that during the 4-month season, the average use of the channel would be three round trips per month per local vessel and one-third that number for transient vessels since these call only intermittently at Juneau during the fishing season for supplies, fuel, repairs, or to sell their catch. This results in an estimated total of 2,485 boat trips during the 4-month season. Operating costs for vessels in this class average $31 per hour--$9 per hour for fuel and $22 per hour for labor (crew of four). The latter figure is based on an estimate provided by the Juneau Employment Center. The total benefits from use of the channel during the fishing season, on the basis of the foregoing assumptions, are 2,485 boat trips x 3-3/4 x $31 = $289,000.

Commercial fishing vessel traffic, both local and transient, is expected to remain close to current levels due to effects of Limited Entry regulations and outlook for future fishery stocks. A nominal annual growth rate of one percent is assumed, based on the possibility of utilization of alternative species and on the possibility of moderate success in planned salmon rehabilitation programs.

Dual-Purpose Boats: Many boats, by nature of their size and design, are classed as sport or recreation boats. Normally, these boats would be used only for recreation, but in an area that has a fishing economy, as does Juneau, many of these boats are used part-time to catch fish for sale to the local canneries. This, according to the fishing regulations of the State, puts them into the commercial fishing classification. Although these boats are usually somewhat larger than the average sports boat (most of them are of the cruiser type) and since they are not equipped like the full-time commercial fishing vessels, for purposes of identification, the State requires them to display the triangular stamp of the State Department of Fish and Game on their starboard bow section. For the purpose of this analysis, 400 boats of the sport and recreation type were classed as dual-purpose on the basis that they display the State stamp. Also, it is estimated that approximately 50 percent of the time they are used for commercial fishing and are used for recreation purposes the rest of the time. It is estimated that, on the average, these boats would use the channel three times a month for four months and, at a cruising speed of 15 miles per hour and at a channel speed of 10 miles per hour, would save about

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1/ Note that 4.5 miles of the 11 mile shorter route would have to be traveled at the reduced channel speed.

2.3 hours on each trip. It is estimated that fuel costs average $4.50/hr and that, when fishing, labor costs average $11 (crew of 2). Thus, commercial fishing benefits to boats in the class would total $15.50 x 6 trips x 2.3 hours x 400 boats = $85,560. Recreation benefits would amount to $4.50 x 6 trips x 2.3 hours x 400 boats = $24,840. This totals $110,400.

Future growth in channel use for this category of craft will reflect a combination of the trends in commercial fishing vessel traffic, discussed previously, and in recreation craft traffic, described in the following section. The composite growth rate for dual-purpose craft channel use, based on the relative share of commercial and recreation benefits, is thus estimated at 1.3 percent annually.

Sport Boats: The area north of Juneau, including the newly established resort at Glacier Bay, is rapidly developing into a prime tourist industry. The annual salmon derby is also conducted in this area. During vacation periods and weekends, the local labor force turns to this avocation and diversion to supplement their income. While some of this activity may be commercial in nature, due to the lack of sufficient information to that effect and for the purposes of this analysis, all of the benefits from use of the channel by boats in this class are assumed to be recreational. For purposes of calculating benefits, savings in operating costs will be utilized to approximate the increased rate of return. Due to a lack of rental operations in this boat class, the rate of return method of benefit calculation is not used. It should be noted that local interests would be required to share some of the first costs of the project. At present, many trips are made over existing channel shoals by boats of this class, but some trips are still made via the longer route around Douglas Island.

The approximately 500 pleasure boats moored in the three Juneau area harbors will receive the most benefit from the proposed project. It is estimated that one-half of these boats would travel through an unrestricted channel at least once each week and the other half once each month during the fishing season. This will result in a maximum of 7,750 trips per year. Of the 350 craft permanently moored in the Auke Bay-Tee Harbor area, the number that would utilize a channel improvement will be in direct relation to the distance that their permanent moorage is from the Juneau area. The 100 boats at Tee Harbor cannot be expected to use the channel more than once per year, while those in Auke Bay may average as many as one crossing per month during the season. This accounts for an additional 1,600 trips. It is expected that few, if any, of the trailered boats would use the channel even under ideal conditions since launching ramps are available both north and south of Juneau. Pleasure craft thus account for approximately 9,350 trips per year.

It is estimated that these boats traveling 20 miles per hour at cruising speed and at 12.5 miles per hour in the restricted channel, could save 1.75 hours of travel time per trip by using the channel. Operating costs for boats in this class are estimated at $3.40 per hour; this is $1.10 per hour less than the same costs for boats in the dual-purpose class because boats in the sports class tend to average slightly smaller in size. On the basis of these estimates, sport boat benefits from use of Gastineau Channel for all travel to the north total $3.40 x 9,350 trips x 1.75 hours = $55,630.

The amount of recreation craft use of the channel could be expected to grow at least in proportion to population, but the number of moorage spaces has been and will continue to be the single most important restriction to the growth of boating activity. Planned enlargement of harbor facilities in the immediate Juneau area is confined to expansion of the Douglas Boat Harbor to accommodate an additional 125 to 150 boats. An additional 500 new mooring spaces are forecast, but most of that growth is likely to occur in the Auke Bay area, which substantially diminishes the average number of trips per boat through the channel. Additional and improved launching ramps at several locations will encourage increased trailering of vessels allowing access to new areas and a decreased use of the channel for these craft also. Based on planned and projected moorage space and its location, sport vessel traffic through the channel is expected to grow at a rate of two percent annually.

Tug Operations: There are presently six tug operators working in the Juneau area on a regular basis. Such cargo as construction equipment and materials, modular units and household goods are typically delivered throughout Southeast Alaska to such communities as Haines, Hoonah, Pelican and Gaustavus. With operating costs ranging between $100 and $190 per hour depending upon the size of the vessel and average speeds of 10 miles per hour, tugs would save about 3-3/4 hours per round trip. A survey of operators and freight tonnage records indicates that approximately 230 trips would be made through an unrestricted channel, 37 percent of which would be accounted for by the larger size vessels. Total savings to tugboats is, therefore, $100 x 145 trips x 3-3/4 hour/trip + $190 x 85 trips x 3-3/4 hour/trip = $115,000 annually. Channel use by this category of vessels can be expected to increase at a rate comparable to population growth and is, therefore, forecast at 3.5 percent annual increase.

Coast Guard Operations: The Coast Guard indicates that two vessels would realize benefits from channel improvements.

A 95-foot Juneau-based patrol boat currently making about 45 trips per year through the channel would save 1-1/2 hours per trip at $315 per hour. This would result in a total savings of about $21,300 per year. Relocation of this vessel to Auke Bay is expected before project completion, however, after which only 25 percent of the savings would be realized because of fewer trips. The resulting average annual cost is $5,325.

A 44-foot Coast Guard vessel based at Auke Bay has an operating cost of $50/hour, would save 1-1/2 hours per trip and would make about 30 channel trips/year. Use of the channel would allow a savings of $2,250 per year. Total Coast Guard savings amount to $7,575 annually. Coast Guard officials indicate that channel use for Coast Guard vessels will grow in approximate proportion to commercial fishing vessel activity.

Charter Boats: There are approximately 15 charter boat operations in the Juneau vicinity, 6 of which operate on a full-time basis. Increased depth would allow an average of 20 trips per year through the channel. Average operating costs are $10 per hour. At cruising speeds of 10 miles per hour and at channel speeds averaging 7.5 miles per hour, 3-3/4 hours per round trip would be saved. Annual savings to owners of these boats would be $10 x 20 trips x 3-3/4 hours x 15 boats = $11,250. As in the case of recreation craft benefit analysis, savings in operating costs are utilized rather than increased rate of return because of data deficiencies.

Charter boat channel traffic is expected to grow at a rate similar to that of population, 3.5 percent annually.

Fisheries Research: The National Marine Fisheries Service biological laboratory at Auke Bay presently has four vessels in the Juneau area. However, only the largest one of these would benefit significantly from an improved channel. The operating costs for this vessel average $75 per hour. The boat makes approximately 12 trips per year to the Auke Bay area and would save four hours per round trip. This would amount to an annual savings of $75 x 12 trips x 3.5 hours = $3,600. National Marine Fisheries Service officials indicate that no increase in vessel traffic is anticipated.

Search and Rescue Efforts: The Juneau Search and Rescue Council, made up of approximately 40 local citizens, is called upon to supplement Coast Guard efforts, spending many hours of sea and air search and rescue that could be substantially reduced by maintaining an improved passage through Gastineau Channel. Records supplemented by memory and best estimates show that annually at least 15 small boats in the sports class are forced ashore in rough waters as they attempt the trip around Douglas Island. Damages range from total destruction with loss of lives to no damage and several hours of inconvenience. For the most part, experienced boatmen do not, however, suffer these damages except when an unexpected storm hits. If there is any chance of danger in going around Douglas Island, these people will wait until the tide is high enough to return to Juneau through Gastineau Channel. In spite of the precautions taken, according to the Juneau harbormaster and the Juneau Search and Rescue Council, approximately $25,000 of boat damage, 200 hours of rescue boat time at $25 per hour, 80 hours of flying time at $75 per hour, and an average of somewhat less than one death result each year from small boats foundering enroute around Douglas Island. These sources indicate that about 75 percent of the above losses could be prevented by full utilization of an improved channel. The benefits that would accrue annually from these savings total 75 percent of the combined $25,000 boat damage, $5,000 rescue boat time, and $6,000 flying time. Without channel improvement, search and rescue efforts and damage can be expected to increase at a rate comparable to the growth in recreation boating activity or about two percent per year.

Ferries: An analysis of possible benefits associated with ferry utilization of the channel was also made. The operating costs of the four vessels that stop at Juneau range from $790 to $540 per hour, with top speeds between 21 and 15 knots. The fastest and largest vessel, the Columbia, would not experience any savings from channel use because the large difference between its cruising speed and the reduced speed necessary to negotiate the channel negates the savings in distance. The other three ferries would experience a limited time savings on each of their approximate total of 360 stops per year at downtown Juneau. Assuming that ferry vessel traffic will increase at an annual rate equal to that of population increase, an annual savings of $202,000 would be realized by ferry traffic if unlimited use of the channel were possible.

STAGE BENEFIT ANALYSIS

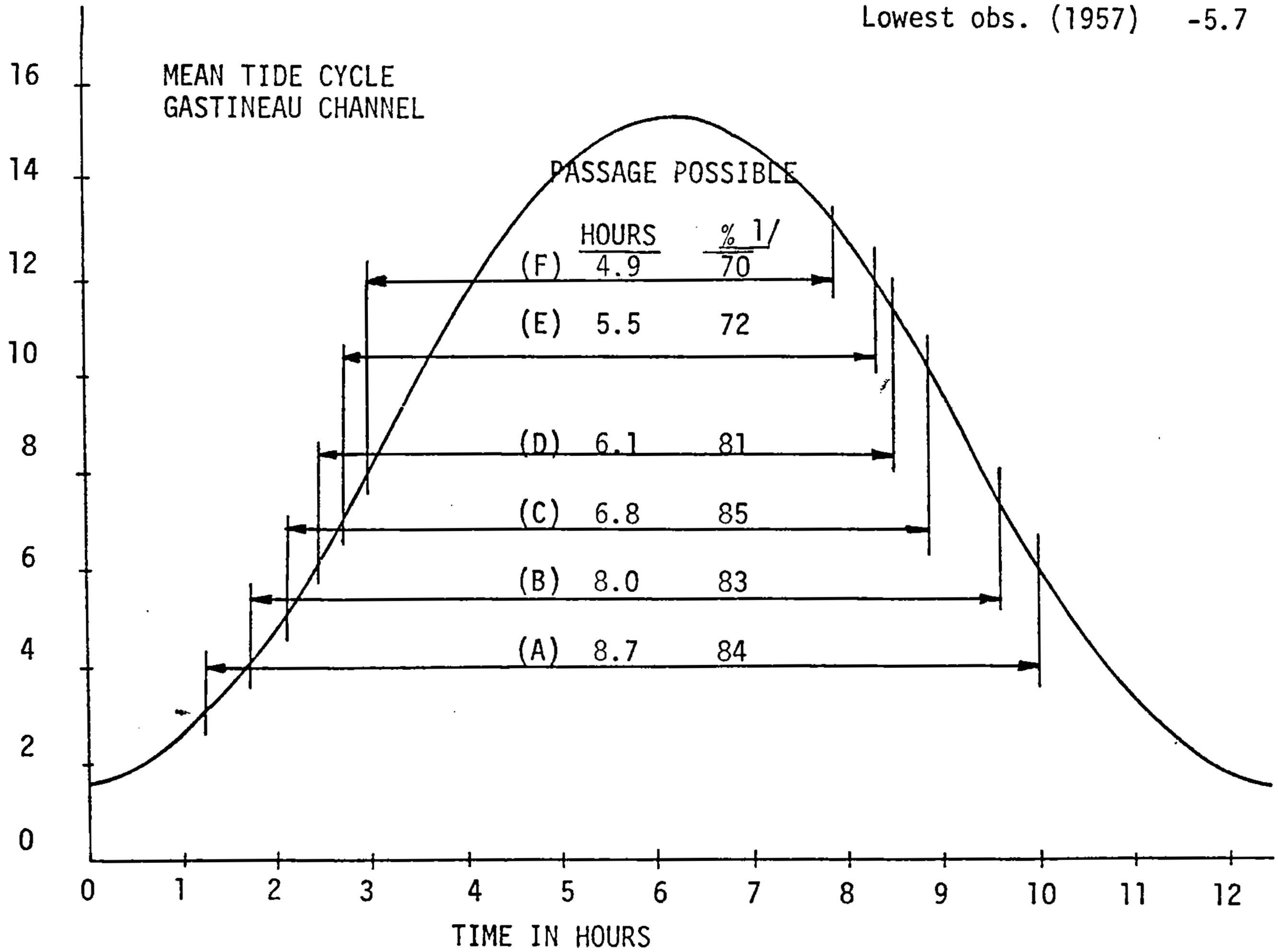
The foregoing presents the total benefits achievable from unrestricted use of the Gastineau Channel. For purposes of analysis, a tide range between MLW and MHW (Figure 1) was assumed. The depth necessary to take full advantage of these benefits, with the exception of those associated with ferry traffic, is between -7 and -8 feet MLLW. At any depth less than this, use of the channel would be restricted for some of the boats being considered and the total benefits would be reduced in proportion to the amount that use was restricted. Thus, the benefits from use of the channel can be expressed as a relation of the percent of the tide cycle during which boat passage is possible.

The analysis is made by stages beginning with the present estimated channel condition of +9 feet MLLW and continuing by 1-foot increments to a depth of -8 feet MLLW. In making this analysis, the following assumptions are made: (a) On a rising tide, boats will enter the channel as soon as the water is the same depth as the boat's draft requirement; and (b) on a falling tide, boats will enter the channel only if there will be 2 feet of water in excess of draft requirement at the time they expect to leave the channel. The additional 2-foot requirement for a falling tide is assumed necessary to compensate for weather conditions

Figure 1

% Time Passage Possible for MLLW Channel

TIDE DATA	
Highest obs. (1948)	22.7
MHHW	16.40
MHW	15.40
Half Tide	13.50
MLW	1.60
MLLW	0.00
Lowest obs. (1957)	-5.7



1/ Percentage of vessel traffic utilizing the channel incorporates allowance for departures from uniform flow to take advantage of channel availability.

Key:

Designation	Type of Vessel
(A) -	Sport
(B) -	Dual Purpose
(C) -	Charter
(D) -	Commercial Fishing, Coast Guard
(E) -	Fisheries Research
(F) -	Tug

which might hasten the falling tide and to leave a margin of time to take care of any unforeseen delays that might be encountered in going through the channel. On the basis of these assumptions, Figure 1 shows the number of hours that the channel is usable for the various classes of boats at a channel depth of MLLW. In this figure, commercial fishing boats, for example, with an average draft of 6 feet and an average speed in the dredged channel of 7.5 miles per hour could enter the channel on a rising tide 2.4 hours after the tide's change. They could continue entering until shortly after the eighth hour of the cycle, at which time there would be just enough time for the last boat to get through the channel safely. This results in a total of 6.1 hours of the 12.4-hour-long tide cycle during which boats of the commercial fishing class could safely use the channel.

It is assumed that the traffic flow throughout the tide cycle would tend, over the long run, to be random and uniform if the channel were passable at all times. When opportunity for passage is discontinuous, however, a larger percentage of total vessel traffic would utilize the channel than indicated by the percentage of the tide cycle during which passage is possible. Specifically it is assumed that boats would depart from the uniform traffic pattern in the case where the delay (or speed-up) time plus time for passage through the channel was less than the time required for travel by the longer route around Douglas Island. A vessel delayed (or speeded up) just a few minutes realizes almost a full measure of time and cost savings, while a boat delayed (or speeded up) an amount of time equal to the time savings from channel passage does not realize any benefits. The benefit realized between these extremes varies linearly. Thus, the shorter route time savings associated with a round trip in each vessel class is added to the hours of possible passage for determination of the percentage of total vessel traffic that would utilize the channel. Continuing the example of commercial fishing boats, while the 6.1 hours of passage time amounts to 49 percent of the tide cycle, 81 percent of vessel traffic during the tide cycle is assumed to take advantage of the channel route. As noted above, since not all the traffic would realize a full measure of benefits, the percentage of total possible benefits is less than the percentage of total vessel traffic. Specifically, it is the percentage of vessel traffic that can utilize the improved channel without adjustment of departure time plus one-half the percentage of additional traffic that utilizes the channel by adjusting the time of departure. For this example, 65 percent of total possible benefits are realized.

Stage benefits to dredging the Gastineau Channel were computed by 1-foot increments, with sample calculations at several depths illustrated in Table 1; benefits are summarized in Table 3. Included in the analysis are recreation benefits which would require that local interests participate to the extent established in guidelines for local cooperation in navigation projects. Total channel use benefits under present conditions amount to $63,800 (Table 1). These benefits would tend to decrease over time if shoaling were to continue. Recent shoaling activity indicates, however, that it could take as many as 10 years to reach +10 feet MLLW. Since changes in the controlling navigation elevation will be so slight, the existing capability for channel use is assumed to continue indefinitely. On the basis of this assumption, dredging the channel to MLLW would result in annual benefits of $476,700. Of this amount, 75 percent is accounted for by present channel use, while the remainder is attributable to projected increases in vessel traffic. At a channel depth of -8 feet, annual benefits would be $758,800, the maximum benefits possible since all the boats under consideration could travel the channel without restriction.

As mentioned previously, benefits will be affected by Juneau's future as the site of Alaska's capital. The assumed impact of capital relocation on vessel traffic in the channel has been summarized previously. There will be no change in commercial fishing, Coast Guard, or fisheries research benefits. Recreation vessel traffic, however, will be reduced. A 47-percent decrease in the 1980 Juneau population has been forecast if the capital is relocated, but with a current pent-up demand for moorage space of two spaces per 100 residents, (as evidenced by boats presently trailered) there will be an estimated decrease in channel use by recreation vessels of only 20 percent. Search and rescue effort savings are directly proportional to recreation traffic and, therefore, will also experience a 20-percent reduction.

Tug and charter operations are assumed to reflect population levels and are, therefore, calculated to be reduced 47 percent. Benefits to dual purpose craft will decline 10 percent, a combination of the impacts experienced by commercial fishing and recreation traffic.

With capital relocation, maximum annual benefits of $822,600 are reduced about 19 percent to $665,258. This same percentage of decline in benefits would result at each stage.

LAND ENHANCEMENT BENEFITS

Depending on its characteristics, some of the material dredged in project construction has a value as fill material. In particular, as much as 1,250,000 cubic yards of suitable dredge spoils could be utilized in construction of a planned expansion to the Juneau International Airport. The dredged material could be pumped directly to the proposed parallel taxiway site adjacent to the existing runway. The airport addition construction is scheduled to begin in approximately 2 years subject to grant application approval and funding. A definite plan to proceed with this work would justify the incorporation of the net value of suitable material as an additional benefit category.

City and Borough of Juneau officials indicate that the fill for the taxiway would have a value of $2.90 per cubic yard in place. Of that amount, about $0.70 is the cost for shaping and compacting the fill material, which would be incurred regardless of source. It would cost an estimated additional $0.30 per cubic yard to deposit the dredge spoils at the site of the taxiway improvement rather than at the more accessible float plane basin area. The net value of each cubic yard of suitable fill material placed at the taxiway site is therefore $1.90.

Almost 100 percent of the material resulting from tidal flat excavation would be suitable fill material. A portion of that material is planned for use in dike construction, but the value of the remainder is properly credited as a benefit to the project. Approximately 85 percent of the material dredged from the channel itself would be suitable for subgrade fill material. These estimates are based on the experience of the initial channel dredging, local sand and gravel extraction operations, and the Alaska Highway Department's channel dredging in 1973.

A summary of the amount of material for which a benefit is claimed, its net value, and the equivalent annual benefit at a 6-5/8 percent discount rate is shown on Table 2.

TOTAL ANNUAL BENEFITS

Stage benefits are combined with the credit for dredge spoils to give total annual benefits which vary according to the plan and the project depth. These annual benefits are summarized in Table 3.

APPENDIX A, TABLE A-1
STAGE BENEFIT COMPUTATION
GASTINEAU CHANNEL, ALASKA

				Benefits					
				Existing Conditions shoaled to +9 ft MLLW		Dredged to 0 ft MLLW		Dredged to -9 ft MLLW	
	Average Cruising Speed (mph)	Average Draft (ft)1/	Total Potential Benefit ($)	% of Total Benefits 2/	Benefits ($)	% of Total Benefits 2/	Benefits ($)	% of Total Benefits 2/	Benefits ($)
Commercial Fishing	10	6	335,200	0	0	65	217,900	100	335,200
Dual-Purpose	15	4	134,700	23	31,000	74	99,700	100	134,700
Sport	20	3	76,200	29	22,100	77	58,700	100	76,200
Tug	10	8	207,000	0	0	55	113,900	100	207,000
Coast Guard	12	6	8,800	0	0	64	5,600	100	8,800
Charter	10	5	20,100	0	0	70	14,100	100	20,100
Fisheries Research	12	7	3,600	0	0	58	2,100	100	3,600
Search and Rescue	--	--	37,000	--3/	10,700	--3/	28,500	--3/	37,000
TOTAL			822,600		63,800		540,500		822,600
Existing Average Annual Benefits					-63,800		- 63,800		- 63,800
Remaining Benefits 4/					0		476,700		758,800

1/ Includes one foot of bottom clearance
2/ Based on the mean tide cycle (Figure 1) and incorporates allowance for departure from uniform traffic flow
3/ Proportional to sport boat channel use
4/ Excludes dredge spoil credit which varies with plan and project depth

APPENDIX A, TABLE A-2
LAND ENHANCEMENT BENEFITS

	PROJECT DEPTH (ft MLLW)								
	+8	+6	+4	+2	0	-2	-4	-6	-8
PLAN 1									
Quantity (10^3 cu yd) 1/	1,005	1,140	1,250	1,250	1,250	1,250	1,250	1,250	1,250
Net Value ($1,000) 2/	1,910	2,166	2,375	2,375	2,375	2,375	2,375	2,375	2,375
Annual Benefit ($) 3/	131,800	149,500	164,000	164,000	164,000	164,000	164,000	164,000	164,000
PLAN 2									
Quantity	782	916	1,070	1,245	1,250	1,250	1,250	1,250	1,250
Net Value	1,486	1,740	2,033	2,365	2,375	2,375	2,375	2,375	2,375
Annual Benefits	102,600	120,100	140,400	163,300	164,000	164,000	164,000	164,000	164,000
PLAN 3									
Quantity	259	394	547	722	1,069	1,250	1,250	1,250	1,250
Net Value	492	749	1,039	1,372	2,031	2,375	2,375	2,375	2,375
Annual Benefits	34,000	51,700	71,700	94,700	140,200	164,000	164,000	164,000	164,000
PLAN 4									
Quantity	1,030	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250
Net Value	1,957	2,375	2,375	2,375	2,375	2,375	2,375	2,375	2,375
Annual Benefits	135,100	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000
EXISTING PROJECT MAINTENANCE									
Quantity					744				
Net Value					1,414				
Annual Benefits					97,600				

1/ Maximum amount needed for airport expansion is 1,250,000 cubic yards.
2/ Net unit value is $1.90 per cubic yard.
3/ It is assumed that benefits are realized in first year of project life.

APPENDIX A, TABLE A-3
TOTAL ANNUAL BENEFITS ($)

Project Depth (ft. MLLW)	Stage 1/ Benefits	Plan 1 Benefits	Plan 2 Benefits	Plan 3 Benefits	Plan 4 Benefits	Existing Project Maintenance Benefits
+8	18,400	150,200	121,000	52,400	153,500	
+6	131,500	281,000	251,600	183,200	295,500	
+4	245,500	409,500	385,900	317,200	409,500	
+2	315,400	479,400	478,700	410,100	479,400	
0	386,100	550,100	550,100	526,300	550,100	483,700
-2	461,100	625,100	625,100	625,100	625,100	
-4	546,800	710,800	710,800	710,800	710,800	
-6	599,500	763,500	763,500	763,500	763,500	
-8	614,600	778,600	778,600	778,600	778,600	

1/ Includes Capital Relocation Adjustment (81%).

APPENDIX B

ENGINEERING

APPENDIX B - ENGINEERING

GASTINEAU CHANNEL, ALASKA

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NAVIGATION CONDITIONS

Gastineau Channel is a narrow strait about 16 miles long that separates Douglas Island from the mainland of southeastern Alaska, and connects Stephens Passage on the east with Fritz Cove on the west. Juneau is located on the mainland side of the channel at about its midpoint. The city of Douglas is located on the north shore of Douglas Island and just to the southeast of Juneau. Gastineau Channel provides a 20-mile shortcut for boats traveling between Juneau and Fritz Cove; it also provides relatively calm waters for navigation. The alternative of going around the south side of Douglas Island places boats in waters that are frequently very hazardous during storms. The authorized navigation project called for a dredged channel about 4.5 miles long at the west end of Gastineau Channel. The channel dimensions were a 75-foot bottom width at mean lower low water (MLLW), 2 feet of advance maintenance, 2-foot allowable overdepth, and side slopes of 1V on 3H.

TOPOGRAPHY AND HYDROGRAPHY

East of Juneau, Gastineau Channel has a fairly uniform width, varying from 4,000 to 6,000 feet. This portion of the channel has a controlling depth of about -45 feet MLLW. West of Juneau, the width varies from about 2,000 feet near Juneau to about 10,000 feet near the western end. The western 5.5 miles of the channel has been described as a giant shoal with a general bottom elevation of +10 to +15 feet MLLW. The shoal is roughly centered on the meeting point of the tides that enter both ends of the channel. The controlling navigation depth in the existing project when surveyed (1967) was +6 feet MLLW. Shoaling since then has resulted in a controlling depth of about +9 feet MLLW. The area tributary to Gastineau Channel covers about 13,000 square miles and includes the rugged and heavily timbered lands and islands bordering the channel itself, as well as the waters of Stephens Passage, Lynn Canal, Icy Strait, and Chatham Strait.

TIDES AND CURRENTS

As previously stated, tides enter both ends of Gastineau Channel and meet roughly in the vicinity of Sunny Point. Since the tides are very closely equal in range and phase, tidal velocities in this area are almost zero. This contributes to growth of the shoal as sediments are brought into the area by tributary streams and tidal currents. The tides display the diurnal inequality typical of the Pacific Ocean. The highest recorded tide in Gastineau Channel is +22.7 feet (2 November 1948). Mean higher high water (MHHW) is +16.4 feet, mean high water (MHW) is 15.4 feet, mean tide level (MTL) is 8.5 feet, mean low water (MLW) is +1.6 feet, and the lowest observed tide is -5.8 feet (16 January 1957), all based on the datum of MLLW.

CLIMATOLOGY AND HYDROLOGY

Juneau lies within the area of maritime influences which prevail over the coastal areas of southeastern Alaska, and is in the path of most storms that cross the Gulf of Alaska. Consequently, the area has little sunshine, generally moderate temperatures, and abundant precipitation. The rugged terrain exerts a fundamental influence upon local temperatures and the distribution of precipitation, creating considerable variations in both weather elements within relatively short distances. Temperature variations, both daily and seasonal, are usually confined to relatively narrow limits by the dominant maritime influences. The differences between normal daily maximum and normal daily minimum temperatures range from about 9 degrees in December to about 18 degrees in June. Extreme maximum temperatures over 80 degrees have occurred in May through August while extreme low temperatures of about -20 degrees have occurred in December, January, and February. Periods of comparatively severe cold, which usually start with strong northerly winds, are most often caused by the flow of cold air from northwestern Canada through nearby mountain passes and over the Juneau icefield, and are generally of brief duration. During such periods, gusty winds, known locally as "Taku Winds", often occur in the city of Juneau and other local areas, but generally do not occur at the airport or in the Mendenhall Valley. During periods of calm or light winds, temperature differences within short distances are frequently very pronounced. Variations in local radiation and drainage produce wide differences in temperatures, particularly between upland or sloping areas and the low, flat terrain which is greatly affected by drainage from higher elevations. The airport, located on low, flat terrain, and in the path of drainage air from the Mendenhall Glacier, averages about 10 days a year with minimum readings below zero. The city of Juneau, located on a noticeable slope portion of a rugged mountain area, averages only about one day a year with minimum temperatures below zero.

The months of February to June mark the period of lightest precipitation, with monthly averages of about 3 inches. After June, the monthly amounts increase gradually, reaching a maximum of over 8 inches during October, after which monthly precipitation tends to decline. Due to the rugged terrain, precipitation tends to vary greatly from locality to locality. The airport receives only about 65 percent of that received in Juneau, even though the two localities are only 8 miles apart. Generally, the first snowfall occurs in late October, but there is usually very little accumulation on the ground at low levels until the last of November. December through March have the largest amounts of snowfall, averaging from 18 to 23 inches per month. Individual storms may produce heavy falls as late as early April, and light falls as late as the middle of May. However, snow cover is usually gone before the middle of April. During some winters, when temperatures are above normal, there is a great deal of thawing which causes slush that later freezes; and there are occasional intervals of rain which freezes into glaze ice on contact with the ground.

The prevailing wind direction in Gastineau Channel, as determined from 12 years of record at the Juneau Airport, is from the east-southeast direction, which is just about coincident with the alinement of the southern half of the navigational channel. From the east-southeast, the maximum instantaneous wind observed was 50 knots, the highest wind of 1-hour duration was 42 knots, and the highest wind of 3-hour duration was also 42 knots. Because of the consistency of the wind velocities from east-southeast for the period of record, the design wind velocity from that direction is taken as 45 knots. The western, or Fritz Cove half of the navigational channel, is alined in a southwest-northeast direction. The only recorded winds of any significance in that alinement occurred from the southwest, yielding a maximum instantaneous velocity of about 30 knots, maximum velocity of 1-hour duration of 20 knots, and maximum velocity of 3-hour duration of 12 knots. Again, because of the consistency of the data, the design wind from the southwest is taken as 25 knots. The only other direction that showed significant wind velocities was from the north, which would have little effect on the project as far as wave generation is concerned and is, therefore, disregarded.

A summary of temperature and precipitation data for a period of record of 29 years at the Juneau Airport is tabulated below:

	Temperature (Deg F)					Precipitation (Inches)			
	Normal			Extremes					
Month	Daily Max	Daily Min	Month	Record Highest	Record Lowest	Normal Total	Max Total	Min Total	Max 24-Hrs
Jan	30.1	20.0	25.1	57	-22	4.00	7.75	0.94	2.74
Feb	32.1	21.4	26.8	50	-22	3.06	8.48	0.68	2.37
Mar	36.5	24.3	30.4	55	-15	3.27	6.36	1.20	1.81
Apr	45.4	30.5	38.0	71	6	2.87	4.33	0.27	1.57
May	53.6	37.6	45.6	82	25	3.24	6.33	1.25	1.39
Jun	60.8	43.7	52.3	86	31	3.39	5.34	1.08	1.92
Jul	62.7	47.8	55.3	84	36	4.49	7.88	1.15	1.88
Aug	61.5	46.6	54.1	83	27	5.02	12.31	1.11	2.39
Sep	55.2	42.5	48.9	72	23	6.67	11.51	2.34	3.17
Oct	46.5	36.7	41.6	61	12	8.33	13.29	2.71	4.66
Nov	39.2	29.4	34.3	56	- 5	6.06	11.22	1.46	3.34
Dec	32.7	24.0	28.4	54	-21	4.22	9.89	1.90	3.56
Year	46.4	33.7	40.1	86	-22	54.62	13.29	0.27	4.66

The main freshwater streams discharging into Gastineau Channel in the proximity of the navigational project are Mendenhall River, Jordan Creek, Switzer Creek, Lemon Creek, and Salmon Creek, all of which enter from the mainland. Fish Creek originates on Douglas Island and discharges into the channel's western end, close to Fritz Cove. Of the above streams, only Mendenhall River, with mean and maximum discharges of 1,100 cubic feet per second (c.f.s.) and 10,000 c.f.s., respectively, and Lemon Creek, with mean and maximum discharges of 220 c.f.s. and 3,000 c.f.s., respectively, have any appreciable flow.

SHOALING

The navigational project was constructed in 1959-1960, with a 75-foot bottom width at MLLW, 2 feet of advance maintenance, approximately 2 feet of overdepth, and side slopes of 1V on 3H. Immediately following construction, rapid shoaling occurred due primarily to side slope sloughing and erosion. A condition survey taken in 1961, approximately 9 months after construction, showed a net accumulation above design lines and grades of about 200,000 cubic yards. A significant amount of this quantity may be attributable to the fact that at the time of initial construction, the dike retaining the seaplane basin was breached, allowing almost the entire volume of the seaplane basin to drain into Jordan Creek during ebb flows, thus flushing large amounts of sediment into the channel. After repair of the seaplane basin dike, shoaling in the vicinity of the Jordan Creek mouth slowed significantly. A condition survey taken in 1963 shows a net accumulation from 1961 of about 200,000 cubic yards, and a survey in 1967 shows accumulation from 1963 of about 225,000 cubic yards, indicating that as the channel aggrades, the sedimentation rate decreases. It has been estimated that another 275,000 cubic yards of sediment has accumulated in the navigational channel from 1967 to date (Jan 1977). Therefore, the total amount of shoaling in the channel since construction in 1960 is about 900,000 cubic yards. The initial dredging quantities for project depth at MLLW for existing channel maintenance are 875,000 cubic yards, somewhat less than the total accumulation because of the Highway Department's 1973 dredging.

Besides the above-mentioned shoaling due to side slope sloughing and the seaplane dike breach, some of the rapid initial shoaling upon construction was due to the increased hydraulic gradient across the tidal flats as a result of the dredged channel being 10 to 15 feet below the adjacent ground. This resulted in higher ebb flow velocities across the flats that were capable of moving large quantities of sediment into the dredged channel. This is especially evident in the form of small deltas formed at the mouths of the tributary creeks and tidal flat drainage channels entering the channel. The extensive side slope sloughing was inevitable, as it has since been determined that the natural side slopes for the channel materials under tidal action are between 1V on 6H to 1V on 10H for the most part, although some of the finer-grained deposits, such as in the vicinity of the mouth of Jordan Creek, may have natural side slopes as flat as 1V on 30H. More detailed discussion of the side slopes is covered in the GEOLOGY AND SOILS paragraph of IMPROVEMENT STUDIES section.

DREDGING BY STATE OF ALASKA

As shown on Plate 2, approximately one-half the navigation channel was dredged in 1973 by the Alaska Department of Highway as a source of embankment materials for the Glacier Expressway between the airport and Juneau. At the close of dredging operations in December 1973, this half of the navigation channel averaged -10 feet MLLW, with a bottom width of 90 feet. It is expected that with the more stable material in this area of the channel, the side slopes will flatten to a fairly stable slope of 1V on 6H, as existed for several years before. This slope flattening will result in a channel with a depth of about -4 feet MLLW and average bottom width of about 100 feet. Without maintenance or providing some means to prevent or reduce the influx of sediments, this part of the channel can be expected to rapidly shoal and attain its pre-1973 dredging condition within a few years.

MODEL STUDIES

A model of Gastineau Channel was constructed and tested from 1964 to 1967 by the U.S. Army Engineer Waterways Experiment Station (WES) at Vicksburg, Mississippi. A report of the study, Technical Report H-72-9, "Navigation Channel Improvement, Gastineau Channel, Alaska," was published by WES in November 1972 and is contained in Appendix C. The paragraphs that follow were excerpted from that report in order to facilitate review. For specific data and details of the study, the reader is referred to the report.

PURPOSE

In June 1961, the U.S. Army Engineer District, Alaska, requested that the Corps of Engineers Committee on Tidal Hydraulics review the shoaling problem and recommend measures which might resolve the problem. At that time, the Committee recommended that more extensive field surveys be made in order to study the problem in more detail and made several generalized recommendations for reducing channel shoaling.

In June 1962, the Alaska District again requested that the Committee review the Gastineau Channel problem. With the more detailed information the Alaska District was able to furnish at that time, the Committee published a report entitled "Navigation Project in Gastineau Channel, Alaska," which listed several specific alternative solutions to the problem as follows: (a) redredge the channel periodically, (b) reduce velocities over the shoal areas with dikes or by reshaping natural contours, (c) localize scouring velocities to paved or enrocked areas so that no bed movement occurs, (d) construct settling basins to trap the sediments, (e) divert tributary streams and sloughs away from the navigation channel, and/or (f) isolate the navigation channel from the tidal flats by means of a continuous dike.

Of these possible solutions, the Committee recommended isolation of the navigation channel by means of a continuous dike as being the only one giving promise of a permanent improvement. The north dike proposed by the Committee would be open at both ends to preserve the tidal conditions north of the dike. It seemed probable that rather sizable volumes of sediment would be carried out of the tidal flats past the ends of the dike; however, because of the abrupt termination of the shoal at both ends, it was not believed that the sediments would be transported around the ends of the dike and into the navigation channel. Much of the material required for construction of the dike would logically be obtained by deepening and widening the navigation channel. This would lead to increased navigation benefits from the project and would satisfy requests of local interests for an enlarged channel. It was believed that an additional benefit which might be realized from this plan would be the reclamation of land for future development.

The Committee further recommended that a hydraulic model study of the problem be undertaken with the following purposes: (a) to study the present current patterns over the shoal areas as a guide to laying out improvement works; (b) to determine the velocities associated with any proposed dike construction, weir construction, or channel diversion; (c) to study dike closure procedures in the event that a land reclamation project is considered in the improvement program. Subsequently, item (c) was removed from the program, and the model study was expanded to include investigation of the effects of enlarging the dimensions of the navigation channel. Field surveys to obtain prototype data were completed in the fall of 1963, and the model study was begun at Waterways Experiment Station in October 1964 with the testing virtually completed in May 1967. A draft report of the study was submitted to Alaska District in October 1969, and the final report was published in November 1972.

DESCRIPTION

The Gastineau Channel model reproduced about 7 miles of the Gastineau Channel from Fritz Cove to within about 1 mile of Juneau, an area of about 15 square miles. Each end of the model terminated in a headbay of suitable area and depth for installation and operation of a tide generator.

The model was constructed to linear scale ratios, model to prototype, of 1:500 horizontally and 1:100 vertically. From these basic ratios, the following scale relations were computed according to the Froudian relations: slope 5:1, velocity 1:10, time 1:50, discharge 1:500,000, and volume 1:25,000,000. Salinity was not reproduced in the model, since an analysis of prototype salinity data indicated that density phenomena had no significant effects on shoaling. One prototype tidal cycle (diurnal) of 24 hours and 50 minutes was reproduced in the model in 29 minutes and 48.5 seconds. Horizontal control was based on the Universal Transverse Mercator grid system, Zone 8, and vertical control was based on MLLW, 1959 revision, USC&GS. The model was approximately 65 feet long and 25 feet wide, covered an area of about 1,600 square feet, and was of fixed-bed construction; it was completely inclosed to protect it and its appurtenances from the weather and to permit uninterrupted operation. The navigation channel was molded in removable blocks so that desired alterations could readily be made as necessary to investigate changes in channel dimensions. The permanent roughness employed consisted of one-half-inch-wide metal strips, although it was subsequently determined that the concrete bed of the model was sufficiently rough to eliminate the need for any additional roughness.

The model was equipped with the necessary appurtenances to reproduce and measure all pertinent phenomena, such as tidal elevations, current velocities, freshwater inflow, dispersion characteristics, and shoaling distribution. Apparatus used in connection with the reproduction and measurement of these phenomena included two primary tide generators and recorders, tide gages, current velocity meters, freshwater inflow measuring weirs, skimming and measuring weirs, dye injection equipment, and shoaling recovery apparatus.

PLANS TESTED

All tests were made for conditions of the spring tide of 4-5 September 1963, which had a diurnal range of 20.6 feet. The tributary inflows were as follows: Mendenhall River, 3,000 c.f.s.; Lemon Creek 1,000 c.f.s.; Fish Creek, 300 c.f.s.; and Sweitzer Creek, 75 c.f.s. The model was operated with freshwater only, since analysis of prototype data indicated that saltwater-generated density currents have no significant effect on the hydraulic or shoaling phenomena of the area. Except for the navigation channel, the model was molded to conform to 1963 prototype hydrography. During the testing phase of the model study, the navigation channel was molded to the design condition being investigated.

It was assumed that any improvement plan actually constructed in the prototype would include redredging the navigation channel to design conditions. Thus, for the base test condition, the channel was molded to design conditions (4 feet deep by 75 feet wide). By conducting a shoaling test of this base condition, it was possible to determine the shoaling rate and distribution pattern in the design channel without the effects of side sloughing. The four improved plans tested with the existing navigation channel consisted of variations of the impermeable north dike proposed by the Committee on Tidal Hydraulics. These plans are shown in Figure 12, Appendix C. Plan 1 consisted of a 26,850-foot-long dike. The plan 2 dike was 24,350 feet long, having been shortened by 2,500 feet on the Juneau end. For plan 3, the dike of plan 2 was shortened by 5,000 feet on the Fritz Cove end, resulting in a 19,350-foot-long dike. For plan 4, the dike of plan 3 was shortened by an additional 2,100 feet on the Fritz Cove end, resulting in a 17,250-foot-long dike, and Fish Creek was diverted from the navigation channel directly into Fritz Cove. The best plan tested (plan 4) was then tested with two possible enlarged navigation channels. Plan 5 consisted of a 12-foot-deep by 150-foot-wide channel with no supplemental improvements, while plan 6 consisted of the same channel with proposed improvements of plan 4. Plan 7 consisted of a 30-foot-deep by 300-foot-wide channel with no supplemental improvements, while plan 8 consisted of the same channel with the proposed improvements of plan 4. (For the purpose of this report, the model study dike plan 4 is essentially identical to Dike No. 1, as shown on Plate 3 of this report.)

CONCLUSIONS

Based on analysis of available prototype information and the results of model tests reported herein, the following conclusions were drawn:

a. The Mendenhall River does not contribute significantly to shoaling of the navigation channel.

b. The heavy shoaling in the navigation channel observed in the first year after construction was caused primarily by sloughing of the side slopes. In addition, a breach in the Juneau Airport seaplane basin caused heavy shoaling at the mouth of Jordan Creek.

c. For any of the dike plans tested in combination with the existing channel, shoaling in the navigation channel will be reduced by about 80 to 85 percent. Diversion of Fish Creek will reduce channel shoaling by about an additional 5 percent.

d. Enlargement of the navigation channel to dimensions of -12 feet MLLW by 150 feet bottom width will increase shoaling in the navigation channel by about 45 percent; enlargement of the channel to -30 feet by 300 feet bottom width will increase shoaling by about 110 percent.

e. The 17,250-foot-long dike and diversion of Fish Creek, in combination with the -12 feet MLLW by 150-foot channel, will reduce shoaling by about 60 percent as compared with base conditions, while the same improvements with the -30 foot MLLW by 300-foot channel will reduce shoaling by about 30 percent.

f. Either of the enlarged channels in combination with the improvements will cause rather heavy shoaling in the Juneau end of the channel.

g. For all of the plans tested, current velocities and current patterns should be satisfactory from the standpoint of navigation.

h. For all plans involving a dike, relatively high velocities will occur near the ends of the dike, along the bankline opposite the ends of the dike and along the bankline at the Juneau end of the airport runway.

i. Because of the head differential measured across all of the proposed dikes tested, a substantial flow would develop across the top of the dike if it were constructed with a top elevation below HHW. This flow could cause severe damage to the structure unless extensive protection were provided.

j. With any of the dike plans, a substantial area behind the dike will remain flooded at the time of low water.

RECOMMENDATIONS

Based on the results of the model tests and the subsequent analysis thereof, the following recommendations were made:

a. The 17,250-foot-long dike (Dike No. 1, Plate 3) and Fish Creek diversion should be constructed if economically justified. The top elevation of the dike should be above HHW, and the dike should be impermeable.

b. The ends of the proposed dike and the bankline in the vicinities of the seaplane basin, the east end of the airport runway, and Vanderbilt Hill should be protected against erosion by relatively high current velocities.

c. It is suggested that the Lemon Creek channel be improved from the upstream end of the proposed dike to its most downstream junction with the navigation channel. This would reduce the lateral flow between Lemon Creek and the navigation channel, and thus reduce the possibility of shoaling in that reach of the channel.

d. If the navigation channel is enlarged, it is recommended the Lemon Creek channel not only be improved, but also be diverted from the navigation channel directly into deep water near Salmon Creek.

IMPROVEMENT STUDIES

Investigation of possible improvement plans was concentrated on those that would isolate the navigation channel from the tidal flats to the north by means of a continuous dike. This was in accordance with the conclusion by the Tidal Hydraulics Committee that this is the only method offering a potentially permanent solution, a conclusion that was substantially affirmed by the model study.

Any dike considered would have to be open at both ends in order to maintain tidal exchange in the tidal flats north of the navigational channel so as to cause the least disturbance to that area's ecology, a requirement stipulated by State and Federal fish and game agencies. Two dike alinements were examined in detail. Under plan 1, shown on Plate 3, Dike No. 1 is a duplication of the best dike plan (model test dike 4) tested in the model study. This dike is alined to utilize the existing dredge spoil piles from the 1959-60 dredging of the navigational channel. Under plan 2, shown on Plate 4, Dike No. 2 is alined as close as possible to the navigation channel, roughly 500 feet, to minimize the area of tidal flat subject to erosion between the dike and channel. Other dike alinements considered were variations of the two above, but offered no economic or functional advantage and, therefore, are not presented herein.

Two other plans not utilizing an isolation dike are presented for comparison purposes. Plan 3, shown on Plate 5, simply consists of dredging the existing navigation channel, with improvements in alinement, widening, and flattening side slopes to IV to 10H. The channel would be maintained by a project dredge. Plan 4, shown on Plate 6, is a complete relocation of the navigation channel into an area of more stable materials to the south of the existing navigation channel, with the latter acting as a sedimentation trap to intercept the material eroded from the tidal flats on the north side of the channel.

An analysis of the shoaling rates and maintenance requirements for each of the four plans above is detailed under MAINTENANCE.

PROJECT FORMULATION

Provision of a navigation channel of sufficient width and depth at all tide stages for all classes of vessels now plying or expected to ply the waters in the Juneau area would be the ideal objective. However, it was found that the benefits associated with the passage of ferry class vessels were insufficient to cover the construction and maintenance costs necessary to provide the required depth. Further, these vessels do not have sufficient head clearance to pass under the bridge connecting Juneau and Douglas Island. The Alaska Department of Highways plans to replace the bridge in the near future, but the new bridge is currently designed to have about the same clearance as the existing bridge. Thus, the exclusion of the ferry vessels scales the navigation channel down to dimensions required to handle fishing boats, tugs and barges, sport boats, and Coast Guard patrol boats. It was found that 54 percent of the boat traffic in terms of trips per year comes from shallow-draft sport boats. However, about 66 percent of the benefits derive from fishing boats and tugs with a maximum draft requirement of about 7 feet and maximum beam of about 20 feet. Based on the Coast Guard's recommendation that for two-way traffic, the channel should have a width at least equal to five times the maximum beam, the resulting minimum channel width at project depth should be 100 feet. As benefits and costs would vary with depth, the optimum depth from an economic standpoint will be that depth where net benefits are maximized.

SURVEYS

Topographic and hydrographic surveys made of the Gastineau Channel area and used in preparation of this report were made in 1961, 1962, 1963, and 1967. Quantities used in estimating the costs of the four plans investigated were based on the 1967 condition survey, adjusted for estimated shoaling between 1967 and 1977.

GEOLOGY AND SOILS

Soil Conditions: The lower slopes of the mountains on both sides of the channel are covered with varying thicknesses of glacial soil composed of silty, sandy gravel or silty, gravelly sand, and containing much fragmental material and scattered well-rounded boulders up to a maximum observed size of about 1 cubic yard. The materials in the navigation channel area in general are in the fine to medium sand size range. The materials consist of about 10 percent in the 1-inch to one-quarter-inch size range, 80 percent in the one-quarter-inch to the No. 40 size range, and about 10 percent in the No. 40 sieve and smaller size range. Soil logs in the Lemon Creek area and in the channel area at the west end indicate that the material is fairly constant throughout. It is reasonable to expect that these materials were transported to the channel area by streams, reworked by tidal action, and exposed by the general uplift of the area. Materials in this size range can be transported by current velocities in the 1 to 2 feet per second range, although a significantly higher velocity would be required to dislodge the in situ material. Therefore, although somewhat conservative, it would appear reasonable to design any channel in the tidal flats to an average velocity of no more than 2 feet per second.

The north shore of Douglas Island is very rocky and it is expected that the channel of plan 4 would entail considerable rock excavation.

The estimated cost of plan 4 is considerably higher than any of the other three plans and further elaboration on the subsurface conditions for this channel is not felt to be warranted.

Dike Alinement: It was noted in the Gastineau Channel model study that a head differential in the form of ponded water on the land side of the dike tested would exist during low tide stages. Such a condition would result in a head differential which could cause an uplift seepage force on the particles in the channel slopes and could result in sloughing or slumping of the slopes. Thus, any dike considered should be set back far enough from the channel to minimize any seepage forces. At this time, 500 feet appears to be an adequate minimum distance. On the other hand, as there is a great expanse of tidal flat area north of the channel that is subject to varying degrees of erosion, it would be prudent to locate the dike as close as possible to the channel to minimize the available surface area subject to such erosion. As previously stated, a minimum distance of 500 feet from the channel would be needed to minimize seepage forces, and it would also be recommended as the maximum distance. Erosion protection on both sides of the dike would be required to prevent damage from tidal velocities and wave action.

Channel Slopes: The most reliable method for determining a reasonable slope is by measuring the performance of the slopes after the dredging operation of 1960, assuming the velocity conditions to be comparable. In 1963, channel slopes of 1V on 5H to 1V on 10H predominated, with some areas as flat as 1V on 30H and some areas as steep as 1V on 3H. By 1967, the majority of the slopes had flattened to the vicinity of 1V on 10H. The existing dredge spoil piles have developed reasonably stable slopes of 1V on 6H to 1V on 15H, having been exposed to wind waves of up to 3 feet. As shown under WAVE ANALYSIS, the channel slopes would be subjected to maximum waves of about 2 feet, generated by boats at low tide stages. Therefore, 1V on 10H slopes appear to be reasonable for design. Steeper slopes could be constructed in the interest of reducing dredging quantities, but would require protection. Protection of the channel slopes by means of a gravel or coarser sized blanket would not be practical or even possible, as there is no known source available in the area capable of producing that size material in any quantity. Some areas of the channel, notably in the vicinity of the mouth of Jordan Creek, would probably slough and erode to flatter slopes than 1V on 10H, necessitating either flatter initial design slopes, protective treatment, or channel widening. Prior to final design, it would be necessary to evaluate the slopes on a reach by reach basis, correlating in situ soil grain size with tidal velocity and wave action to insure a reasonable slope.

Rock and Gravel Sources: The Alaska Department of Highways developed a rock quarry for armor rock in the construction of the Glacier Expressway. The source is about one mile up the Lemon Creek Valley from

Sunny Point, an average one-way haul distance to the ends of Dike No. 1 of about 5 miles. The source has not been evaluated by the Alaska District, but in view of its acceptability by the State, it is felt to be capable of producing sufficient armor rock of required quality, size, and quantity for either dike plan. Rock of quarry spall size is available in large quantities for a small royalty from the A-J gold mine tailings, about 1 mile east of Juneau, a one-way average haul distance of about 9 miles. Gravel for dike slope bedding would be available in sufficient quantity from a privately owned borrow pit near Sunny Point. Other sources are probably present, but would more than likely be privately owned. There are no other known State or Federally-controlled rock or gravel sources in the area.

WAVE ANALYSIS

Wind Generated Waves: Because of the narrow characteristics of the channel area, it was seen that an effective fetch length, in accordance with paragraph 3.432 of the Shore Protection Manual (SPM), should be evaluated. The effective fetch length from the east-southeast direction was found to be 0.8 miles (statute), and the effective fetch from the southwest was found to be 1.9 miles (statute). For the purpose of computing the theoretical wave heights, deep-water conditions were assumed because most of the fetch lengths lie in deep water. Thus, the wave heights from the east-southeast and southwest directions are computed as follows:

East-southeast:

Wind Velocity V = 45 knots

Effective Fetch F = 0.8 mile, say 1 mile

From Figure 3-15, page 3-36, SPM:

Deep-water Wave H_0 = 2.9 feet

Deep-water Wave Period T_0 = 3.3 seconds

Deep-water Wave Length $L_0 = 5.12\ To^2 = 55$ feet

Ground Elevation at Dike Toe = 12 feet MLLW

Design Stillwater Top Elevation = +22.7 MLLW

Depth of Water d, at dike toe = 22.7 - 12 = 10.7 feet

$d \div L_0 = 10.7 \div 55 = 0.1948$

From table C-1, SPM, shoaling coefficient H ÷ Hó = 0.9170 Refraction was found to be negligible; therefore, the significant wave height H_s = 2.9 (0.9170) = 2.6 feet. The depth of water 7 wave heights (22.7 feet) from the dike toe is about 10 feet. 1.3 (2.6) = 3.4, which is less than d, indicating that the design wave will not be affected by the water depth, and that it will be a nonbreaking wave. Therefore, design wave height H = 2.6 feet.

Southwest:

Wind Velocity V = 25 knots

Effective Fetch F = 1.9 miles, say 2 miles

From Figure 3-15, SPM:

Ho = 1.8 feet

T_o = 2.8 seconds

L_o = 5.12 (2.8)(2.8) = 40 feet

Ground Elevation at Dike Toe = +10' ± MLLW

Water Depth at Dike Toe = 22.7 - 10 = 12.7

d ÷ L_o = 12.7 ÷ 40 = 0.318

From table C-1, SPM, shoaling coefficient = 0.9547 Again, refraction is negligible and H_s = 1.8 (0.9547) = 1.7 feet. Water depth 7 wave heights (12 feet) from the dike is about 12 feet. 1.3 (1.7) = 2.2, which is less than the water depth, indicating that in most instances, the wave will be nonbreaking and, therefore, the design wave height H = 1.7 feet.

Boat-Generated Waves: ASCE Paper No. 5102, "Investigation of Ship-Generated Waves," Journal of the Waterways and Harbors Division, by Robert M. Sorensen, describes a study conducted in the Oakland Estuary by the University of California at Berkeley under a contract with the U.S. Army Corps of Engineers Coastal Engineering Research Center. The study consisted of running a number of vessels past recording wave gages installed at various distances from the sailing line. The vessels used were small tugboats 40 to 50 feet long, large tugboats approximately 100 feet long, pleasure boats 25 feet long, a Navy destroyer escort 306 feet long, and a fishing vessel 64 feet long. Water depths in the study area averaged about 35 feet. Wave heights at the various gages were recorded for each vessel for different speeds. The highest wave recorded was 2.6 feet at a gage 100 feet from the sailing line. The wave was generated by a tugboat 100 feet long, operating at a speed of 12 knots. At the same speed and 300 feet from the sailing line, the wave recorded was 1.5 feet. This drastic reduction in wave height with increasing distance from the sailing line was typical of all the runs. Because the study entailed use of vessels closely approximating the fleet that would be using Gastineau Channel, and similarity of water depths (the maximum water depth in Gastineau Channel would be about 31 feet, assuming occurrence of the maximum recorded tide of 22.7 MLLW and channel bottom of -8 MLLW), it is concluded that the maximum wave that could possibly be expected to be generated in Gastineau Channel by boats would not exceed 3 feet, and that maximum wave height that could reach a dike 500 feet from the channel would not exceed 1.5 feet. Also, assuming a sailing line along the side of the channel, the maximum boat-generated wave that could impinge on the channel slopes would probably not exceed 2 feet.

CHANNEL DESIGN

Alinement: The channel alinement that would be recommended under improvement plans 1, 2, and 3 is shown on Plates 3, 4, and 5. It departs from the existing channel alinement mainly at the ends of the channel. At the Juneau end, the channel alinement is changed near Salmon Creek. Likewise, the alinement for about the last one-fifth of the channel at the Fritz Cove end is realined for ease of navigation. Further changes, such as widening in the areas of direction changes, could be added later during final design if economically justified. The increase in dredging quantity for the recommended alinement over the existing alinement is on the order of 0.5 percent, and the extra cost thereof is trivial compared to the navigational benefit gained. Further soils exploration would have to be conducted, however, especially at the Juneau end, to make sure that the underlying materials would be dredgeable. Possible improvement could be made in the alinement near the present mouth of Switzer Creek, but the increase in quantities, approximately 40 percent, was not felt to be justified compared to the navigational benefit to be gained. Under plan 4, the channel would be completely isolated from the existing channel, as shown on Plate 6. This alinement would traverse through much more stable materials, which would minimize erosion of the channel and side slopes. Also, the existing channel would perform essentially the same function as a dike on the north side of the channel by intercepting sediments eroded from the tidal flats and preventing their entry into the navigational channel. Extensive materials exploration would be required to determine the characteristics and relative quantities, particularly rock, that would be encountered.

Depth: As stated in PROJECT FORMULATION, the optimum bottom depth is the depth at which net benefits are at a maximum. Maximum benefits occur at a depth that will allow usage of the channel at all stages of tide. The deepest draft vessels expected to use the channel have a draft requirement of 7 feet. Based on a 1-foot minimum freeboard and safety considerations discussed on page A-24 of Appendix A, the minimum elevation for 100 percent usage (based on diurnal tide) would be between -8 feet and -9 feet MLLW.

Disposal: Excavated materials would be disposed of in the presently inactive float plane basin adjacent to the Juneau Airport runway, as shown on Plates 3 through 6. The capacity of this area is estimated to be about 5 million cubic yards, which is sufficient to accommodate initial construction requirements for all of the considered plans for channel project depths to -10 feet MLLW, including advance maintenance and overdepth dredging, plus most of the expected future maintenance requirements. The city of Juneau has developed a 10-year master plan to improve the airport, which calls for filling the float plane basin as part of the construction of a new runway roughly parallel to the existing runway. The existing runway would be utilized as a taxiway. Should the master airport plan be developed before channel maintenance is begun, the maintenance dredge materials could be disposed of in a number of selected locations in the tideflats, such that the materials could be readily available for use by the city of Juneau, State agencies, etc.

DIKE DESIGN

Alinement: Dike No. 1, plan 1, shown on Plate 3, duplicates the alinement of the best dike plan tested in the model study and by utilizing the existing dredge spoil piles, would require the least amount of fill material. Dike No. 2, plan 2, shown on Plate 4, is alined roughly 500 feet parallel to the channel and represents the alinement that would result in the least amount of maintenance dredging. It would also require the greatest volume of fill for the initial construction. Other dike alinements between the two did not appear to offer any particular economical or functional advantage and were, therefore, not considered further. The two dike plans were cost analyzed in detail (Table 1 and Table 2) to determine which has the lesser total annual cost. Plan 2, with dike No. 2, has a somewhat lower total annual cost and would be the dike plan recommended.

Top Elevation: It was recommended in the model study report that the dike would have to be constructed to a top elevation that would preclude its being overtopped. Any overtopping would result in flow across the dike and would require erosion protection. The required top elevation is determined by finding how high the design wave will run up the slope of the dike and adding this to the design top stillwater level. In this case, although MHHW is only +16.4 MLLW, the highest observed tide of 22.7 MLLW is used as the top stillwater level. In paragraph Wave Analysis, it was found that the highest design wave is 2.6 feet from east-southeast. The wave runup for this wave is computed as follows: From paragraph 7.21, SPM, the equivalent deep-water wave height H_0' must be obtained first as the runup R, is obtained from its relationship with H_0' and d, the depth at the structure.

$H/H_0' = 0.917$; $H_0' = H \div 0.917 = 2.6 \div 0.917 = 2.9$

$d \div H_0' = 10.7 \div 2.9 = 3.7$

$T = 3.3$, $T^2 = 10.9$

$g = 32.2$, $gT^2 = 32.2\ (10.9) - 351$

$H_0' \div gT^2 = 2.6 \div 351 = 0.0074$

$H_0' \div T^2 = 2.6 \div 10.9 = 0.239$

From Figure 7-20, SPM, for a slope of 1 on 6 (covered later in this section), $R \div H_0'$ is estimated at 0.3

$R = 0.3\ (2.6) = 0.8$

From Figure 7-13, SPM, runup correction for scale effect = 1.045

Corrected R = 1.045 (0.8) = 0.84, say 0.8

Therefore, the minimum required top elevation is

22.7 + 0.8 = +23.5 MLLW, round to +24' MLLW

Top Width: The top width is governed by the minimum required by construction equipment to effect any future needed repairs, and is generally taken as 12 feet.

Side Slopes: For the type of materials that will be dredged and used to construct the dike embankment, a side slope of 1V on 6H was found to be the slope taken in water for any length of time.

Slope Protection: As the dike embankment material will consist mainly of fine sand, it would require some cover for protection against tidal velocities, and on the channel side, additional protection against wave action. On the land side, a one-foot-thick gravel layer would be sufficient to protect against the highest allowable tidal velocity of two feet per second. On the channel side, the one-foot-thick gravel layer is needed to act as a filter for the outside rock protection. The rock protection is sized from the stability formula for graded riprap presented in paragraph 7.373, SPM:

$$W_{50} = \frac{w_r H^3}{K_{RR}\ (Sr - 1)^3 \cot a}$$

For rock protection on the channel side in the reaches subjected to just boat waves:

w_r = 170 pounds/feet^3

H = 1.5 feet (wave height at dike would be about 1/2 the wave generated by boats)

S_r = 170 ÷ 64.4 = 2.64

cot a = 6

K_{RR} = 2.5

and W_{50} is the 50-percent size of stone, in pounds.

W_{50} = 170 (3.4) ÷ 2.5 (4.42) (6) = 19 pounds

W_{max} = 3.6 W_{50} = 3.6 (19) = 32 pounds

W_{min} = 0.22W_{50} = 0.22 (19) = 2 pounds

Size of maximum stone is about 8 inches (Table 7-11, SPM).

Therefore, except for the reaches subject to attack by wind waves, a one-foot layer of quarry spalls approximating the above gradation would suffice. For the reaches of dike and at the Juneau end of the dike subject to the wind-generated waves developed previously, and using the larger wave height of 2.6 feet:

W_{50} = 170 (17.6) ÷ 2.6 (4.42) (6) = 45 pounds

W_{max} = 3.6 (45) = 162 pounds

W_{min} = 0.22 (150) = 10 pounds

From Table 7-11, SPM, W_{max} size is about 1.1'

A two-foot layer is recommended to cover inaccuracies, etc. Projecting the influence of the wind-generated waves to the different dike locations gives the limits of the reaches needed to be protected with armor rock, shown on Plates 3 and 4. In addition, the Juneau end of the dike is wrapped with the armor rock section from a distance of 100 feet from the end on the channel side to 50 feet from the end on the land side.

Tidal Velocity Relief Excavation: The model study pointed out that, with construction of a dike, rather high tidal velocities would be encountered between the dike and the Glacier Expressway and between the dike and the float plane basin dike. Excavation to reduce the exit velocities was adopted on the basis that it is a more positive method of achieving the velocity reduction, and it would provide a means to insure complete drainage of the tidal flats at low tide which is desirable from a dike stability standpoint and is also a requirement stipulated for ecological reasons. Other methods of reducing the exit velocities, such as pile dikes, would depend upon increasing the channel roughness sufficiently to effect the reduction, but this would also raise the water surface and probably result in ponding at low tide stages. A fair analysis of such a method really could not be made without additional model study as there is no other way to arrive at the effect on channel roughness that such structures would have. Aside from that, it is very doubtful that a "field" of pile dikes or other structures would be esthetically acceptable. At a public hearing at Juneau on 13 July 1971, many Juneau area residents expressed strong desires to keep the effect on the Gastineau Channel tideflats to a minimum.

Although surface current photos were taken during the study's various runs and displayed in the report, they covered mainly the channel itself. Therefore, in order to estimate the magnitude of the velocities to expect, a cubature analysis was employed, whereby the average velocity across a given section at any time is found by dividing the average discharge through the section at that time by the cross-sectional area at that time. Although the model study found that flood tide velocities were somewhat higher than ebb flow velocities in some areas, only the ebb flow velocities are considered. This is based on the rationale that even though flood tide velocities may dislodge material, the material will redeposit at slack high tide, and the following ebbtide velocities would not be high enough to dislodge them again. The velocities of particular concern are the ones during ebbtide that are capable of dislodging and transporting materials into the channel area. The object of this exercise was to be able to predict what the average ebbtide velocity would be at any stage of the tide for these various areas. Knowing this, the cross-sectional area required to reduce the velocity to the two feet per second criteria, developed in GEOLOGY AND SOILS, could then be determined. After finding the required areas for different sections to the limits of the higher velocity areas, an estimate of the volume of material that would have to be excavated could be made.

The first step in the cubature analysis was to select the critical sections in the high velocity areas. This was done by inspection and are the sections "A," "B," "C," and "D" shown in plan on Plates 3 and 4. In the next step, the cross-sectional areas of each section for various stages of the tide were found. Curves showing tide elevation versus cross-sectional area were plotted and are shown in Figure 3 of Plates 12 and 13. Next, surface areas for various contour elevations above each section were found and plotted against tidal elevation, shown in Figure 1 on Plates 12 and 13. Next, tidal discharges using the surface areas and increments of elevation drop and the rate of tidal drop from Figure 3, Plate 11, were computed and curves showing ebbtide discharge versus ebbtide elevation were developed and are shown in Figure 2 on Plates 12 and 13. Finally, using the discharge-elevation curves and cross-sectional area-elevation curves, elevation versus ebbtide velocity curves were developed for each section and are shown in Figure 4 of Plates 12 and 13. Plates 7, 8, 9, and 10 show the cross-sections at the above sections and the extent of required excavation for each section for dikes 1 and 2.

For plan 1, required tidal velocity relief excavation was computed to be 1,261,000 cubic yards, of which 515,000 cubic yards would be used for construction of dike No. 1. The balance of 746,000 cubic yards would be disposed of in the float plane basin disposal area. Because of possible encroachment upon the Glacier Expressway, as indicated on Plates 7 and 8, additional riprap, quarry spalls, and bedding materials would be required along the reach of highway affected to insure its stability.

For plan 2, required tidal velocity relief excavation was computed to be 1,458,000 cubic yards, of which 935,000 cubic yards would be used to construct dike No. 2 and the balance of 523,000 cubic yards would be disposed of in the float plane basin disposal area.

Stream Diversion: In order to provide continuous drainage of the streams traversing the flats and for the low areas that would be formed behind either of the dikes, pilot channels would have to be excavated. Jordan Creek could be diverted eastward into Switzer Creek, which in turn would be diverted into Lemon Creek. An alternative would be to divert Jordan Creek westward into Mendenhall River. The latter is the one preferred by the State Fish and Game Department on the basis that it would cause the least problem to migrating fish. However, it also would require much more excavation. In addition to Jordan and Switzer Creeks, Fish Creek on Douglas Island would be diverted to discharge into deep water at Fritz Cove, as shown on Plates 3, 4, 5, and 6. These pilot channels would be expected to meander from their realinement, which might cause a minor maintenance problem if they impinge upon the dike slope. However, the location and timing for such an occurrence is unpredictable, and no specific maintenance costs have been identified.

Check Dams: For existing project maintenance, check dams on Jordan and Switzer Creeks would be required. These would prevent channel bottom degradation and consequent transport of the scoured materials into the navigation channel. Dredging of the channel to any depth below the existing inverts of these two creeks' confluence with the channel will steepen their gradients, thus increasing channel velocities and resulting in channel bottom degradation until an equilibrium gradient is once again achieved. Jordan Creek would require 6 check dams, while 4 would be needed for Switzer Creek. At an estimated cost of $10,000 each, the series of check dams would cost $100,000.

MAINTENANCE

Shoaling Rates: Condition surveys, after project completion in 1960, were taken in 1961, 1963, and 1967. In addition, it was estimated that another 275,000 cy of material had accumulated from 1967 to January 1977. From these, the total amounts of shoaling between surveys and the average annual shoaling rates were found as follows:

Period	Total Shoaling	Average Annual Shoaling	Average Depth
1960-1961	200,000 CY	200,000 CY	-1.2 ft. MLLW
1961-1963	200,000 CY	100,000 CY	+1.5 ft. MLLW
1963-1967	225,000 CY	56,000 CY	+4.0 ft. MLLW
1967-1977	275,000 CY	27,500 CY	+6.7 ft. MLLW

The model study demonstrated that the shoaling rate decreases with decreasing depth, which is in agreement with the above data. The shoaling rate that occurred after completion of the channel in 1960 until 1961 was due in great part to rapid side slope sloughing, while the shoaling from 1961 to 1963 probably occurred primarily from bedload. Because the model study base test, which was used as the basis for comparison with all other model runs, consisted of setting the channel at bottom width of -75 feet, elevation MLLW, with 2 feet of advance maintenance and 2 feet of overdepth, the prototype shoaling rate of the channel in its 1961 condition was used to represent the model verification shoaling rate. This was found to be about 125,000 cubic yards per year by determining the slope of the channel shoaling mass diagram curve at the year 1961, as shown on Plate 11. The base test shoaling was 143.5 percent of the shoaling verification. Thus, for the base condition with a total bottom depth of -4 feet MLLW, the shoaling rate would be 1.435 x 125,000, or 180,000 CY per year. The model study showed that for a channel 150 feet wide at elevation -12 feet MLLW, including 2 feet advance maintenance and 2 feet overdepth, the shoaling increased by 45 percent over the base test. For simplification of calculations and because the amount of error introduced is small, it was assumed that the rate of shoaling for any channel width would be directly proportioned to the base 75-foot channel width. Thus, for the depth of -12 MLLW, a 75-foot channel would have a shoaling rate of 1.225 x 180,000, or 221,000 CY per year. It was also assumed that for any depth between -4 feet MLLW and -12 feet MLLW, the shoaling rate would vary uniformly between 180,000 and 221,000 CY per year. Shoaling rates for any depth below -12 feet MLLW were extrapolated in proportion to the above and shoaling rates for depths above -4 feet MLLW were obtained from the channel shoaling mass diagram derived from the channel surveys. For the existing channel alinement with 75-foot bottom width, and for the recommended channel alinement with

100-foot bottom width, with 1V or 3H sideslopes, 2 feet advance maintenance and 2 feet overdepth, the shoaling rates for various bottom depths are as follows:

Channel Bottom Elevation (Ft. MLLW)	Shoaling Rate (CY/Yr) 75' Width	100' Width
+10	6,000	8,000
+ 8	11,000	15,000
+ 6	20,000	27,000
+ 4	45,000	60,000
+ 2	75,000	100,000
0	108,000	144,000
-2	145,000	193,000
-4	180,000	240,000
-6	190,000	254,000
-8	200,000	267,000
-10	211,000	281,000
-12	221,000	295,000
-14	231,000	308,000

For plan 1, the model study concluded (Appendix C, page 45) that dike improvements utilizing the existing spoil piles would reduce the base shoaling by about 90 percent for a depth of -4 feet MLLW, and by about 60 percent for a depth of -12 feet MLLW. It was assumed that the shoaling reduction percentage between the above elevations would be prorated between 90 and 60 percent and that the shoaling reduction percentage for below -12 feet MLLW would be extrapolated at the same rate.

It was also assumed that for elevations above -4 feet MLLW, the shoaling reduction percentage would be prorated uniformly from 90 percent to a maximum reduction of 98 percent at elevation +12 feet MLLW, which is about the average elevation of the tidal flats adjacent to the channel. It was assumed that these reductions would also obtain for any channel width. The shoaling rates for various project depths for plan 1 (100-foot wide channel with 5 feet advance maintenance) were estimated as follows:

Project Depth Elevation (Ft. MLLW)	Percent of Base Shoaling Rate	Shoaling Rate CY/Year
+6	7.5	.075 x 240,000 = 18,000
+4	8.5	.085 x 240,000 = 20,000
+2	9.5	.095 x 240,000 = 23,000
0	13.8	.138 x 240,000 = 33,000
-2	21.3	.213 x 240,000 = 51,000
-4	28.8	.288 x 240,000 = 69,000
-6	36.3	.363 x 240,000 = 87,000
-8	43.8	.438 x 240,000 = 105,000

For plan 2, because of the great reduction of tidal flat area subject to erosion between the dike and the channel, it was estimated that the shoaling rate would be about two-thirds of that for plan 1. The shoaling rates for various project depths for plan 2 (100-foot wide channel with 5 feet advance maintenance) were estimated as follows:

Project Depth Elevation (Ft. MLLW)	Shoaling Rate (CY/Yr) (2/3 of Plan 1)
+6	12,000
+4	13,000
+2	15,000
0	22,000
-2	34,000
-4	46,000
-6	58,000
-8	70,000

For plan 3 (improved channel alinement for navigation, 100-foot wide channel with 5 feet advance maintenance, no dike improvements), the shoaling rate for a given project depth was taken as the rate at 2 feet below that depth to more closely approximate the average shoaling rate in the advance maintenance prism. Therefore, the shoaling rates for various project depths for plan 3 are as follows:

Project Depth Elevation (Ft. MLLW)	Shoaling Rate (CY/Yr)
+6	60,000
+4	100,000
+2	144,000
0	193,000
-2	240,000
-4	254,000
-6	267,000
-8	281,000

For plan 4 (no dike improvements, 100-foot channel width, 5 feet advance maintenance, 2 feet overdepth), it was estimated that the shoaling rate would be about one-tenth of that for plan 3 because the existing channel and adjacent ground, which is generally lower than that adjacent to the plan 4 channel, would intercept and retain most of the sediments coming from the tidal flats and upland sources. Therefore, the shoaling rates for plan 4 for various project depths were estimated as follows:

((

Project Depth Elevation (Ft. MLLW)	Shoaling Rate (CY/Yr)
+6	60,000 (0.10) = 6,000
+4	100,000 (0.10) = 10,000
+2	144,000 (0.10) = 14,000
0	193,000 (0.10) = 19,000
-2	240,000 (0.10) = 24,000
-4	254,000 (0.10) = 25,000
-6	267,000 (0.10) = 27,000
-8	281,000 (0.10) = 28,000

For the existing channel (no dike improvements, 75-foot channel width, 3.75 feet advance maintenance, 2 feet overdepth), the shoaling rate for a given project depth was taken as the rate at 1-foot below that depth to more closely approximate the average shoaling rate in the advance maintenance prism. The shoaling rates for various project depths are therefore estimated as follows:

Project Depth Elevation (Ft. MllW)	Shoaling Rate (CY/Yr)
+6	33,000
+4	60,000
+2	92,000
0	127,000
-2	163,000
-4	185,000
-6	195,000
-8	206,000

Dredging Frequencies: The model study determined that certain sections of the channel shoal faster than others and therefore, the dredging frequency would be determined by these sections. It was assumed that the shoaling pattern for the base test obtains for any plan without dike improvements (existing channel, plans 3 and 4) and that the shoaling pattern for the base test with dike improvements obtains for all dike improvement plans (plans 1 and 2). The dredging frequencies for each plan for various project depths were found by dividing the advance maintenance volume capacity by the shoaling rate for each channel section in accordance with the shoaling patterns determined in the model study. For all plans, allowance was made for widening or deepening the controlling sections to bring their advance maintenance capacity on par with the majority of the other channel sections, which minimized frequency of dredging without significantly increasing the initial channel dredging quantities. The dredging frequencies for the plans considered for various project depths are tabulated as follows:

Project Depth (Ft. MLLW)	Frequency in Years Plan 1	Plan 2	Plan 3	Plan 4	Existing Channel
+6	9	14	2.0	9	2.0
+4	8	13	1.0	5	1.0
+2	7	11	0.7	4	0.6
0	5	8	0.6	3	0.5
-2	3	5	0.5	2	0.3
-4	2	4	0.4	2	0.3
-6	2	3	0.4	2	0.3
-8	2	2	0.4	2	0.3

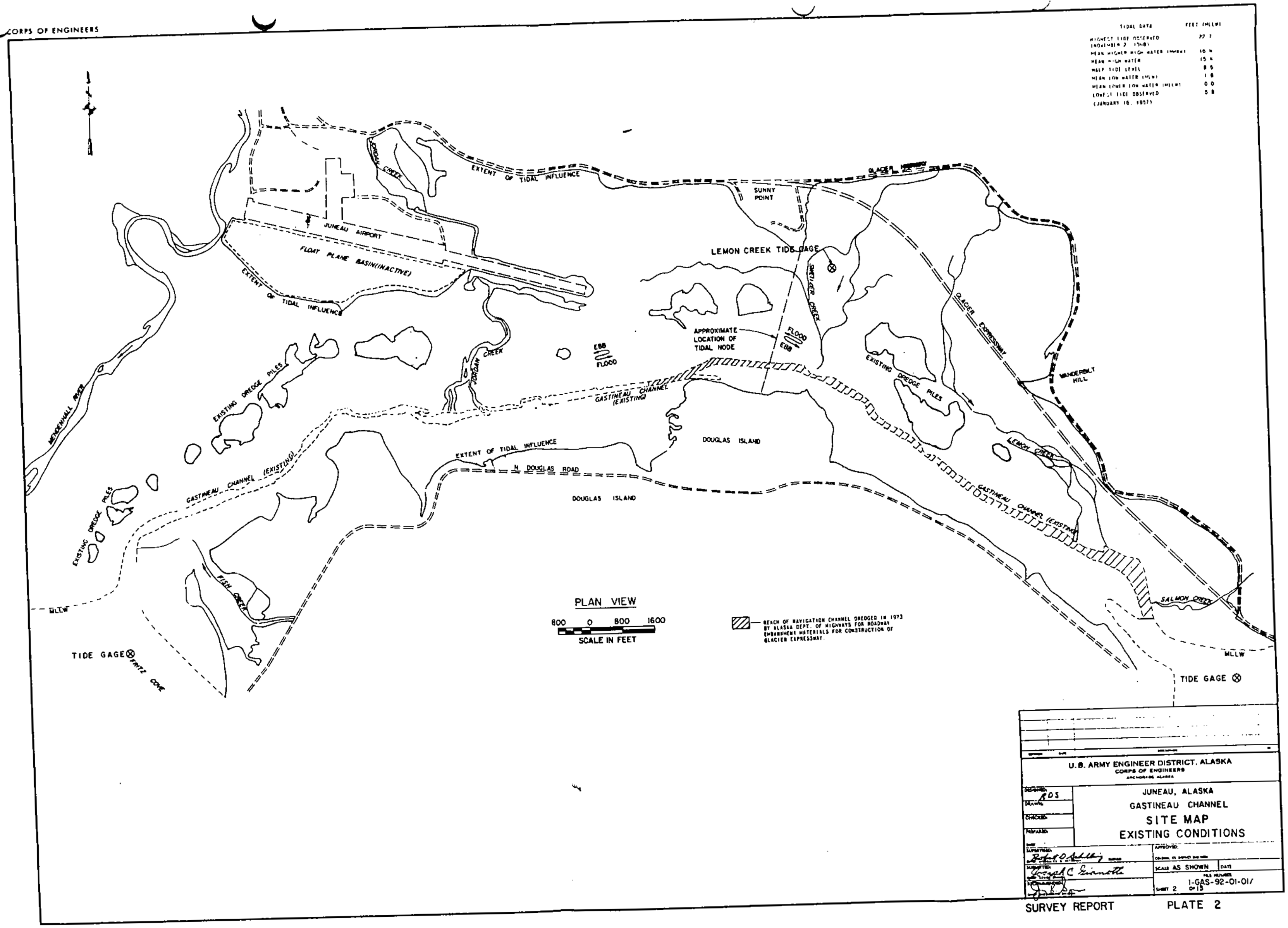
Annual Maintenance Dredging Costs: For each project depth, it was conservatively assumed that the full amount of the base shoaling would still be incurred the first year after initial dredging in order to allow for side slope sloughage, etc., in some of the less stable areas of the channel. It was also assumed that this allowance would be reduced by 50 percent each succeeding year until the annual shoaling rate was reached. Maintenance dredging costs were based on the use of a 20-inch pipeline dredge because of the dredging quantities and because of the distance to the locally-designated dredge disposal site in the float-plane basin area. An alternate dredging plant consisting of a barge-mounted crane with a dredging bucket and dump scows was considered for the project depths with least quantities but was rejected because of excessive operating costs and disposal problems. Mobilization and demobilization costs were estimated at $150,000, dredging and disposal costs were estimated at $2.05 per cubic yard, and an allowance of 30 percent was made for contingencies, E&D, and S&A. Also investigated was maintenance dredging by project-owned dredging equipment. Again, because of the quantities and pumping distance, a 20-inch pipeline dredge was found to be the most practicable. The estimated cost of the dredging plant, including work boats, pipeline, booster pump and barge, and other supportive equipment, delivered to Juneau, is $4,400,000. The annual amortization and interest cost of the plant at 6-5/8 percent interest for an assumed life of 30 years is $341,000. The operating costs of the dredge are estimated to be $2.05 per cubic yard.

For plans 1, 2, and 4, it was found least costly to have the maintenance dredging done by contract. For plan 3, it was found least costly to have the maintenance dredging done by contract for project depths above elevation -2 feet MLLW and by project dredge for project depths below -2 feet MLLW. For the existing channel, it was found least costly to have maintenance dredging done by contract for project depths above -4 feet MLLW and by project dredge for project depths below -4 MLLW.

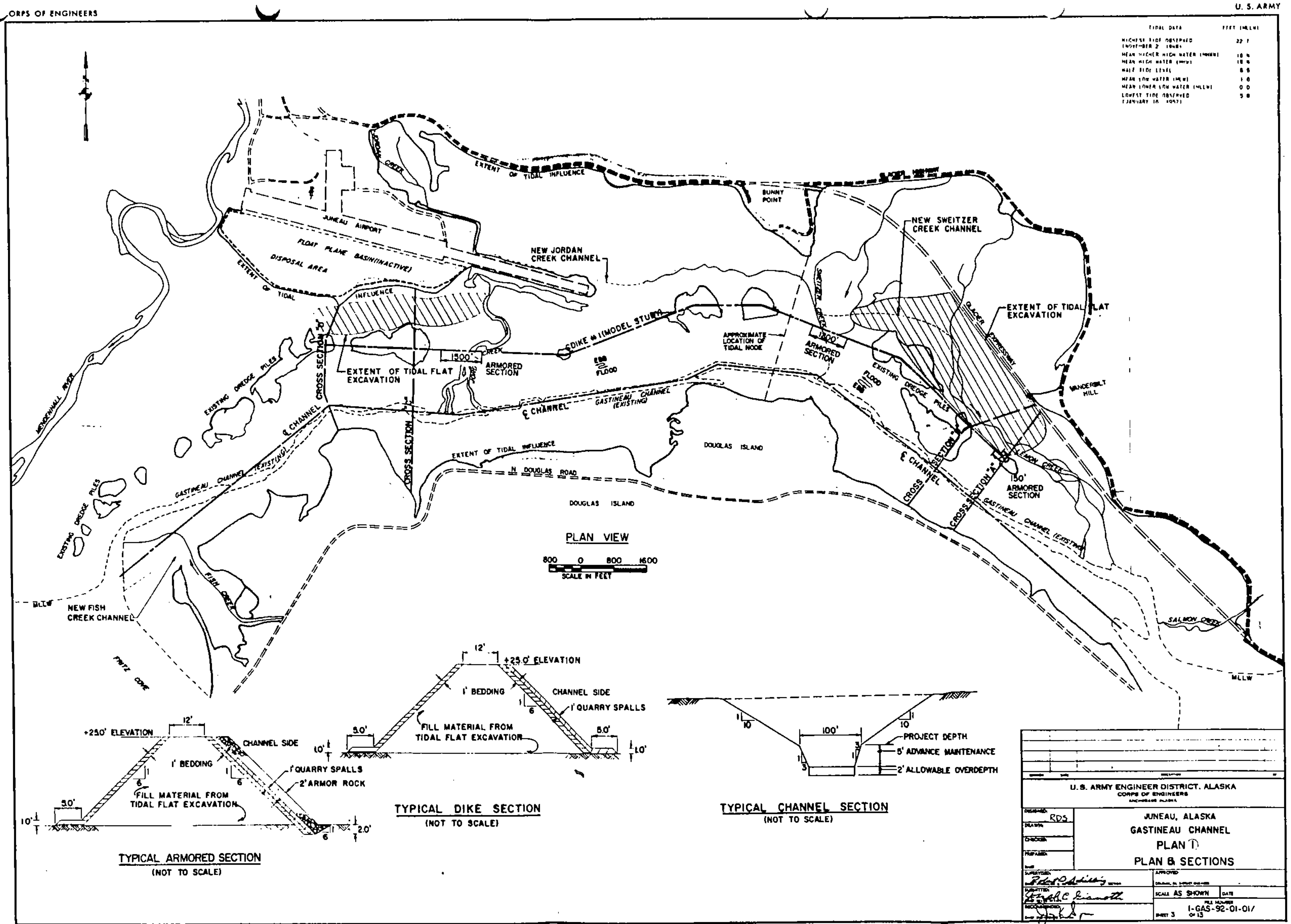
Annual Dike Maintenance Costs: For the plans involving dike construction, plans 1 and 2, it was assumed that repairs to the armor rock and quarry spall layers and vegetative cover would have to be made twice during project life and that each occurrence would involve about 10 percent of the initial quantities. Each occurrence would also require survey costs of about $10,000 and plant mobilization and demobilization costs of about $75,000. The average annual dike maintenance costs, assuming that repairs are made in year 20 and year 40, are estimated at $19,000 for plan 1 and $17,000 for plan 2.

PROJECT COSTS

Detailed cost estimates for the existing project and for each improvement plan considered for various project depths are shown in Tables B-1 through B-5.

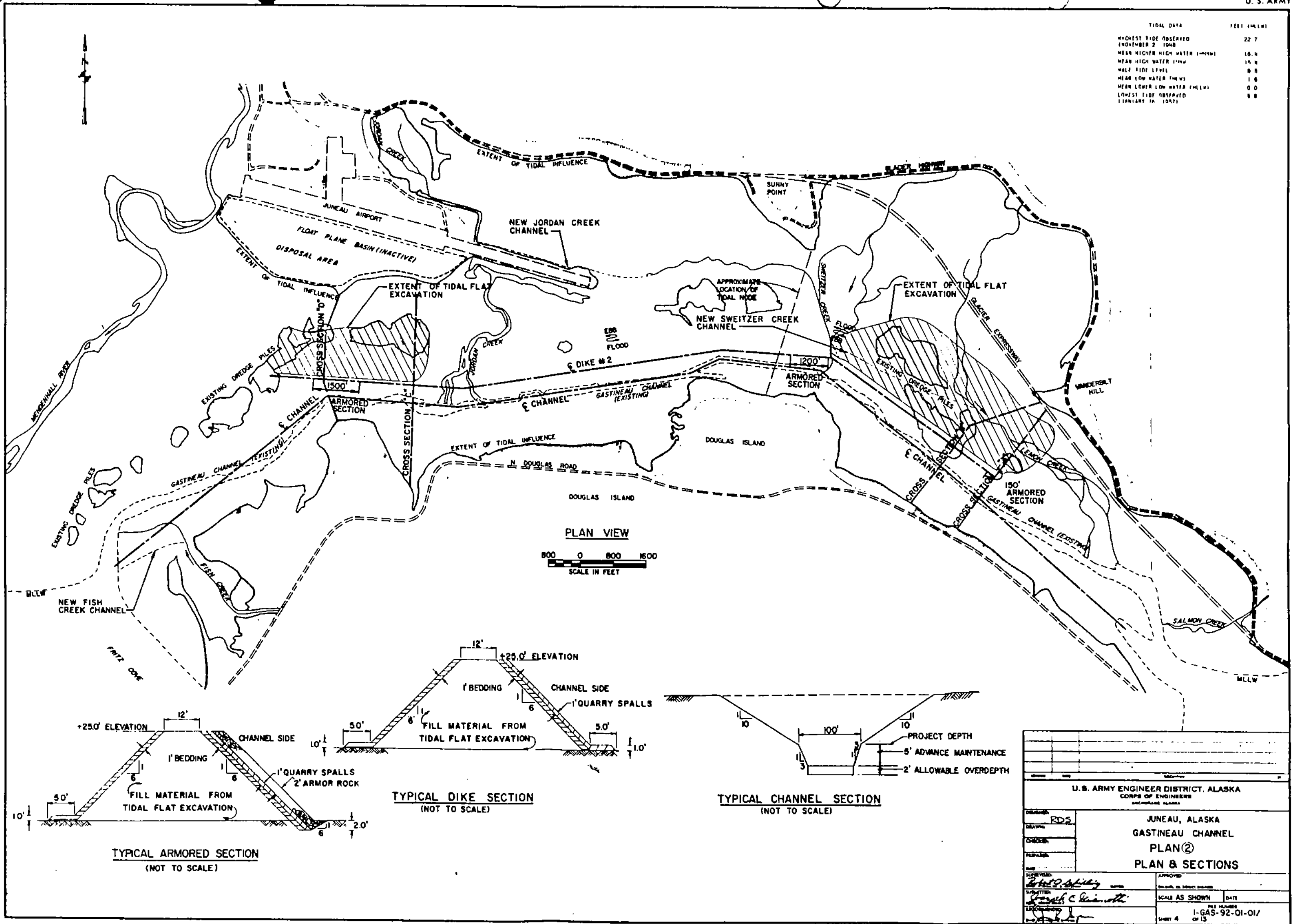


SURVEY REPORT PLATE 2



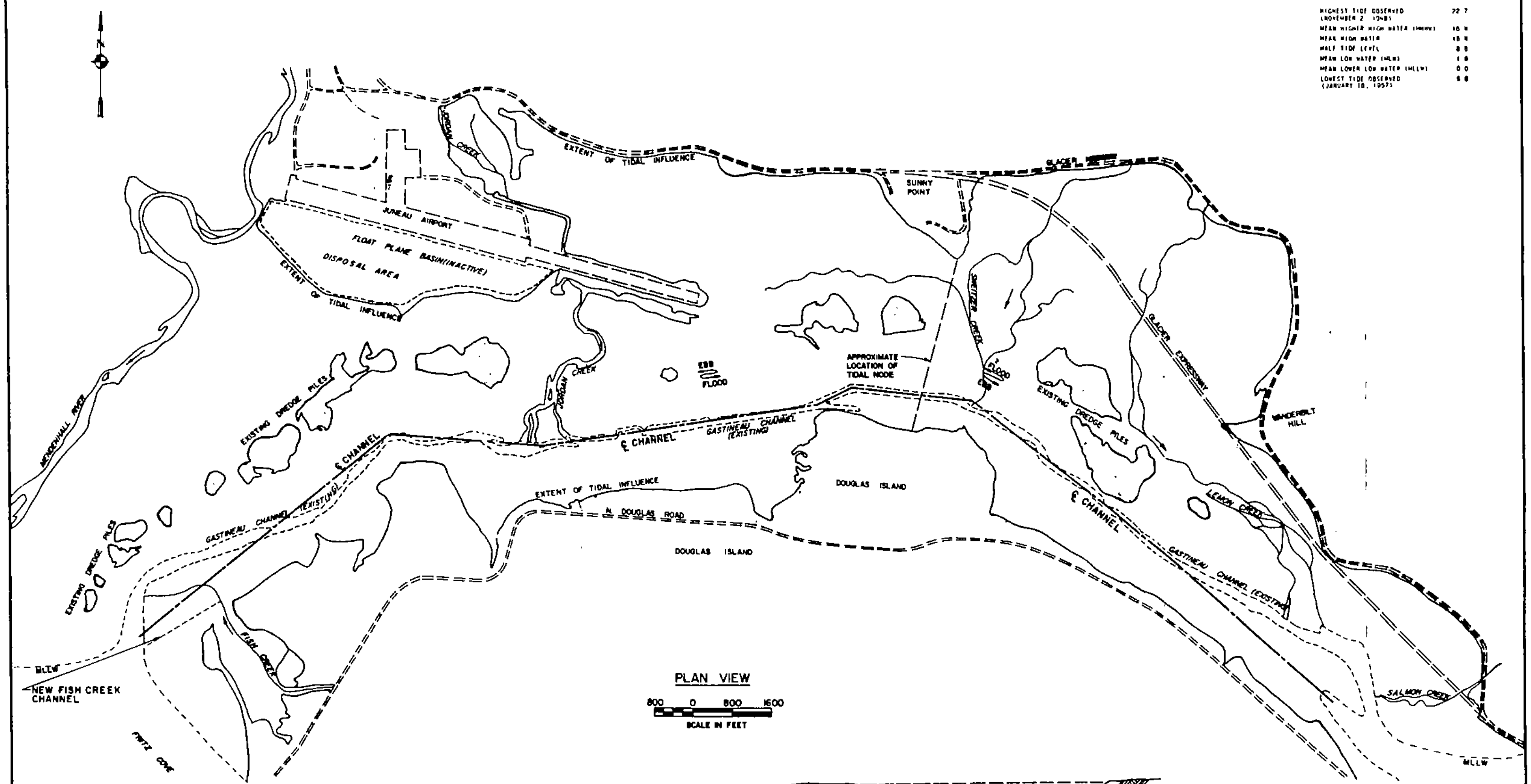
SURVEY REPORT PLATE 3

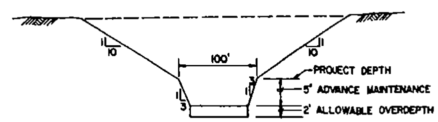
CORPS OF ENGINEERS U. S. ARMY



SURVEY REPORT PLATE 4

CORPS OF ENGINEERS U. S. ARMY





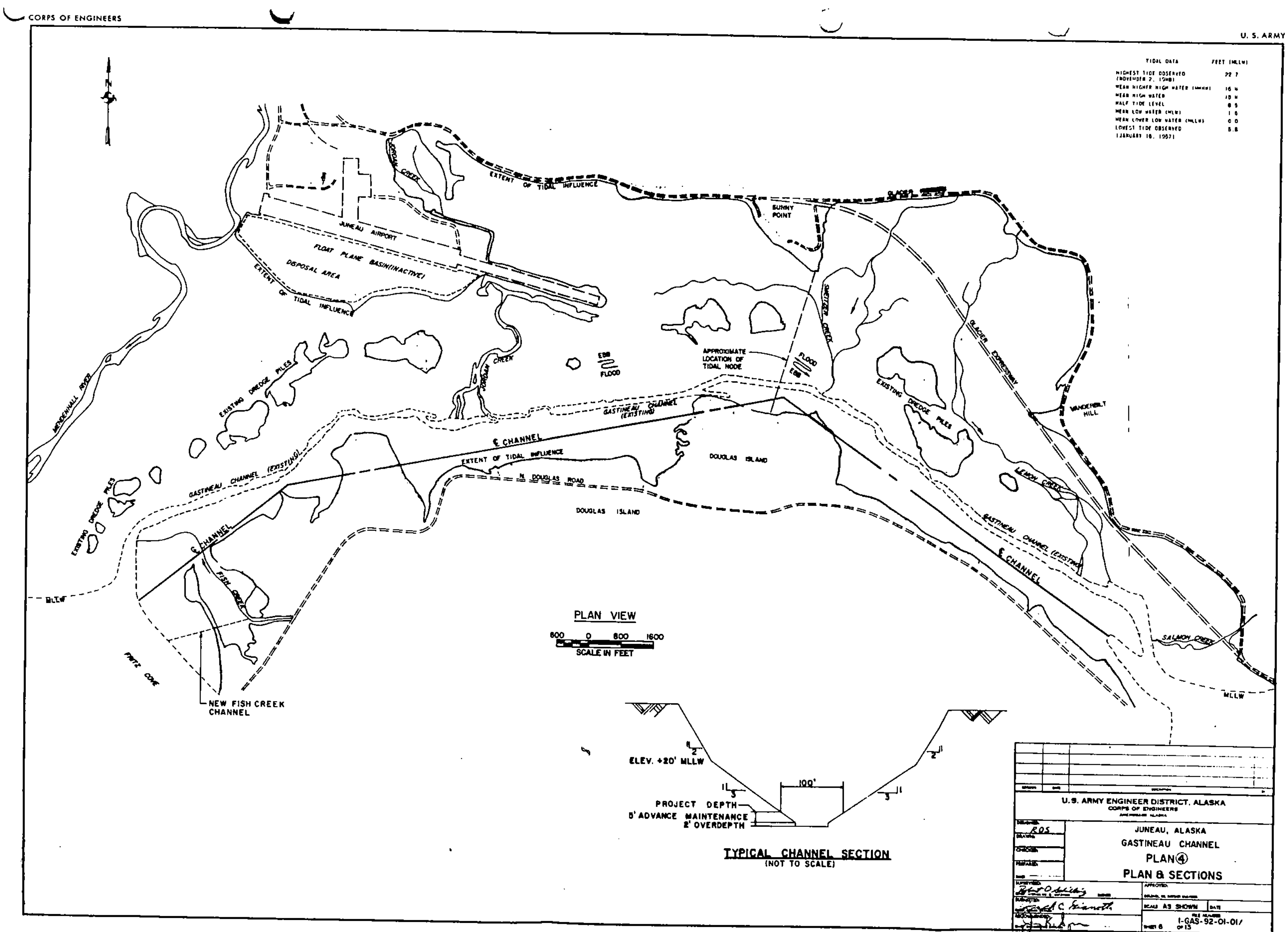
TYPICAL CHANNEL SECTION
(NOT TO SCALE)

U. S. ARMY ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS

JUNEAU, ALASKA
GASTINEAU CHANNEL
PLAN ③
PLAN & SECTIONS

SCALE AS SHOWN
FILE NUMBER 1-GAS-92-01-01/
SHEET 5 OF 13

SURVEY REPORT PLATE 5

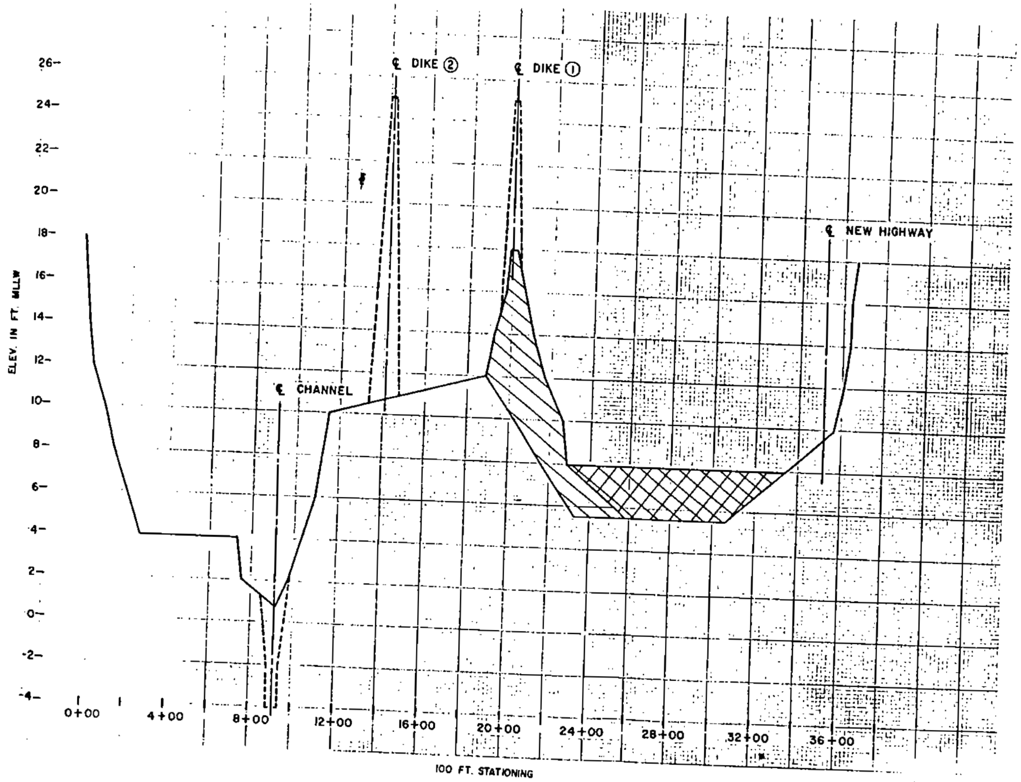


SURVEY REPORT

PLATE 6

CORPS OF ENGINEERS

U. S. ARMY



SECTION "A"

HORIZONTAL: 1" = 200'
VERTICAL: 1" = 2'

EXCAVATION REQUIRED FOR PLAN ②

EXCAVATION REQUIRED FOR PLAN ①

U.S. ARMY ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS

DESIGNED: WFC
DRAWN:
CHECKED:
PREPARED:
SUPERVISED:
SUBMITTED:
RECOMMENDED:

JUNEAU, ALASKA

GASTINEAU CHANNEL

CROSS SECTION A

APPROVED:

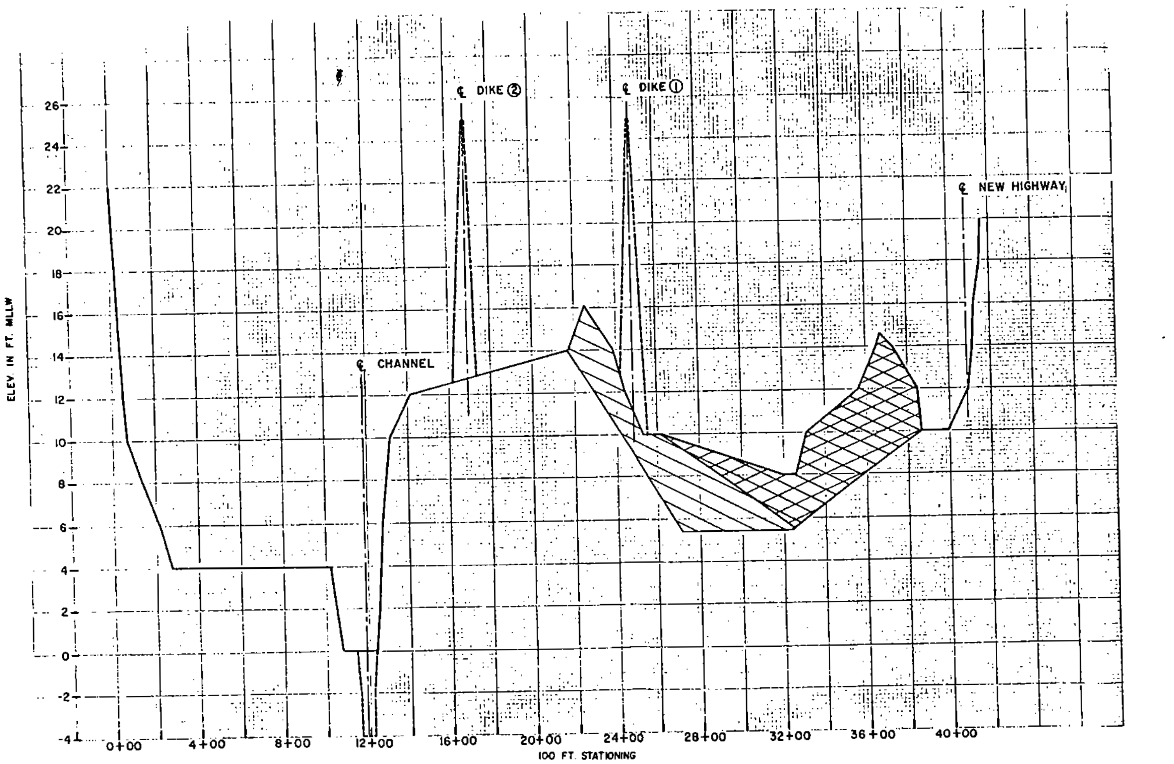
SCALE

DATE

FILE NUMBER
SHEET 7 OF 13 1-GAS-92-01-017

SURVEY REPORT

PLATE 7



SECTION "B"

HORIZONTAL: 1" = 200'
VERTICAL: 1" = 2'

U.S. ARMY ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS

JUNEAU, ALASKA

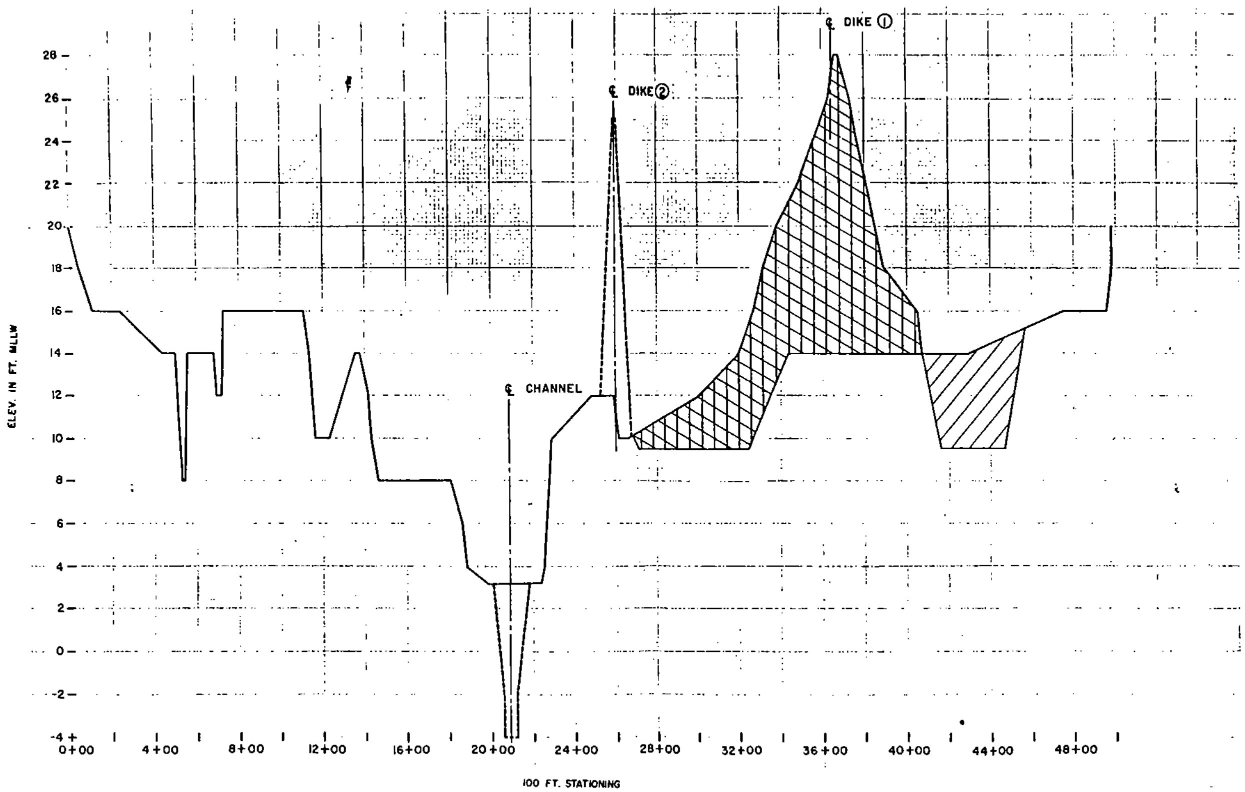
GASTINEAU CHANNEL

CROSS SECTION B

1-GAS-92-01-01/

CORPS OF ENGINEERS

U. S. ARMY



SECTION "C"

HORIZONTAL: 1" = 200'
VERTICAL: 1" = 2'

EXCAVATION REQUIRED FOR PLAN ②

EXCAVATION REQUIRED FOR PLAN ①

U.S. ARMY ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS

JUNEAU, ALASKA

GASTINEAU CHANNEL

CROSS SECTION "C"

FILE NUMBER 1-GAS-92-01-01/

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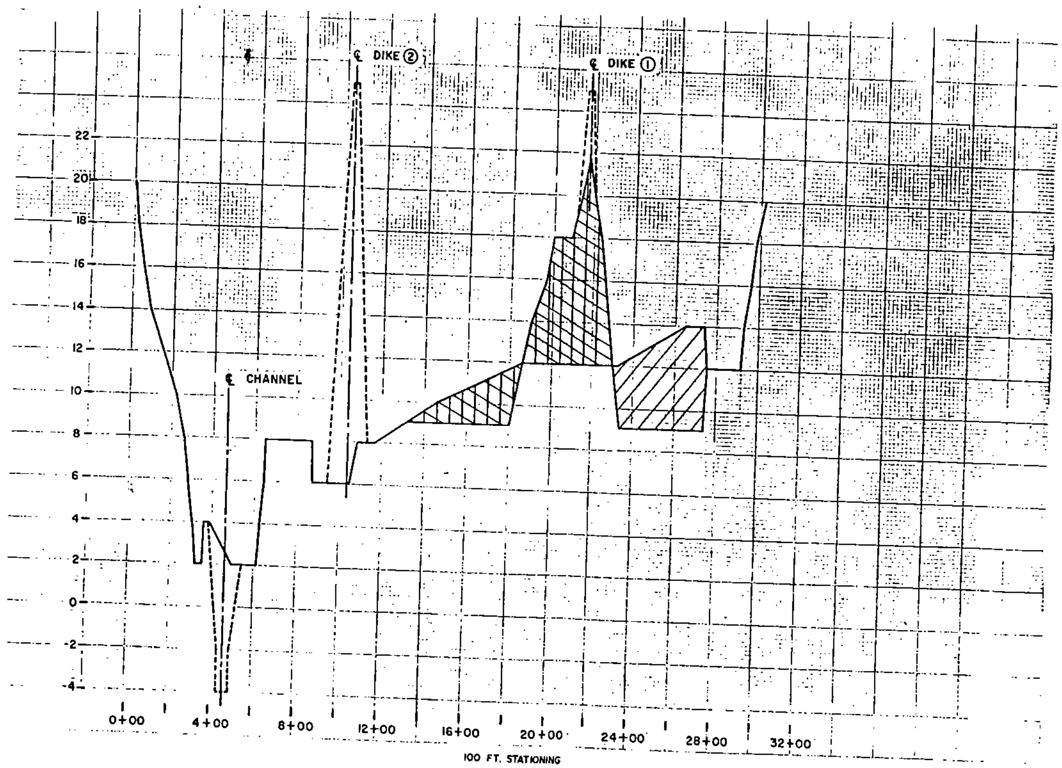
SURVEY REPORT

PLATE 9

CORPS OF ENGINEERS U. S. ARMY



SECTION "D"

HORIZONTAL: 1" = 200'
VERTICAL: 1" = 2'

EXCAVATION REQUIRED FOR PLAN ①

EXCAVATION REQUIRED FOR PLAN ②

U.S. ARMY ENGINEER DISTRICT, ALASKA CORPS OF ENGINEERS	
DESIGNED: WFC	JUNEAU, ALASKA
DRAWN:	GASTINEAU CHANNEL
CHECKED:	CROSS SECTION "D"
PREPARED:	
SUPERVISED:	APPROVED:
SUBMITTED:	SCALE / DATE
RECOMMENDED:	SHEET 10 OF 13 — FILE NUMBER 1-GAS-92-01-01/

SURVEY REPORT PLATE 10

CORPS OF ENGINEERS

U. S. ARMY

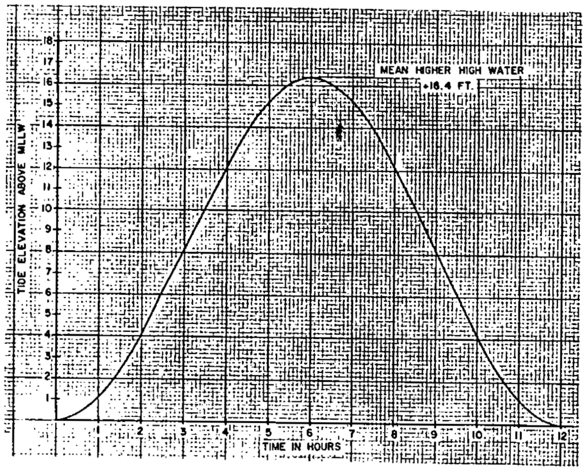


FIGURE 1
MEAN DIURNAL TIDE CURVE

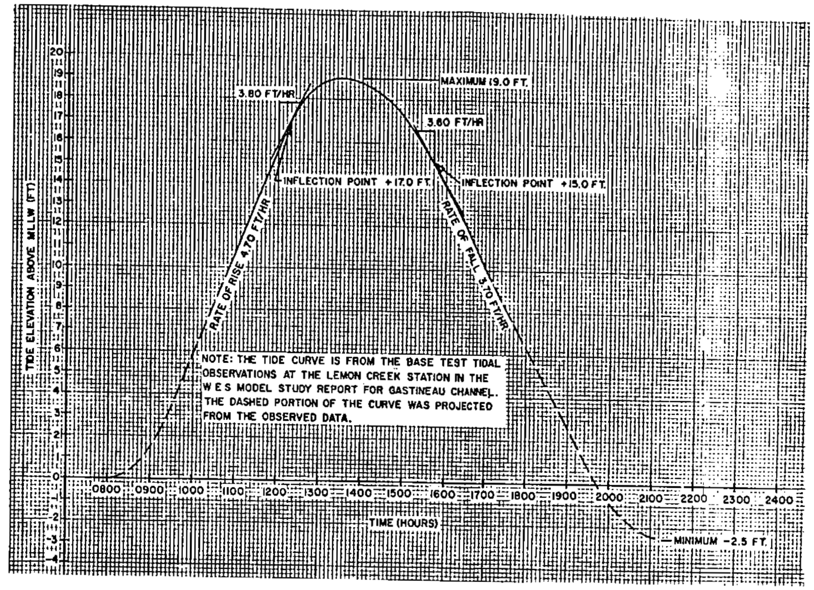
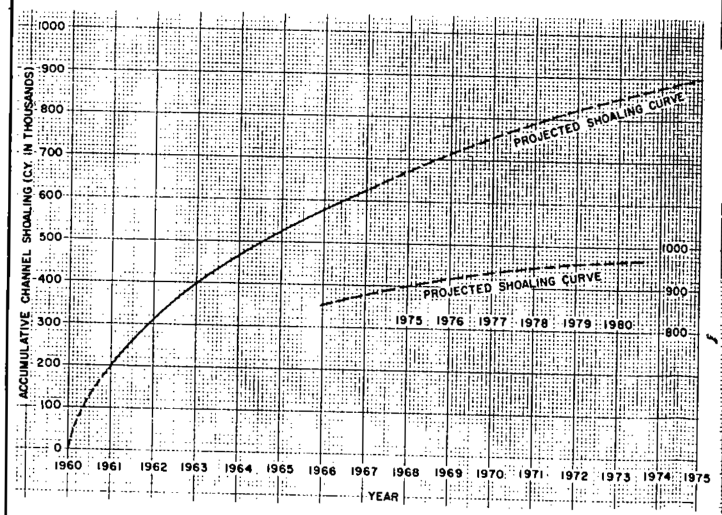


FIGURE 2
TIDE CURVE FOR AREA NORTH OF DIKE



GASTINEAU CHANNEL ACCUMULATIVE SHOALING CURVE

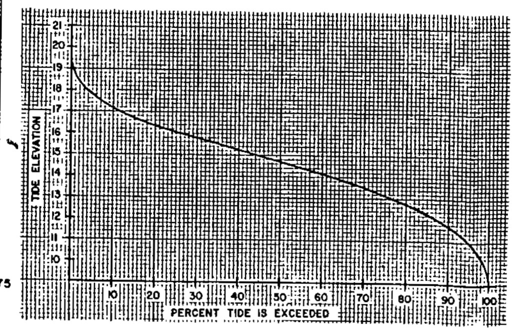


FIGURE 3
PERCENT TIDE IS EXCEEDED FOR MEAN MAXIMUM HIGH TIDE

U.S. ARMY ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

JUNEAU, ALASKA
GASTINEAU CHANNEL
TIDE AND SHOALING DATA

DESIGNED: WFC
DRAWN:
CHECKED:
PREPARED:
SUPERVISED:
SUBMITTED:
RECOMMENDED:
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SCALE
DATE
SHEET 11 OF 15
FILE NUMBER 1-GAS-92-01-01/

SURVEY REPORT

PLATE 11

CORPS OF ENGINEERS

U. S. ARMY

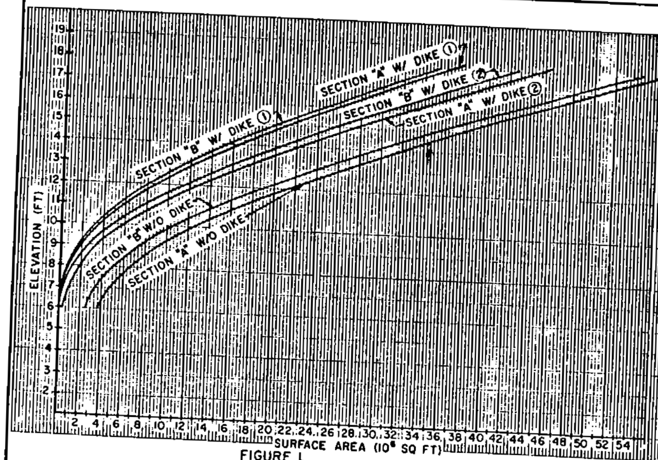


FIGURE 1.
ELEVATION VS SURFACE AREA
SECTION "A" & SECTION "B"

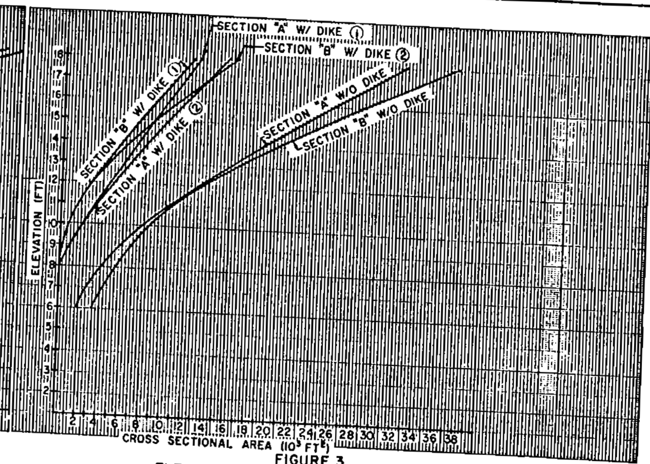
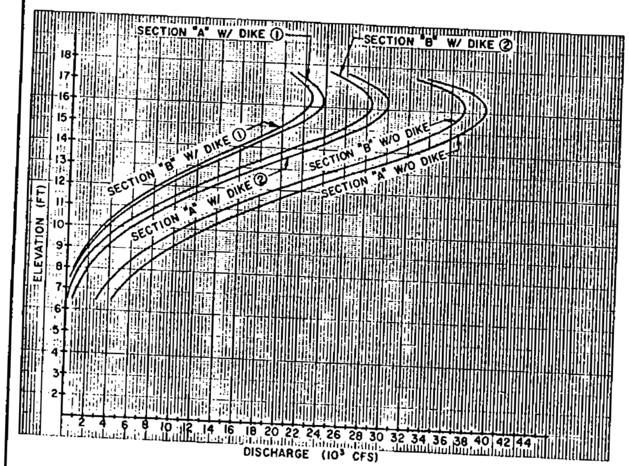


FIGURE 3.
ELEVATION VS CROSS SECTIONAL AREA
SECTION "A" & SECTION "B"



ATION VS EBB TIDE DISCHARGE
TION "A" & SECTION "B"

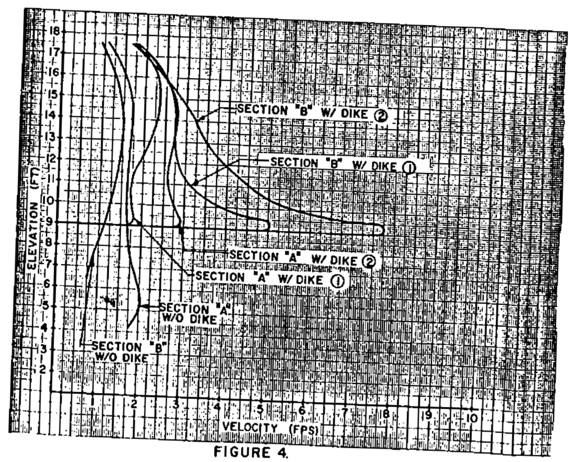


FIGURE 4.

ELEVATION VS EBB TIDE VELOCITY
SECTION "A" & SECTION "B"

U. S. ARMY ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

JUNEAU, ALASKA
GASTINEAU CHANNEL
TIDAL VELOCITY AND
DISCHARGE CURVES
SECTIONS A & B

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SURVEY REPORT

PLATE 12

CORPS OF ENGINEERS

U. S. ARMY

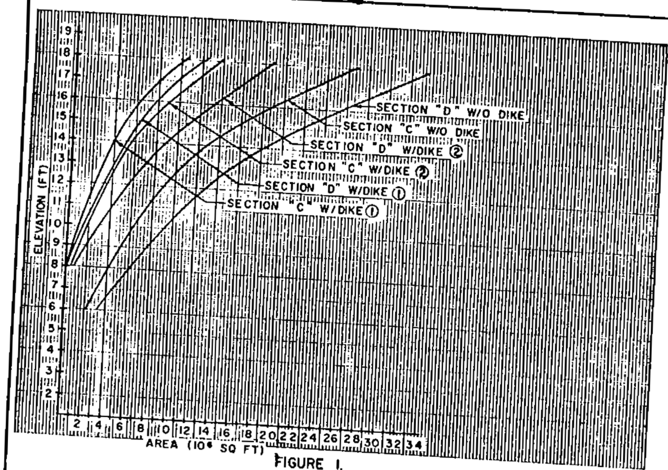

FIGURE 1.
ELEVATION VS SURFACE AF
SECTION "C" & SECTION "D"

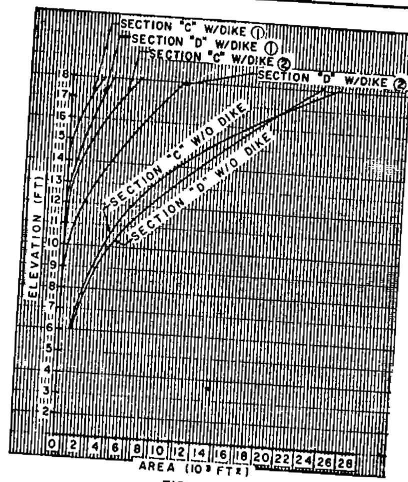

FIGURE 3.
ELEVATION VS CROSS SECTION AREA
SECTION "C" & SECTION "D"

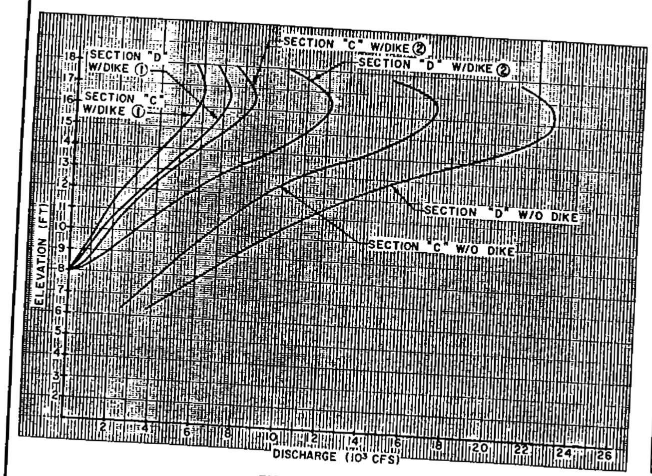

FIGURE 2.
ELEVATION VS EBB TIDE DISCHARGE
SECTION "C" & SECTION "D"

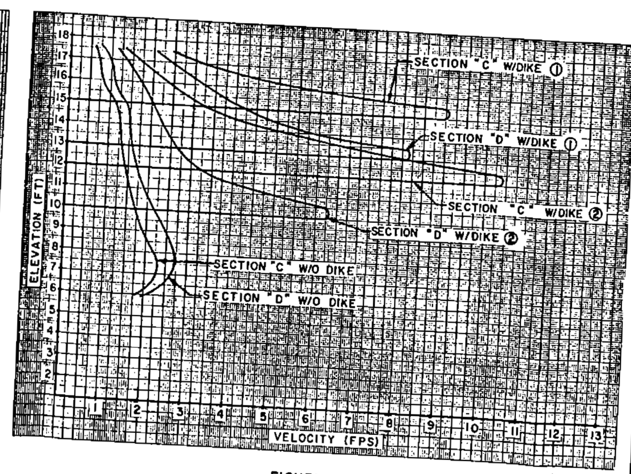

FIGURE 4.
ELEVATION VS EBB TIDE VELOCITY
SECTION "C" & SECTION "D"

U.S. ARMY ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS

JUNEAU, ALASKA
GASTINEAU CHANNEL
TIDAL VELOCITY AND
DISCHARGE CURVES
SECTIONS C & D

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SCALE | DATE
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SURVEY REPORT

PLATE 13