generally in the range of 4,000 to 8,000 lbs. per square foot for spread footings. Stability of the dense soil is good, and the liquefaction and settlement potentials are low.

Extensive cobbles and boulders found there would create moderately difficult excavation conditions, but cuts and exposed slopes would be stable at relatively steep angles. Precautions to prevent boulder slides should be provided during excavation. Slope stability is good, and only the small slopes along streams which have been over steepened by erosion present stability problems. These areas may be cut to a stable configuration or avoided entirely with only a small loss of area. Removal of the surface peat and silt near bluffs would contribute to increased water infiltration and may possibly increase bluff erosion.

Dock Site

- Topography

Topography at the proposed dock area consists of a narrow (200 feet or less), level beach which is submerged or only a few feet above water during extreme high tides. The shore slopes southward at a rate of about 20 to 40 vertical feet per mile. Bluffs up to 120 feet high with slopes of 30° to 40° border the beach strand on the north. The bluffs are cut by numerous small streams which have formed narrow channels. Ground surface above the bluffs also slopes to the south at about 50 feet per mile.

The bluffs are continuously eroding and the toe of the slope often has deposits formed by erosion debris or slumped material. This material forms a bench about 10 to 30 feet above extreme high water.

- **Subsurface Conditions**

A thin layer of soft gray silt covers the beach between mean and low tide levels. Three test borings and two probes indicate that soft or loose deposits of silt and sand extend to a depth of about 15 feet, below which is found very dense silty sand (Figures 3.15 and 3.16) The very dense material resembles the material of the Nikolai moraine which has been mapped as extending across Cook Inlet. The borings indicate that only a relatively thin marine deposit covers the very dense material of the moraine. A log for the boring Test Hole 2 is shown in Figure 3.17. The marine deposits contain fine sand, silt, and clayey silt. The silt resembles rock flour, being generally nonplastic and only slightly compressible (C_c = .1).

- **Dock Construction**

The soils in the proposed dock area have excellent bearing capacity below the Recent soft, loose marine deposits (Figure 3.16). However, boulders are present and may create difficult pile driving conditions.

The existing beach is narrow with little or no back beach area, and lack of space may limit the amount of activity near the dock. The beach is generally only a few feet above extreme high water, and portions of it may have to be raised to provide protection against high water. The bluffs which border the site on the north are steep and are eroding continuously. They also represent a hazard of landslides onto the narrow beach. The slopes should be stabilized if activity were to occur near the toe of the steep slopes. The bluffs are composed of very dense, granular material and should be stable at about a 1½:1 slope, provided water is prevented from eroding the bluffs.

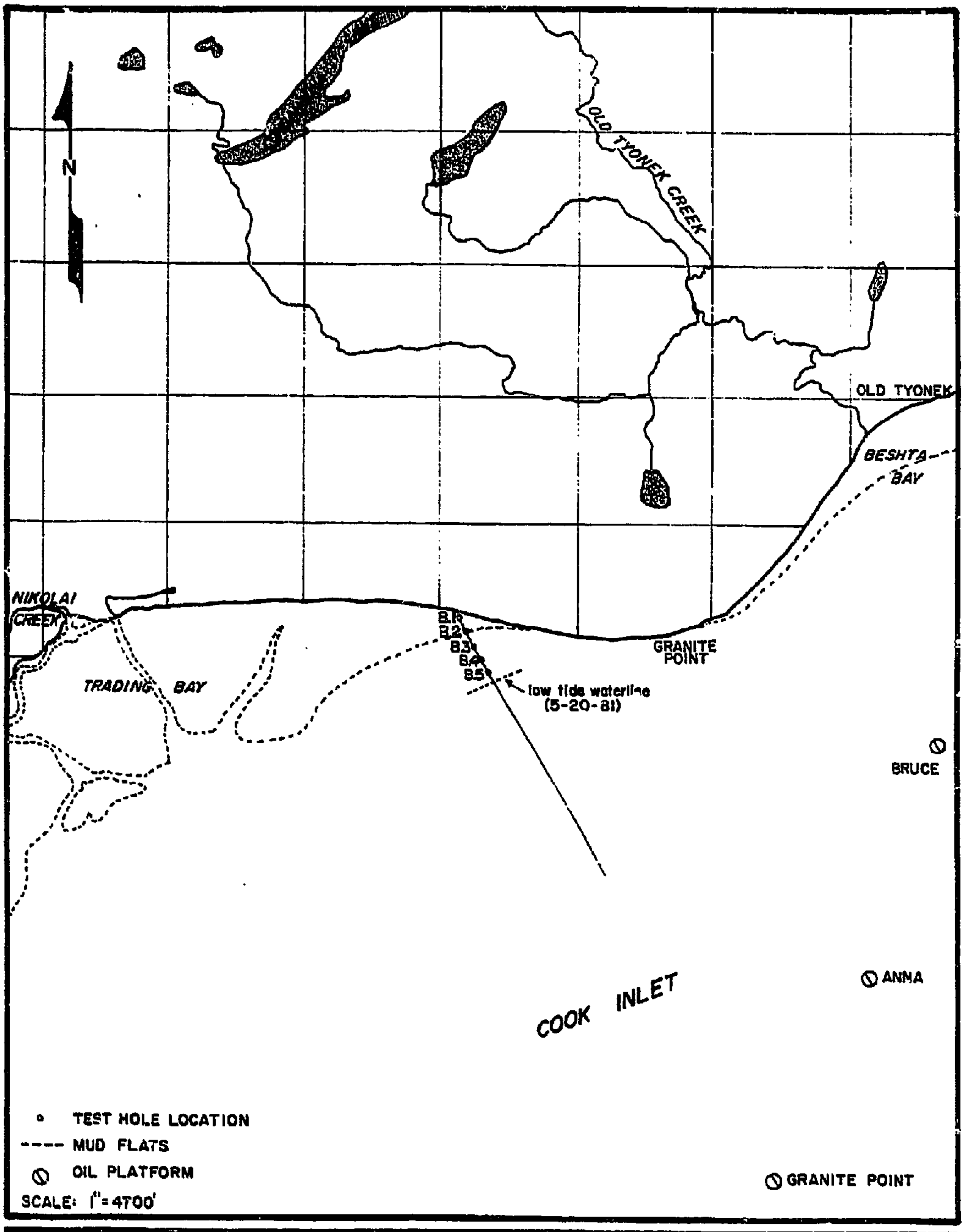


FIGURE 3.15 DOCK SITE TEST HOLE LOCATIONS

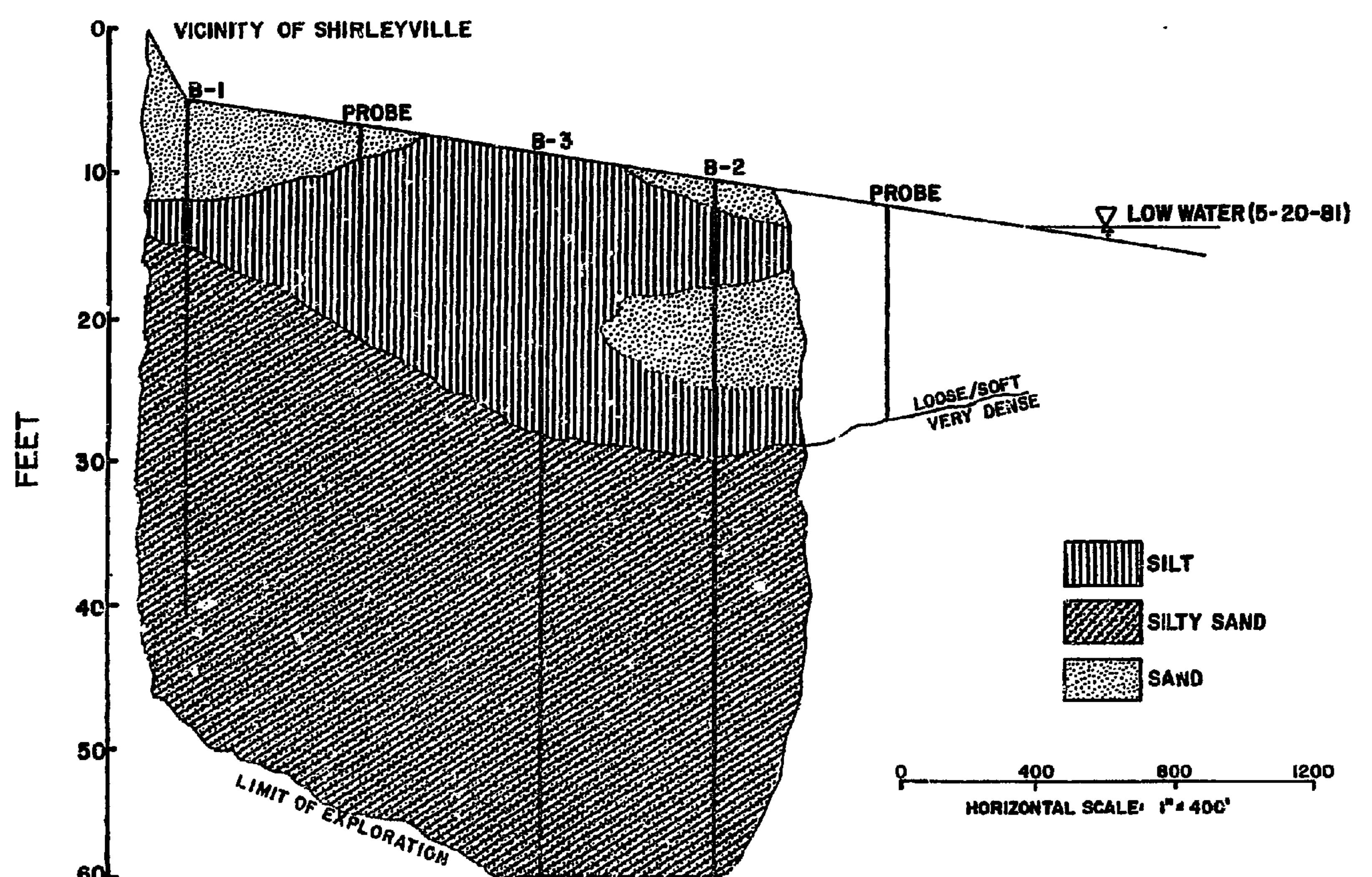


FIGURE 3.16 DOCK SITE IDEALIZED SOIL PROFILE

W.O. NO. 913132
LOGGED BY O. H.

BORING 2 - DOCK

ELEVATION = Refer to Profile

DEPTH (FEET)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	OTHER TESTS	N (BLOWS/FT)	SOIL	DESCRIPTION	DEPTH
0					SP	NFS, BROWN SAND, SATURATED, MEDIUM DENSITY	
				7	ML	F-4, GREY SANDY SILT, NON-PLASTIC, SATURATED, SOFT	2.0'
10				13	SM	F-2, GREY SILTY SAND, SATURATED, MEDIUM DENSE	8.0'
				5	ML	F-4, GREY SILT WITH SILTY SAND LENSES, NON-PLASTIC TO SLIGHTLY PLASTIC, SATURATED, SOFT	14.0'
20				125	SM	F-2, GREY SILTY GRAVELLY SAND, MAXIMUM PARTICLE SIZE TO 2"+, MOIST, VERY DENSE	19.0'
				100			
30			MA				
40				112			
						BOTTOM OF TEST HOLE = 48.0'. COMPLETED 5/20/81.	48.0'
50							

FROST DEPTH

KEY

PP = UNCONFINED COMPRESSIVE STRENGTH (PENETROMETER) (TSF)
TV = SHEAR STRENGTH (TORVANE) (TSF)
MA = MECHANICAL ANALYSIS
LL = LIQUID LIMIT (%)
PI = PLASTIC INDEX
☐ - GRAB SAMPLE
◪ - SPT SAMPLE
■ - 2.5" I.D. SPOON SAMPLE 340 # WEIGHT, 30" FALL
S - SHELBY TUBE - PUSHED
▽ - GROUND WATER TABLE WHILE DRILLING

LOG OF BORING

DOWL

FIGURE 3.17

Erosion of the beach appears to occur at a rate of about 2 feet per year as shown by aerial photographs. Dock structures would need protection from tidal current, ice scour, and wave action. Protection in the form of riprap could be provided from several sources. Boulder deposits occur on-site and appear to be widespread, but their quality and quantity are unknown. Quarry sites containing volcanics and intrusives of Jurassic time exist at elevations above the outwash/moraine plateau and at various locations throughout Cook Inlet.

Transportation Corridor and Mine Areas

The proposed mine sites include the Capps coal field area and the west half of the Chuitna coal fields (Center Ridge).

° Topography of Mine Areas

The topography in the Capps and Chuitna coal fields includes areas of significant mass wasting potential due to water runoff, frost action, slope and other natural features. The ground surface is covered with many small hummocky hills indented with small cirques. The surficial features (patterned ground) indicate surface frost action is occurring primarily in the uplands. The presence of permafrost in the Capps coal field area is highly possible. During hand probes, several samples obtained below 5 feet in depth were very cold to the touch.

° Surficial Conditions at Mine Areas

The ground cover within the area of the Capps and Chuitna coal fields consists of a thin layer of moss, grasses, wild flowers and low woody plants. Field observations noted a cyclic build-up of surficial soils. The mosses are gradually covered by wind-blown sands and/or volcanic ash. Figure 3.18 illustrates a typical shallow soil profile of the Capps area. Soils tests show the sands to

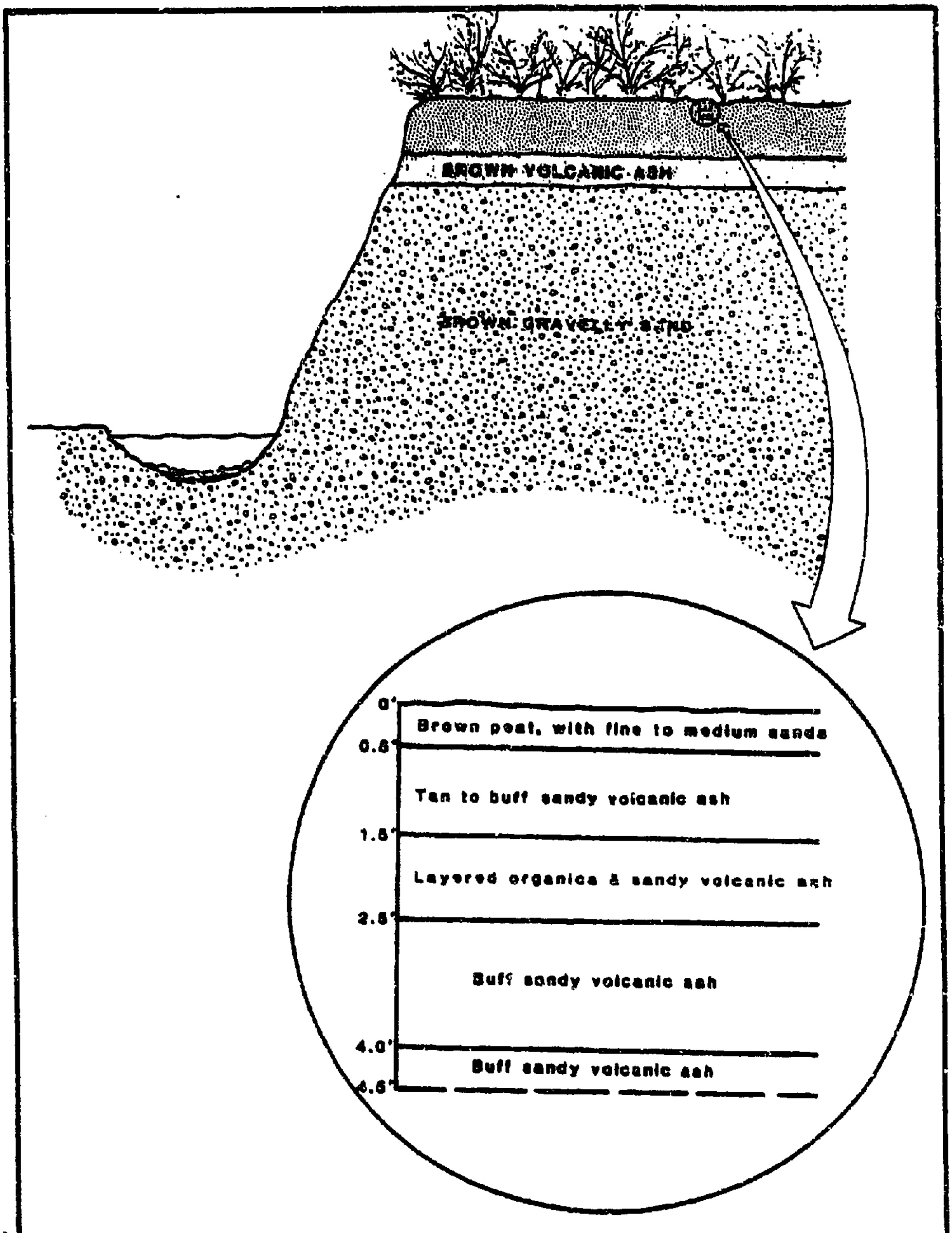


FIGURE 3.18. TYPICAL SOIL PROFILE OF CAPPS AREA, ALASKA

be well-sorted with 68% retained between the #40 and #200 screens. A grain size analysis of the ash shows 48.5% is sand and 41.6% is minus #200 grain size.

- Transportation Corridor

The transportation corridor traverses the upland tundra of the Capps Field area, passes through the transition zone between the tundra and mixed high brush where the Chuitna Field is located, and enters the lower elevation which is dominated by mixed high brush/spruce and hardwood forest area near tidewater.

The surface vegetation changes from grasses and moss to alders and grasses with root systems which extend 18 inches or more. The topsoil here has developed to a greater extent than the soils of the Capps area, however, it is still bisected with layers of sandy volcanic ash. Figure 3.19 shows a typical section/soil profile for the Chuitna Field area.

- Trafficability

The trafficability of the upland Capps coal field area is very poor. Layered organics and volcanic ash have been observed in recent field reconnaissance to range from a few feet to more than six feet in depth. In addition, the groundwater table is relatively high, having been located in several test probes at depths from 20 to 60 inches.

Construction Materials

- Surficial Geology

Subsurface soils investigations were performed in the proposed plant and town sites and surrounding areas in order to observe the existing soil conditions, and to determine on-site aggregate

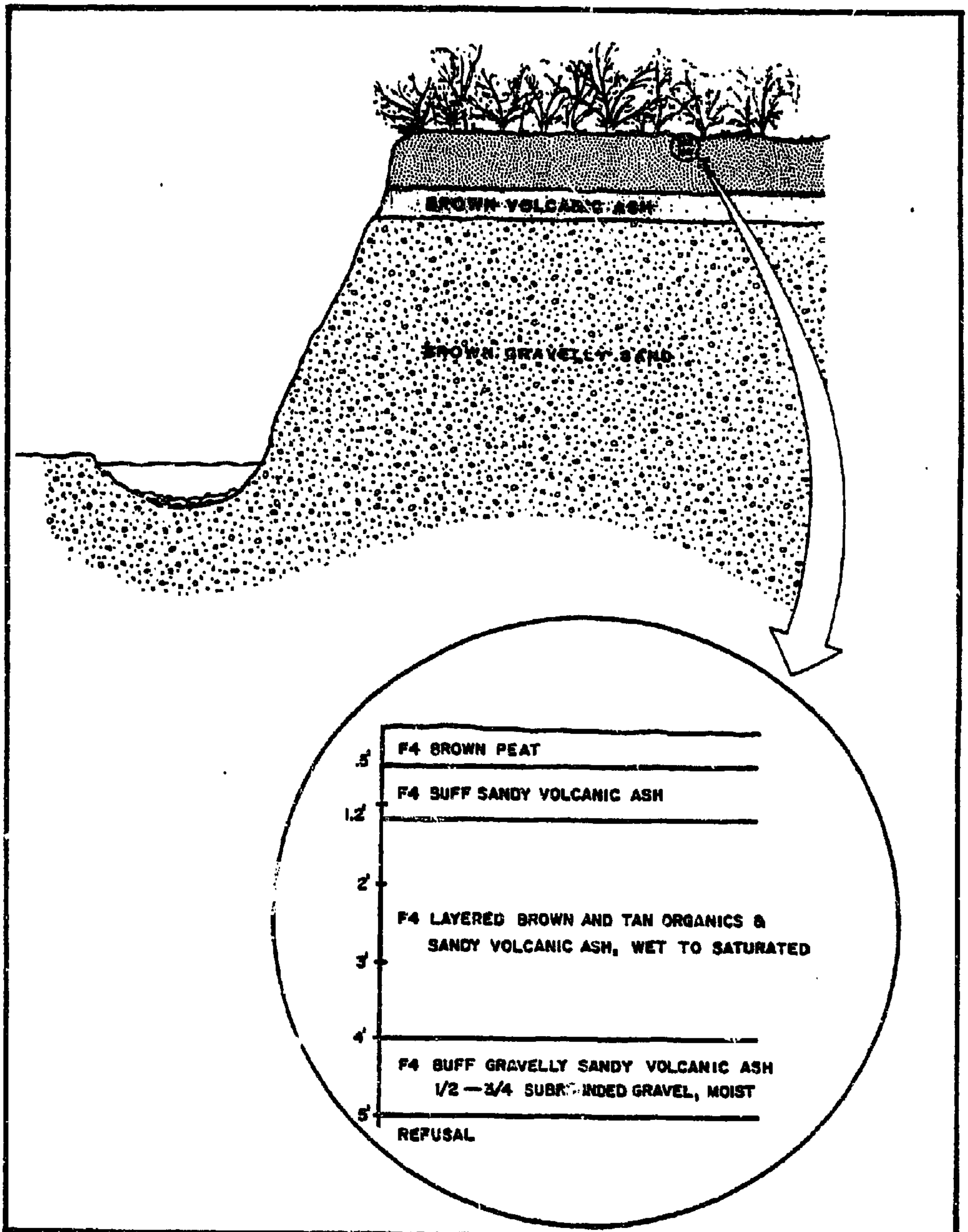


FIGURE 3.19 TYPICAL SOIL PROFILE OF CHUITNA AREA

sources. The investigation was confined to existing roads and accessible logging trails in the plant and town site areas. Random grab samples were also taken along the transportation corridor. Sufficient quantities of on-site aggregate resources for use in concrete, bituminus paving, railroad ballast, and classified fill do not appear to be present within the immediate plant or town sites. It is suspected there are moderate quantities of on-site aggregate, but the quantities are probably too small to be used for any major construction purposes.

The soils encountered in the proposed development areas are considered to be glacial in origin. The glacial deposits are generally divided into two types: Till, nonstratified drift, and moderate to well bedded diamicton; and stratified drift. The till is considered to be a direct glacial deposit and the stratified drift is considered to be deposited by a fluid medium less viscous than glacier ice, i.e. water or air.

Two distinct kinds of glacial till are found in the plant and town sites and surrounding areas. An upper layer of coarse, angular till was observed to depths of 0 to 8.5 feet, but is suspected to be deeper in some areas. It appears to be unsorted, virtually unweathered material containing all particle sizes. Boulders 10 feet or more in diameter are scattered erratically on the ground surface. Rock fragments are of all sizes, are angular to subangular, and contain some subrounded particle shapes. Lithologically, the parent material is primarily volcanic, ranging from non-visicular to visicular in texture, with little visible matrix. The upper soils often exhibit a silty sandy matrix, which may contain some organics leached from the surface organic soils.

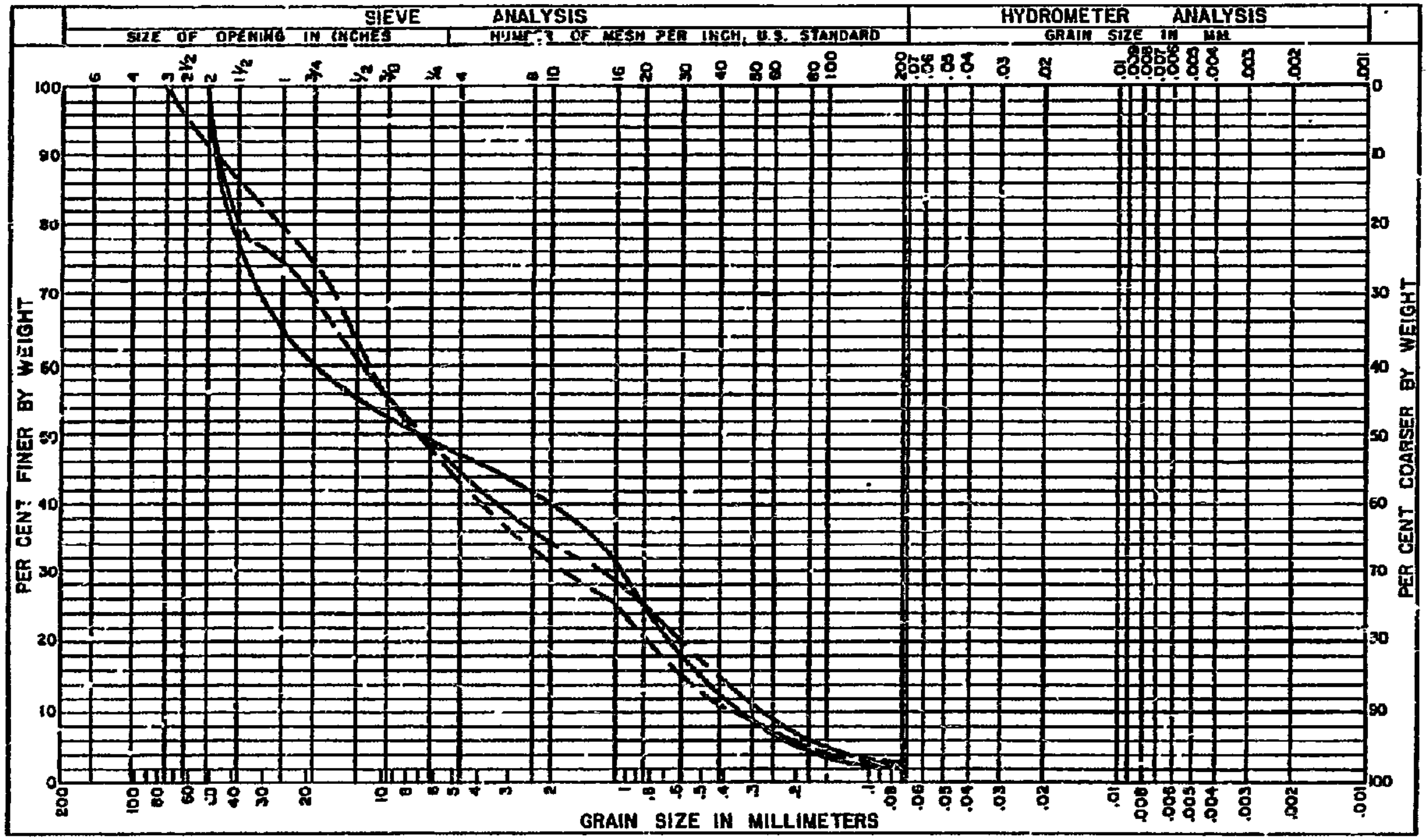
A second type of glacial till is found below the upper till. It is a poorly sorted, silty gravelly sand mixture, with occasional angular to subrounded cobbles and boulders. This till appears to have undergone a higher degree of weathering than the overlying till.

Various amounts of soil stratification were observed along road cuts and in pits. Generally the deep soil is considered to be non-stratified to moderately stratified and has been mapped as "ground moraine deposit -- primarily diamicton".

There are areas on the plant site where stratified tills are present. These deposits generally cap small knolls, eskers, and kames which are characteristic of the moraine topography. Most sites have already been scalped to build access roads for removing timber. The soil below this shallow surface material is a till composed of silty, gravelly sand. Poor accessibility caused by deep, soft peat prevented investigation of many of the potential aggregate source areas.

Random aggregate samples were taken at road cuts and existing gravel pits, both on and off the site, but no significant sources of aggregate were found. The search was extended to the Chackachatna River area and the lower reaches of the Chuitna River. The Chuitna River area has had little glacial activity and generally contains coarser material than the moraine areas.

Potential aggregate sources were examined as a part of this study. The Chakachatna riverbed and the accompanying old stream channels were considered. The sample tested was taken near the existing bridge, however similar material was observed about four miles east of the river. Other potential material sources include the existing pit at Tyonek, and Test Pit 6, where sample 1 which is representative of on-site material, was taken at a depth of 4 feet (Figure 3.7). Nearly unlimited quantities of material are expected to be present in the Chakachatna River area but on-site quantities are expected to be severely limited. Gradations of the samples tested are shown in Figure 3.20. The Chakachatna River sample was not entirely representative of the material in the field, because the natural deposit contains an abundance of large gravels and cobbles not reflected in the sample.



KEY	LOCATION	SAMPLE NO.	DEPTH	UNIFIED CLASS.	FROST CLASS.	SOIL DESCRIPTION
– – – – – –	Tyonek Gravel Pit	--	--	GW	NFS	Sandy Gravel
————	Chakachatna River Bridge	--	--	GP	NFS	Sandy Gravel
——— ———	Plant Site	TP 6, Sa 1, @4'	--	GP	NFS	Sandy Gravel

W.O. 12780

FIGURE 3.20 GRAIN SIZE DISTRIBUTION — GRADATION CURVE

A limited soils testing program was conducted in August 1981. Samples were obtained in the Capps Field area from exposed glacial till and volcanic ash. Grain size analyses were performed on the sand and volcanic ash, and Atterberg Limits were determined for the volcanic ash. In addition, a Los Angeles Abrasion Test (American Society for Testing and Materials [ASTM] C131-55, grading E) was performed on a surface grab sample of the glacially deposited volcanics in the Capps uplands.

The grain size analysis on the sand revealed a well-sorted sand with 68% retained between the #40 and #200 screens. This, in combination with field observations, indicates the mode of deposition was by wind. Because of the dark color of the sand and the surrounding dominant volcanic rock type, the sand is most likely derived from volcanic rocks and ash.

The grain size analysis of the volcanic ash reports 48.5% is sand and 41.6% is minus #200 grain size. An Atterberg test was run on the ash, and confirmed it to be non-plastic. Other volcanic ashes in the field were plastic.

The Los Angeles Abrasion Test on "glacial" till which had been reworked by surface runoff, reported a 15.6% loss by abrasion. This is considered a very acceptable percentage loss and suggests that this material could be used for a railroad ballast or for road construction. Figure 3.21 illustrates the results of the abrasion test.

- <u>Concrete Aggregates</u>

The Chakachatna River material shows the most favorable gradation of the three samples tested for both coarse and fine portland cement concrete aggregates. Table 3.1 shows the gradation of the three samples broken down on 1½" and #4 sieves. Both fractions of the test sample meet the appropriate ASTM C33 gradations.

Testing | Exploration | Chemical | Materials | Inspection

ALASKA TESTLAB

LOS ANGELES ABRASION ASTM C131-55

Size. Fraction	A	B	C	D	E	F	G	Grading Used	
3" to 2-1/2"					2500 gm*				
2-1/2" to 2"					2500 gm*				
2" to 1-1/2"					5000 gm*	5000 gm*			
1-1/2" to 1"	1250 gm					5000 gm*	5000 gm	1253.1	
1" to 3/4"	1250 gm						5000 gm	1252.2	
3/4" to 1/2"	1250 gm	2500 gm						1253.4	
1/2" to 3/8"	1250 gm	2500 gm						1249.9	
3/8" to 1/4"			2500 gm						
1/4" to #4			2500 gm						
#4 to #8				5000 gm					
Total Weight	5000 gm	5000 gm	5000 gm	5000 gm	10,000 gm	10,000 gm	10,000 gm	5008.60	Actual Wt. (A)
No. of Balls	12	11	8	6	12	12	12	4158.6	Wt. Ret #12 (B)
								850.0	Loss A - B
								17.0	% Loss $\frac{(A-B)100}{A}$

* Tolerance ± 2%/size fraction

Project: Beluga - Methanol Plant
Location: Tyonek
Client: CIRI/Placer - Amex
Pit Sampled: A2501
Date: 6/6/81

W.O. D12780
Tech. CJP

FIGURE 3.21 ABRASION TEST RESULTS

Table 3.1

FINE CONCRETE AGGREGATES, #4 MINUS

Sieve	Percent Passing: Chakachatna River	Percent Passing: Tyonek Pit	Percent Passing: On-Site	ASTM C33 Specs
4	100	100	100	95-100
8	87	80	82	80-100
16	68	39	66	50-85
30	38	34	46	25-60
50	19	16	27	10-30
100	9	10	11	2-10
200	5	8	4	0-5*
F.M.	2.79	3.01	2.68	2.3-3.1
Absorption	2.9	3.6	3.3	--
Apparent Sp. G.	2.81	2.71	2.76	--

*0-3 is concrete subject of abrasion

Sieve	Percent Passing: Coarse Concrete Aggregates, 1½" to #4			ASTM C33 Size 467 Specs
1½"	100	100	100	95-100
1"	60	86	87	--
3/4"	44	72	71	30-70
½"	30	45	54	--
3/8"	16	30	32	10-30
#4	0	0	0	0-5
Absorption	1.6	1.2	--	--
Apparent Sp. G	2.77	2.69	--	--
L.A. Abrasion	26	17	--	50 Max.

The oversized coarse gravel and cobbles would be wasted as a part of the concrete aggregate operation, but would probably be useful in some of the other products discussed below. The amount of material passing the #200 sieve in the Chakachatna River sample is only marginally within specifications. Washing of the sand or selective mining of the pit to decrease the amount of material passing the #200 sieve may be desirable to improve the efficiency of this material as concrete aggregate. Los Angeles abrasion loss on the coarse fraction of this sample is within specification limits, although higher than for some aggregates in the area.

The Tyonek pit material has grading deficiencies which would be a problem for production of portland cement concrete. It has a slight excess of coarse sand in the #4 and #8 ranges, and an excess of material passing the #200 sieve. It is slightly deficient in the medium sand fraction passing the #30 and retained on the #100. These deficiencies could be overcome by processing the sands through a classifying plant and wasting some of the unwanted sizes. In the coarse aggregate, the Tyonek pit material has an excess of material passing the 3/8-inch and retained on the #4. This (pea gravel) material decreases the economy of the concrete by increasing the cement content required to achieve a given strength level, and tends to cause poor finish-ability of the concrete. Therefore, if this source is used it is recommended that a large portion of the pea gravel size be wasted from the concrete aggregate. It may be possible to utilize some of the wasted pea gravel in other materials. The Tyonek pit material would probably be quite durable under abrasive conditions as indicated by its low loss in the Los Angeles abrasion test.

The on-site material as represented by the sample from Test Pit 6 typically is too silty for use as concrete aggregate. A test sample taken from an area with lower silt content than typical shows a gradation which could be processed to provide satisfactory concrete aggregates. The sand in that sample conforms to ASTM C33 specifications for concrete sand except that an excessive amount passes the #100 sieve. This deficiency could easily be corrected by washing the sand. The coarse fraction of this material has an excess of the pea gravel sizes, some of which would need to be wasted to provide a satisfactory concrete aggregate.

Coarse aggregate sizes other than 1½-inch maximum shown on Table 3.1 would also be practical to manufacture from the materials investigated. A 1½-inch maximum aggregate size would probably be economical to produce from the Chakachatna River material, while a finer coarse size, perhaps 3/4 to 1 inch nominal, would be more practical to produce with the Tyonek or on-site materials. It would also be possible to introduce crushed gravel into the coarse concrete aggregate. This would give a greater latitude in the potential gradations available, particularly with the Chakachatna River source.

No matter which source is selected for use as concrete aggregate, further testing should be performed to verify the acceptability of the source. Particles consist mostly of a mixture of coarse and fine-grain igneous rocks. Certain fine-grain igneous materials and glassy igneous minerals are alkali reactive. It is possible to compensate for alkali reactive constituents in aggregates if their presence is known beforehand. Therefore it is recommended that alkali reactivity tests be performed on any aggregate source considered for use. Also useful would be to produce some laboratory concrete test batches with materials tentatively selected for use. It would then be possible to check the workability of the concrete and the water demand, and to determine proper design strength levels for that aggregate source. If concrete placements which would be subjected to freeze-thaw action in a damp environment are contemplated, freeze-thaw tests of specimens of hardened concrete might also be considered.

• Asphalt Concrete Aggregates

Table 3.2 shows a typical aggregate grading for asphalt concrete. The material coarser than the #4 sieve in asphalt concrete consists mostly of crushed particles. The gradation of the coarse material could be controlled by controlling the crushing process, provided there is sufficient oversize material to provide a good crusher feedstock. The Chakachatna River source has abundant coarse gravel and cobbles that could provide large quantities of crusher feedstock. The other two sources would have smaller quantities of oversize material, but probably would have enough for production of asphalt concrete in limited quantities.

It is usually not practical to crush a fine asphalt aggregate to achieve a desired gradation, but it is necessary to find a material with a fine fraction graded within specifications or to blend several materials to obtain the desired gradation. None of the three sources contains a fine aggregate graded entirely to meet the specification shown on Table 3.2 for fine aggregate. The Chaka-

Table 3.2

TYPICAL ASPHALT CONCRETE SURFACE COURSE
(Asphalt Institute IVb)

Sieve	Percent Passing
3/4"	100
3/2"	80-100
3/8'	70-90
#4	50-70
#8	35-50
#16	--
#30	18-29
#50	13-23
#100	8-16
#200	4-10

Material coarser than #4 sieve should be mostly crushed gravel.

chatna River fine aggregate is deficient in materials passing the #50, #100 and #200 sieves for use as an asphalt concrete aggregate. The Tyonek pit material is deficient in the sizes passing the #50 sieve and retained on the #200 sieve. The grade of the on-site material more closely approximates the asphalt specification, but is deficient in material passing the #200 sieve. Other on-site materials have more material passing the #200 so it is expected that a satisfactory blend could be achieved. If either the Chakachatna or the Tyonek material were used for asphalt concrete, it is recommended that a fine silty sand or sandy silt be blended with the natural material to produce a more desirable gradation for asphalt concrete. The exact blend would depend on which source is selected. The Tyonek pit material showed high resistance to abrasion using the Los Angeles abrasion test and would be expected to produce an asphalt concrete more resistent to traffic abrasion than would the Chakachatna material. The gradation on Table 3.2 is simply typical of what may be used for asphalt concrete. It may be worthwhile to test gradations outside that specification, as a wide range of gradations is capable of producing acceptable asphalt concrete.

- Crushed Base Course

Surfaces which are to be paved with asphalt concrete probably require a greater quantity of crushed base/leveling course than of aggregate for asphalt concrete. A typical gradation of base/leveling course is shown on Table 3.3. Since it is primarily a crushed product the gradation of the coarse material must be controlled by the crushing process. Efficient materials for processing into a base course would be those with a relatively high percentage of material coarser than the 3/4-inch screen. Use of sufficient quantities of coarse material would allow material from any of the three sources Chakachatna, Tyonek or on-site, to be processed into acceptable base course material. Some base course specifications may allow a larger maximum size than shown on

Table 3.3 and some allow a greater percentage passing the #200 sieve. No material with a "D" value less than 50 when tested for susceptibility to degradation during agitation in water according to Alaska Test Method T-13 should be used to produce base course.

- Railroad Ballast

Table 3.4 shows a typical gradation for railroad ballast. This is an open graded coarse aggregate containing a mixture of crushed and natural particles. Any of the three sources considered could be used as a raw material source for railroad ballast. If the Chakachatna River material were used, large quantities of coarse gravel and cobbles for crusher feedstock would be available, but the number of crushed particles in the finished product would probably be greater than required by the specification. If railroad ballast were being produced from either the Tyonek or on site source at the same time concrete aggregate were being produced, the oversize material wasted from the concrete aggregate could be crushed and utilized in the railroad ballast, while pea gravel sizes undesirable in the concrete aggregate could be wasted from the concrete aggregate and utilized in the railroad ballast as part of the uncrushed material.

The relative quantities of the different types of materials needed are important in selecting the most practical pit from which to borrow. The Chakachatna River material is expected to produce the largest quantity of coarse gravel and cobbles for crusher feedstock. The other sources would provide larger quantities of naturally rounded medium-size particles. If exceptionally large quantities of concrete were required, sands from any of the three sources could probably be processed through classification into an acceptable gradation. If the quantities of concrete would not justify importation of a classification plant, the Chakachatna River material shows the most favorable natural gradation of sand. Use

Table 3.3

TYPICAL BASE COURSE
(State of Alaska D-1 Specification)

Seive	Percent Passing
1"	100
3/4"	70-100
3/8"	50-80
#4	35-65
#8	20-50
#40	8-30
#200	0-6
Crushed Particles	70% + #4 single face

Source: DOTPF 1981 Standard Specifications for Highway Construction.

Table 3.4

TYPICAL RAILROAD BALLAST
(Alaska Railroad G-2)

At least 70% of material coarser than #4 seive should be crushed.

Seive	Percent Passing
1½"	100
1"	65-100
½"	35-75
#4	10-35
#8	0-10
#16	0-5
Crushed Particles	21-60

Source: Typical Alaska Railroad Construction Specification.

of waste materials from one product in another product can improve the economics of aggregate production, and could have an affect on selection of the pit site.

GEOLOGIC HAZARDS

Seismicity

The Cook Inlet-Susitna Lowlands, the setting for the proposed project, are included in a region of great seismic and volcanic activity associated with the subduction zone formed as the Pacific Ocean plate dips below the North American plate. Features of this collision zone include the arcuate Aleutian Island chain of volcanos and many, but not all, of the recorded large seismic events in Alaska.

Major fault systems have been identified in the general area Figure 3.22, and include the Aleutian Megathrust (subduction zone), Castle Mountain, Bruin Bay, Lake Clark, and Border Ranges faults. Each of these, as well as other more distant features, is capable of producing seismic events, but the frequency and magnitude associated with each system are not well known due to the relatively short length of record, which is generally the case throughout Alaska. Since 1899, nine Alaska quakes have exceeded Richter magnitude 8, and more than 60 have exceeded magnitude 7. Thirteen earthquakes of magnitude 6 or greater have occurred in the Cook Inlet region during that time. The general project area lies at the border between Zones 3 and 4 in the 1979 Uniform Building Code, but historical seismicity indicates a high level of seismic activity for all of upper Cook Inlet.

c Aleutian Megathrust

The subduction zone between the North American and Pacific Ocean tectonic plates is topographically expressed in the North

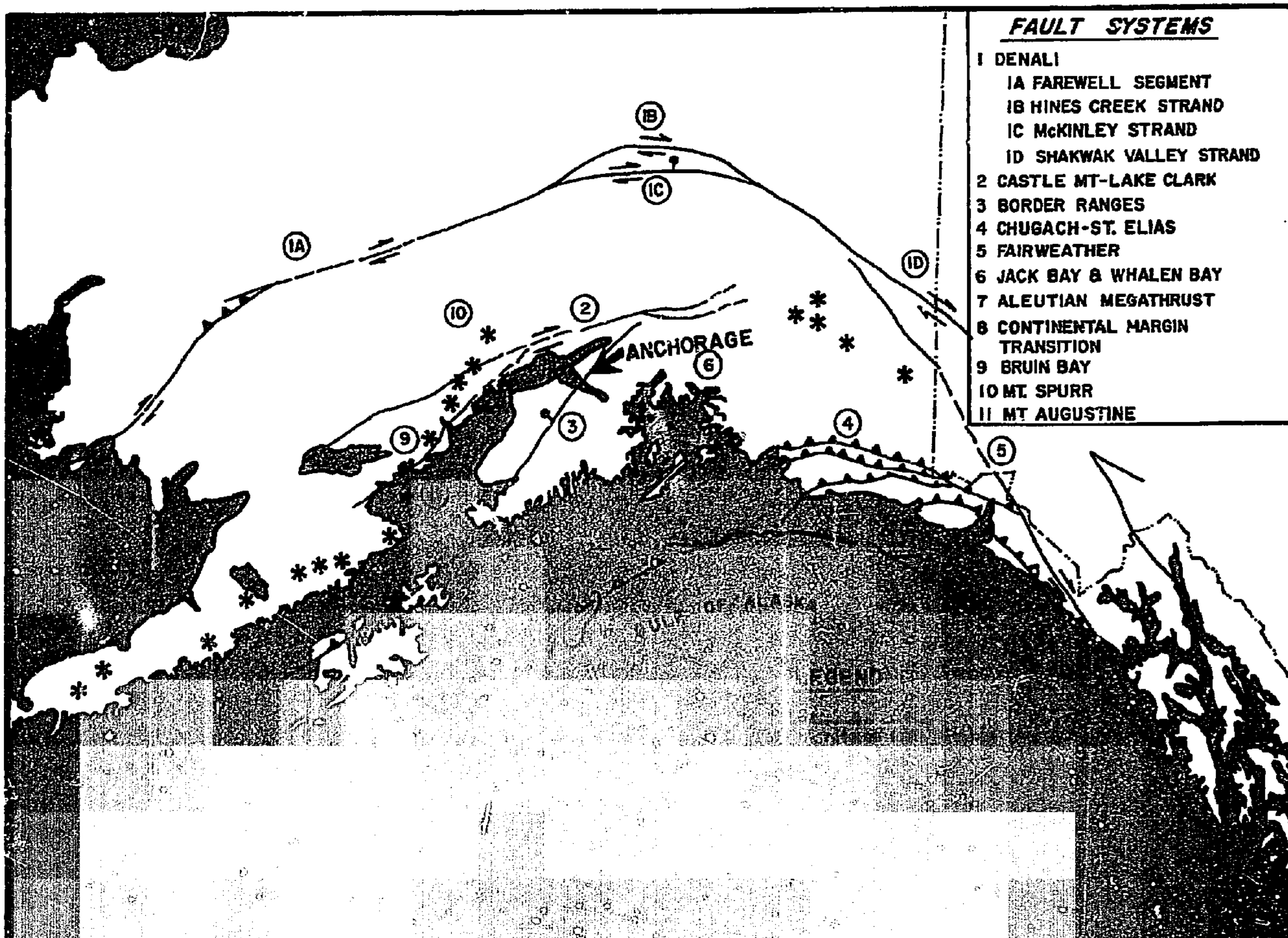


FIGURE 3.22 MAJOR FAULTS IN SOUTHCENTRAL ALASKA

Pacific by the arcuate Aleutian Island chain, the mountains which form the Alaska Peninsula, and the deep Aleutian oceanic trench. The subduction zone in this area of the Pacific is thought to be a shallow, north dipping (reverse fault) thrust zone termed a "megathrust". The unusually shallow (10°) angle of thrust is inferred from hypocentral locations and fault plane solutions of the earthquakes that continually express the tectonic realignment along the northern limits of the Pacific Ocean Plate. Although a simplistic interpretation of earthquake epicenters and topographic expression implies the Aleutian megathrust is a smooth circular arc with a radius of approximately 800 miles (1,280 kilometers) it is now believed that the arc is composed of relatively short straight line segments joined together at slight angles. It is further thought that these segments are tectonically independent. There has been a tendency for the hypocenters of large earthquakes to occur near one end of these blocks, and for the accompanying aftershocks to spread over the remaining portion, so that during large events strain is released over an entire segment of the megathrust zone, stopping abruptly at the discontinuity between individual segments.

Nearly the entire Aleutian Arc between 145°W and 170°E has ruptured in a series of great earthquakes (M_L greater than 7.8) since the late 1930s. The most recent great event was the 1964 Prince William Sound earthquake, which was the largest ever recorded on the North American continent (M_L = 8.3 to 8.6). It is believed that this activity is typical rather than atypical for the area, and that future earthquakes of magnitude 7.9 or larger can be expected along the megathrust.

Continual motion along the thrust system produces a large amount of regional subsidence and uplift due to plate warpage, and is responsible for the orogenesis (mountain building) for the region. The proposed plant site lies outside the zone of major vertical movement produced by the 1964 event. Although large displacements of 35 to 50 feet were noted elsewhere in Alaska, only about one foot of vertical displacement was noted by residents of Shirleyville, a small settlement near Granite Point.

- Castle Mountain Fault

The proposed plant site lies in an area which is near the ends or juncture of three major faults, the Castle Mountain, Bruin Bay, and Lake Clark faults. Continuity of these faults has been inferred by gravimetric methods, but no surface expressions tie them together.

The Castle Mountain Fault has been classified by various investigators as both a right-lateral strike slip fault and a steeply dipping reverse fault. Right-lateral slip was observed in Cretaceous units, and dip-slip motion has occured since Miocene time. Schmoll has indicated the fault was active east of the Susitna River in Holocene time, but Recent movement west of the river is unknown (Schmoll, et al , 1981).

The magnitude of earthquakes associtated with this fault generally is small (M_L = 3.0 to 4.5), and their focal depths are shallow--generally less than 50km. However, it is thought that six recorded earthquakes with magnitudes greater than 6.0 have occurred on the fault. The maximum historical earthquake is believed to be 7.3 in 1943, but uncertainty exists concerning its location.

The Castle Mountain Fault is capable of producing a magnitude 8.0 earthquake based on its length of about 215 miles (exclusive of the Lake Clark Fault), but a probable maximum is 7.5.

- Bruin Bay Fault

It is postulated that the Bruin Bay Fault passes through the plant site and joins the Castle Mountain Fault through the Moquawkie

Contact. No surface lineaments are noted at the site, but Congahbuna Lake has been suggested as a surface feature of the fault (Schmoll, et al , 1981).

The activity of this fault system has not been established in Recent time, but Tertiary movement is suspected. More extensive investigations should be performed to determine its activity and location, since this is the closest fault to the proposed plant site. The length of the fault (320 miles) implies that it could produce seismic events with magnitudes greater than those associated with the Castle Mountain Fault; however, no Holocence activity is known.

- Lake Clark - Lone Ridge Fault

It is postulated that the Lake Clark Fault is a continuation of features similar to the Castle Mountain Fault. However, a gravimetric study indicates different tectonic blocks are involved. It is also postulated that the Lone Ridge lineament belongs to the Lake Clark system (Detterman, et al). This ridge lies north of the Chuitna coal field and exhibits steep scarps.

- Border Ranges Fault

The Border Ranges or Knik Fault is located across Cook Inlet from the proposed site and forms a boundary of the Cook Inlet lowlands. A magnitude 7.0 earthquake has been estimated to be the maximum expected for the Border Ranges Fault, but little physical evidence is available concerning its activity. No fault movement has been documented for the past 10,000 years near Anchorage, suggesting that part of the fault is inactive.

- Seismic Design Considerations

Seismic considerations significantly affect the design of structures in the Cook Inlet region. Risk studies based solely on historic seismicity in the upper Cook Inlet region (Anchorage and vicinity) indicate peak rock accelerations of about 0.4g have a 10% chance of exceedence in 50 years, and peak rock accelerations of 0.17g have a 50% chance of exceedence in the same design period. These values have been calculated for Anchorage during previous investigations, but a regional study indicates that similar values should apply to adjacent areas including the plant site. The features which contribute to seismicity indicate that a 7.5 magnitude earthquake would be reasonable for a closely occurring earthquake, and an 8.5 earthquake may be expected from a distant earthquake attributable to the Aleutian Megathrust or other large fault. Frequency of these events for Anchorage is shown on Figure 3.23. The Castle Mountain and Bruin Bay faults probably could produce greater accelerations than the values given above, but these accelerations constitute the maximum credible accelerations at the site and have a low probability of occurrence. Boore (Boore, et al., 1978) indicates that peak accelerations of 0.8 to 1.0g would be expected from major activity on the nearby faults, such as the Castle Mountain or Bruin Bay fault.

Frequency contents of distant and near earthquakes would differ appreciably, but little information is available on the frequency content of Alaska earthquakes. However, comparison with California earthquakes indicates that "design earthquakes" should differ for near and distant sources, i.e. a higher frequency content for close earthquakes than for distant earthquakes. The peak rock acceleration may be used as a scale factor for design earthquakes from close or distant sources. However, the peak rock accelerations and design earthquakes were not determined during this investigation.

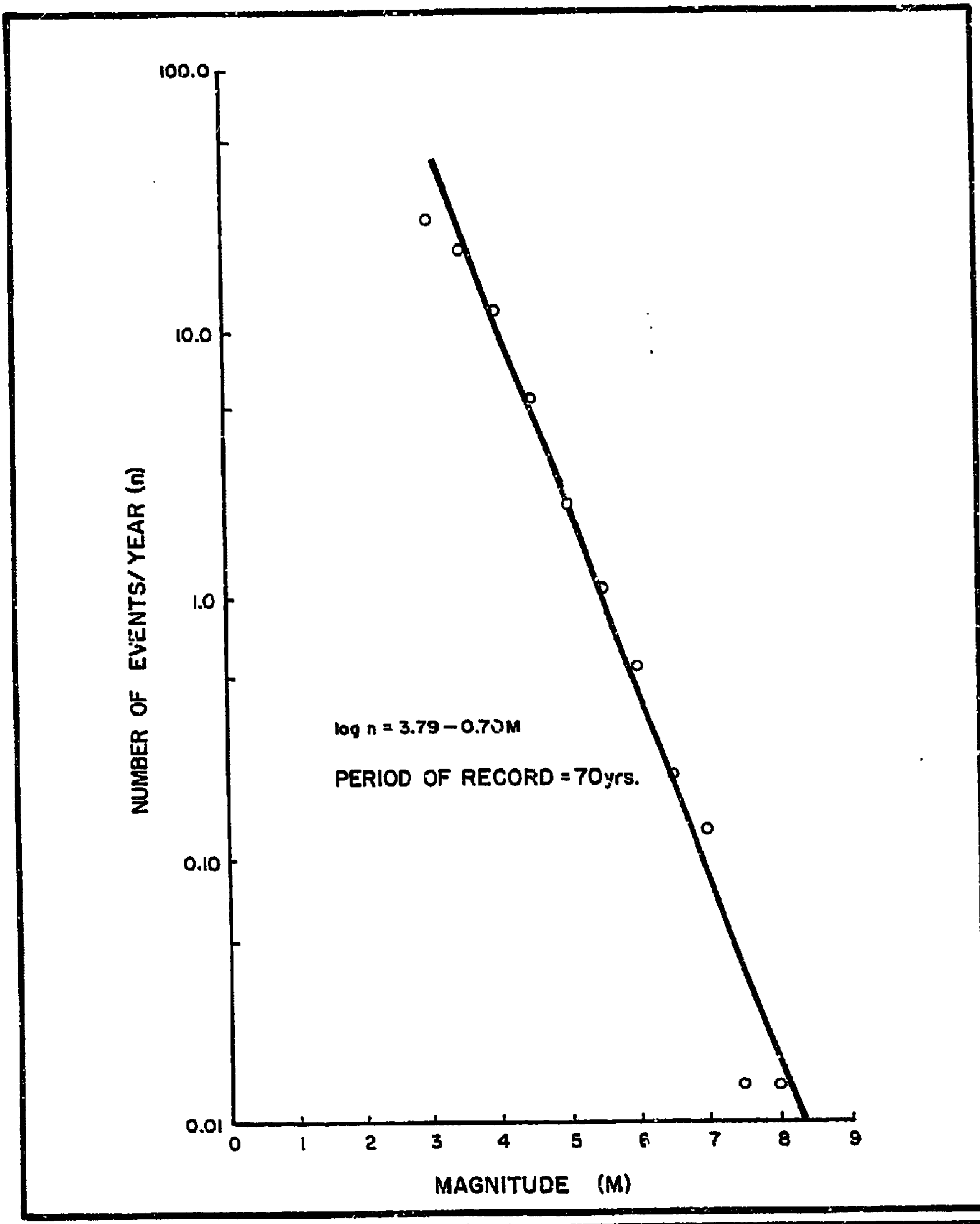


FIGURE 3.23 CUMULATIVE MAGNITUDE FREQUENCY RELATIONSHIP (ANCHORAGE REGION)

Peak ground acceleration is a function of the input rock acceleration, soil response, and the soil-structure interaction. The very dense soils which underlie the plant site indicate that surface motion would not differ largely from the input motion, but an investigation of ground motion should be performed for the site.

The dense soil will offer excellent protection against liquefaction or subsidence since it is already near its densest condition. Peat in the area may contribute to amplified ground movement during earthquakes if it is incorporated into foundations or if it underlies filled areas.

The effects of seismic motions may include some slope instability, but only in those areas which have been over-steepened by erosion. Bluff areas near the proposed plant site appear to have been relatively stable during the 1964 event except for areas along the beach and rivers which had been over-steepened by erosion. Slope failure did occur during the 1964 event along the steep bluffs northeast of the site. The proprietor of Shirleyville indicated that his house was damaged by an earthslide which occurred soon after the 1964 earthquake, but that the slope was stable during the event. Frost and water may have contributed to this phenomena of delayed slope failure. However, it must be concluded that many of the slopes in the area were not affected by the 1964 earthquake. The beach bluffs typically receed 2 to 3 feet per year due to erosion or due to shallow, slump type failures regardless of earthquake activity.

The bluffs adjacent to the plant site appear to be stable for all expected earthquake accelerations, provided large toe cuts are avoided and large loads are not applied at the top of bluffs. Some small, locally over-steepened slopes exist, but these areas could be avoided or cut to a stable configuration.

Ground Failure

Local ground subsidence is not likely due to the dense state of the soil at the proposed plant site, but surface faulting along the Bruin Bay/Moquawkie Contact (Figure 3.22) could have severe consequences to development if it were to occur. Local investigations should be performed to determine the fault's activity and possibly the location and alignment of its surface expression. Since peat in this area is saturated, an investigation using trenching would be relatively difficult without extensive dewatering. The problems associated with surface faulting through developed areas could be avoided by restricting development in the area of possible ground faulting as inferred by linear features, such as Congahbuna Lake.

Landslides

Landslides in the Beluga area often occur within the Kenai Formation. The soils consist of low-grade sedimentary sandstone, conglomerates, siltstone, and claystone. Most of the slides occur on steep slopes which are undercut by stream action and/or where frost action, surface and subsurface water, and gravity have contributed to slides. Some tectonic activity due to movement along the Castle Mountain Fault and earthquakes may also play a significant role in landslides in the area.

The Capps Glacier slide is a very large slide covering approximately five square miles. The land has a stepped slump topographic appearance. Many large coal blocks lie in a random orientation in relation to the surrounding insitu coal beds. The Capps Glacier slide is active with the most recent movement observed occurring adjacent to the top of the escarpment in Section 25, T14N, R14W, Seward Meridian.

A subsurface soils investigation performed by the USGS (Yehle, et al , 1980) indicated the strength index test on unconfined compressive strengths on a drill hole made in the Capps Field ranged from 0.20 to 4.20 MPa (29 to 609 psi) with an average of 1.74 MPa (252 psi). The test hole material ranged from soft soil to soft rock.

During field reconnaisance by DOWL Engineers (1981), the observable surface outcrops in landslide areas are low-grade sedimentary rock which is slightly to poorly cemented and friabie. It appears to break down readily in water and is clearly affected by freeze-thaw cycles when surface water is present.

Along the Chultna River and its tributaries, large and small slides are easily observed. Many slides are due to oversteepening of high-cut banks by stream action and surface runoff. Resistive beds of coal jut out from the face of the carved river banks. When enough underlying soil is eroded below a resistive bed, large blocks of coal fall into the stream channels.

<u>Volcanos</u>

Five active volcanos are found in the Cook Inlet region. The most recent eruptions were by Mr. Spurr in 1953 and Mt. Augustine in 1976. Mt. Spurr is located about 40 miles from the proposed plant site near the Capps Glacier. Mt. Augustine, located in south Cook Inlet near Kamishak Bay, is considered potentially explosively eruptive and is under observation by the USGS. The USGS should be able to provide warning if activity becomes imminent

Volcanic deposits of 1 to 2 feet of ash from numerous eruptions were found in the vicinity of the proposed plant site, and these deposits are being mapped to determine historical volcanic activity in the region. The most recent ash fall at the proposed plant site occurred following the eruption of Mt. Augustine in 1976.

The volcanics in the Beluga area are Miocene or younger in age. The Capps upland is covered by a reported 0 to 100-foot thick cap of glacial till which is made up of silts, sands, gravel, cobbles and boulders. Most of the till is derived from extrusive and intrusive volcanics.

Many ash falls (nu'ees ardentes) have occurred. The eruption of Katmai, in 1912, 240 miles south of Beluga, produced an ash and sand flow of nu'ee ardente origin which formed sandy tuff 100 or more feet thick over 53 square miles. One such ash fall also covered an observable area of six miles, and likely much more, in the Beluga area. Flora prints of plant leaves are easily observed at the base of the ash fall. The ash fall has been described as a lappilli (composed of volcanic ejecta 4mm-32mm in diameter). Lappilli was observed, during field studies by DOWL Engineers, near the uplands at the 2,400-foot elevation and on banks of the Chuitna near Botts Creek at elevations of 750 to 800 feet. In both areas, the volcanic ash tuff overlies a coal bed ranging in thickness from a few feet to 7± feet where easily observed.

Tsunamis

Tsunamis are great sea waves most often caused by rapid vertical displacement of the ocean floor or submarine landslides. Two tsunamis have been recorded in lower Cook Inlet since 1883. Mt. Augustine errupted in 1883 and produced a 25-foot-high wave at English Bay; and the 1964 Prince William Sound earthquake produced a 4-foot-wave at Saldovia. These locations are 70 to 90 miles from the proposed site.

The restricted opening of Cook Inlet provides some degree of protection from incident tsunamis generated along the potential source areas along the Pacific Rim. In 1964, the Prince William Sound earthquake produced only a few feet of tidal disturbance inside Cook Inlet, although coastal areas such as Seldovia recorded some tsunami damage. Tsunamis generated in Cook Inlet may have severe impacts on coastal structures, but the plant site is at sufficiently high elevation to preclude tsunami damage.

Permafrost

No permafrost was detected in any of the borings. In addition, surface reconnaissance indicates little evidence of shallow permafrost. It is also unlikely that this south-facing area has deep permafrost. Sample temperatures were at or above 42°F, but some sample heat gain is usually associated with auger drilling. The upland areas may have some permafrost present but this is not confirmed.

Additional Geologic Hazards

Slope stability in the plant and town site areas is good, but slopes in the vicinity of the proposed construction dock are generally unstable and may require stabilization.

Other hazards were noted by Schmoll (USGS, 1980) in his preliminary report regarding the surficial geology of the area. Gravitational spreading of surficial deposits which produced graben-like features was noted along the Nikolai escarpment. However, this area is about 10 miles northwest of the proposed plant in an area of much steeper escarpments than found in the areas of the plant and town sites.

Volcanic clasts were observed within a few miles of the plant site and may indicate an unsuspected level of volcanic activity, or they may represent glacially transported volcanic debris. Additional investigation to determine the origin of this material should be considered.

The mountains north and west of the project site are extensively glaciated, among them being the Capps and Triumvirate glaciers. The glaciers present no foreseeable hazard to the higher portions of Nikolai margin, but the Triumvirate Glacier forms a dam creating Strandline Lake which then empties into Beluga River. Glacier dams can be unstable and have caused numerous floods, but a flood of this nature would not affect the proposed plant, town, or dock sites.

survey/soil investigation

upper Chuitna River area

vicinity Congahbuna Lake

upper Capps - exposed coal seam

4.0 HYDROLOGY

GROUNDWATER

Introduction

The availability of industrial quantities of groundwater in the study area is dependent on the existence of fairly extensive deposits of highly permeable granular materials which contact areas of high recharge capacity. The Chuitna River, although currently cutting its way through consolidated formations, may have some abandoned channel areas in which sufficient depths of gravels have been deposited so that a shallow groundwater or induced filtration situation may be developed. However, throughout the upland area from Nikolai Creek to the Beluga Lowlands the unconsolidated formations consist predominantly of impermeable glacial till with scattered and isolated deposits of sand -- ranging from silty sand to gravelly sand. As a result, production of previously drilled wells in the general area ranges from 0 to 50 gallons per minute (gpm). The only well of 500 gpm or more we know of in the Beluga area is at the Chugach Electric Association power plant. The vicinity of the Chakachatna River appears favorable for high groundwater production, perhaps 1,000 gpm or greater, due to extensive gravel deposits and sizable rivers to provide recharge. However, no production wells are known in that area. Information obtained by others drilling seismic shot holes in the Nikolai Creek flats area indicated that the Nikolai Creek area is underlain by gravel which might provide a substantial water source. A supply adequate for the proposed new town development may be available along the toe of the escarpment near the town site.

It is against this background that the water exploration program for this project was developed. The program included drilling two test wells, Test Well #1 in the Nikolai Creek Flats area and Test Well #2 within the proposed methanol plant site (Figure 4.1). An observation well, Well #3, was drilled near Test Well #1.

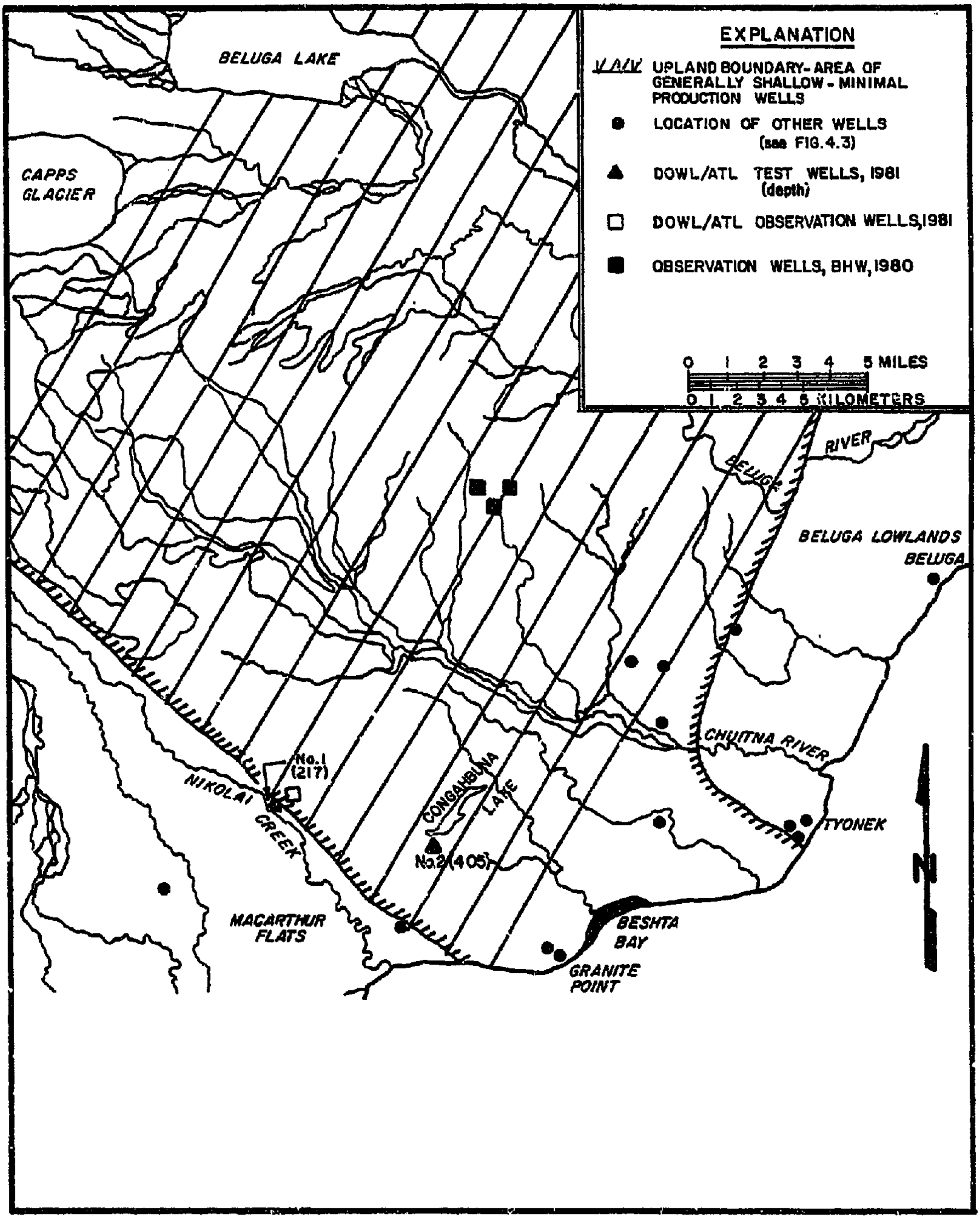


FIGURE 4.1 WELL LOCATIONS, GRANITE POINT AREA

Available Supply

° Nikolai Creek Flats

The vicinity of Nikolai Creek Flats appeared to be the most promising for development of high production wells within a reasonable distance of the proposed plant site. It did not appear that industrial quantities of groundwater could be obtained within a 2±-mile radius of the proposed plant site. However, it was felt that if an extensive shallow gravel or coarse sand aquifer existed in the Nikolai flats area, the creek would provide sufficient recharge to insure the long-term production of the formation. Since road construction would have been necessary to gain access to the flats nearer to the proposed town or plant sites, it was decided to drill the test well near the logging road bridge approximately six miles upstream from the plant site. It was felt that specific test information from this site could be combined with other generalized sources of subsurface information of the area to provide a reasonable indication of the groundwater potential in similar areas of the Nikolai flats nearer the proposed town and plant sites.

The primary objective of drilling in this area was to determine if relatively shallow aquifers exist which are recharged by Nikolai Creek; the drilling was to be shallow, less than 200 feet deep. Two holes were drilled, Test Well #1 and Well #3, which demonstrated that, at least in the area of the bridge, no such aquifer exists (Table 4.1). This verifies the surficial geologic mapping of the area done by USGS. The drilling did determine, however, that a series of predominantly fine-grain materials which are under considerable artesian pressure underlie the general area. These formations begin at a depth of 55± feet below the surface and extend beyond the maximum drilling depth of 217 feet. Although artesian leaks around the casings of Wells #1 and #3 were measured at 75 and 150 gpm, respectively, it was found that

Table 4.1

TEST WELL #1

SUMMARY OF DRILLER'S LOG

Drilled 5/16/81 to 5/19/81 - By M-W Drilling

Depth (Feet)	Description
0.0 - 0.5	Fill
0.5 - 24.0	Silty Gravel with Water
24.0 - 40.0	Gravelly Silt - Dry
40.0 - 48.0	Silty Gravel - Damp
48.0 - 133.0	Silty Sand with Water - Flowing
133.0 - 172.0	Sandy Clay with Water - Flowing
172.0 - 213.0	Gravelly Sand with Water - Flowing
213.0 - 217.5	Silty Sand with Water - Flowing

Screen was installed from 182 to 200 feet and the well was surged 22½ hours. The water would not clean up. The well was pumped one-half hour at 180± gpm with a drawdown to 150 feet. The estimated sustained well capacity at this depth interval is about 100± gpm. There was an artesian leak around the casing at 75± gpm which was unaffected by pumping from the screened interval. The leak was sealed by grouting. The static water level was calculated at 79 feet above the surface.

the formations were too fine and variable in gradation to be tapped by a naturally developed well. Although a screen was set in Well #1, a period of surging did not wash the fines from the formation sufficiently to perform a meaningful pump test.

It is possible that wells of 200 to 300 gpm capacity could be developed in these formations using an artificially gravel-packed construction method. The water in these formations is of very good quality (Figure 4.2) and has a static level 79 feet above the surface at Well #1.

- Plant Site

Because of the poor water production history and relatively shallow depths to bedrock reported in the upland area, Test Well #2 to be drilled on the plant site was intended primarily to prove firsthand that significant quantities are not available in that area. The well also could verify the shallow depth to bedrock. In fact, Test Well #2 was drilled to a depth of 405 feet without encountering bedrock (Table 4.2). This is deeper than bedrock was expected based on the information reported by Magoon, Adkinson and Egbert (USGS 1978) (Figure 4.3).

Test Well #2 was located near the Congahbuna drainage so that any shallow aquifers which may be associated with that drainage could be detected, as well as any deeper formations. The well did demonstrate that approximately 15 feet of good water-bearing formation exists at the depth of 40 to 55 feet. However, it is expected that the production potential of that aquifer would be relatively insignificant, being limited by the availability of excess water in the Congahbuna drainage system. This water-bearing formation was not tested. From 328 to 395 feet, a water-bearing silty gravelly sand was encountered which has a static water level (artesian pressure) approximately 25 feet above the surface. A screen was installed in that formation and a 24-hour pump test

CHEMICAL & GEOLOGICAL LABORATORIES OF ALASKA, INC.

TELEPHONE (907)-279-4014 274-3364 — ANCHORAGE INDUSTRIAL CENTER 5633 B Street

ANALYTICAL REPORT

CUSTOMER: DOWL Engineers — SAMPLE LOCATION: Alaska

DATE COLLECTED: 6-9-81 — TIME COLLECTED: 10:00

SAMPLED BY: --- — SOURCE: Well #2

REMARKS: Beluga Methanol 6" Pipe, Filtered Sample
Artesian Flow Around Csg. — From 85'± level

FOR LAB USE ONLY
RECVD.BY: LMG — LAB #: 7818-2
DATE RECEIVED: 6-10-81
DATE COMPLETED: 6-19-81
DATE REPORTED: 6-19-81
SIGNED: *[signature]*

	mg/l		mg/l		mg/l
[]Ag,Silver	<0.05	[]P,Phosphorous	0.17	[]Cyanide	
[]Al,Aluminum	<0.05	[]Pb,Lead	<0.05	[]Sulfate	2.3
[]As,Arsenic	<0.10	[]Pt,Platinum	<0.05	[]Phenol	
[]Au,Gold	<0.05	[]Sb,Antimony	<0.10	[]Total Dissolved Solids	83
[]B,Boron	<0.05	[]Se,Selenium	<0.10	[]Total Volatile Solids	
[]Ba,Barium	<0.05	[]Si,Silicon	12	[]Suspended Solids	
[]Bi,Bismuth	<0.05	[]Sn,Tin	<0.05	[]Volatile Suspended Solids	
[]Ca,Calcium	11	[]Sr,Strontium	0.08	[]Hardness as $CaCO_3$	41
[]Cd,Cadmium	<0.01	[]Ti,Titanium	<0.05	[]Alkalinity as $CaCO_3$	64
[]Co,Cobalt	<0.05	[]W,Tungsten	<1	[]	
[]Cr,Chromium	<0.05	[]V,Vanadium	<0.05	[]	
[]Cu,Copper	<0.05	[]Zn,Zinc	<0.05	[]	
[]Fe,Iron	<0.05	[]Zr,Zirconium	<0.05	[]	
[]Hg,Mercury	<0.10	[]Ammonia Nitrogen-N		[]mmhos Conductivity	140
[]K,Potassium	1	[]Kjedahl Nitrogen-N		[]pH Units	7.5
[]Mg,Magnesium	3.4	[]Nitrate-N	<0.1	[]Turbidity NTU	
[]Mn,Manganese	<0.05	[]Nitrite-N		[]Color Units	5
[]Mo,Molybdenum	<0.05	[]Phosphorus (Ortho)-P		[]T.Coliform/100ml	
[]Na,Sodium	12	[]Chloride	3	[]	
[]Ni,Nickel	<0.05	[]Fluoride	<0.10	[]	

FIGURE 4.2 — GROUNDWATER QUALITY

Table 4.2

TEST WELL #2

SUMMARY OF DRILLER'S LOG

Drilled 5/20/81 to 5/29/81 - By M-W Drilling

Depth (Feet)	Description
0.0 - 4.0	Fill
4.0 - 20.0	Silty Gravel
20.0 - 40.0	Silty Gravel - Damp
40.0 - 54.5	Lose Gravel with Water - Blows 30gpm
54.5 - 85.0	Gravelly Clay - "Hardpan"
85.0 - 92.0	Silty, Sandy Gravel
92.0 - 293.0	Gravelly Clay with Some Boulders
293.0 - 297.0	Silty Coarse Sand with Water - Blows 3 gpm @ 293
297.0 - 328.0	Gravelly Clay
328.0 - 395.0	Silty Gravelly Sand with Water
395.0 - 405.0	Clay

Screen was installed from 355 to 385 feet and the well was surged for 21 hours, which was adequate to clean up the well. A 24-hour pump test at 149 gpm caused drawdown to 102± feet. The well was grouted at the surface (there was no artesian leak). The static level was calculated at 25± feet above the surface.

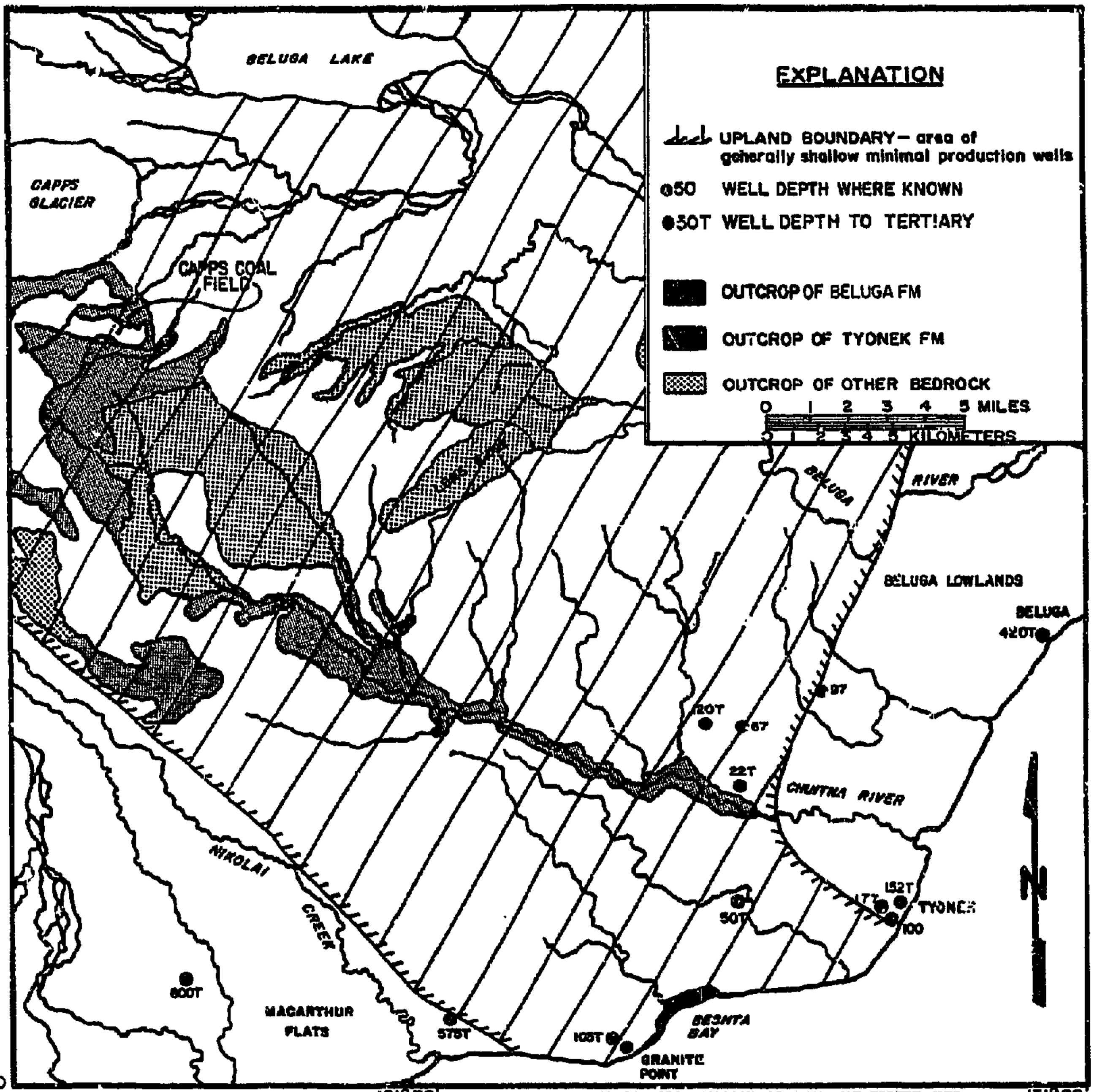


FIGURE 4.3

GRANITE POINT AREA
BEDROCK OUTCROPS AND DEPTH TO BEDROCK IN WELLS

was performed to determine the production potential. The test showed that the transmissivity (T) of the aquifer in the area is quite low (2,380 gallons per day per foot [gpd/ft]) (Figure 4.4). After 8 hours of pumping, the test also indicated that the cone of influence encountered a major impermeable boundary, reducing the effective T to about 840 gpd/ft. This formation could be used for minor intermittent demands of 100 gpm or less. It is unlikely that this water-bearing formation is extensive under the plant site location.

- Existing Uses

Small domestic wells serve the Union Oil Company and ARCO facilities at Granite Point; the Kodiak Lumber Mill camp near the North Foreland, and the Chugach Electric Association facility at Beluga. None of these wells is near enough the proposed project to be influenced by withdrawals there. Other than these wells, the groundwater resources in the Beluga region are virtually untapped

SURFACE WATER

Existing Sources

- Lakes

Numerous shallow lakes dot the landscape between the Beluga River to the north and the Chakachatna River to the south (Figure 4.5). Of these, the largest is Congahbuna Lake located just north of the proposed plant site. Some consideration was given to the possible use of Congahbuna as a source of cooling water. A summary of the known information about the lakes of the Beluga region is contained in Table 4.3. Additional information on many of these lakes is being gathered as part of an ongoing field program.

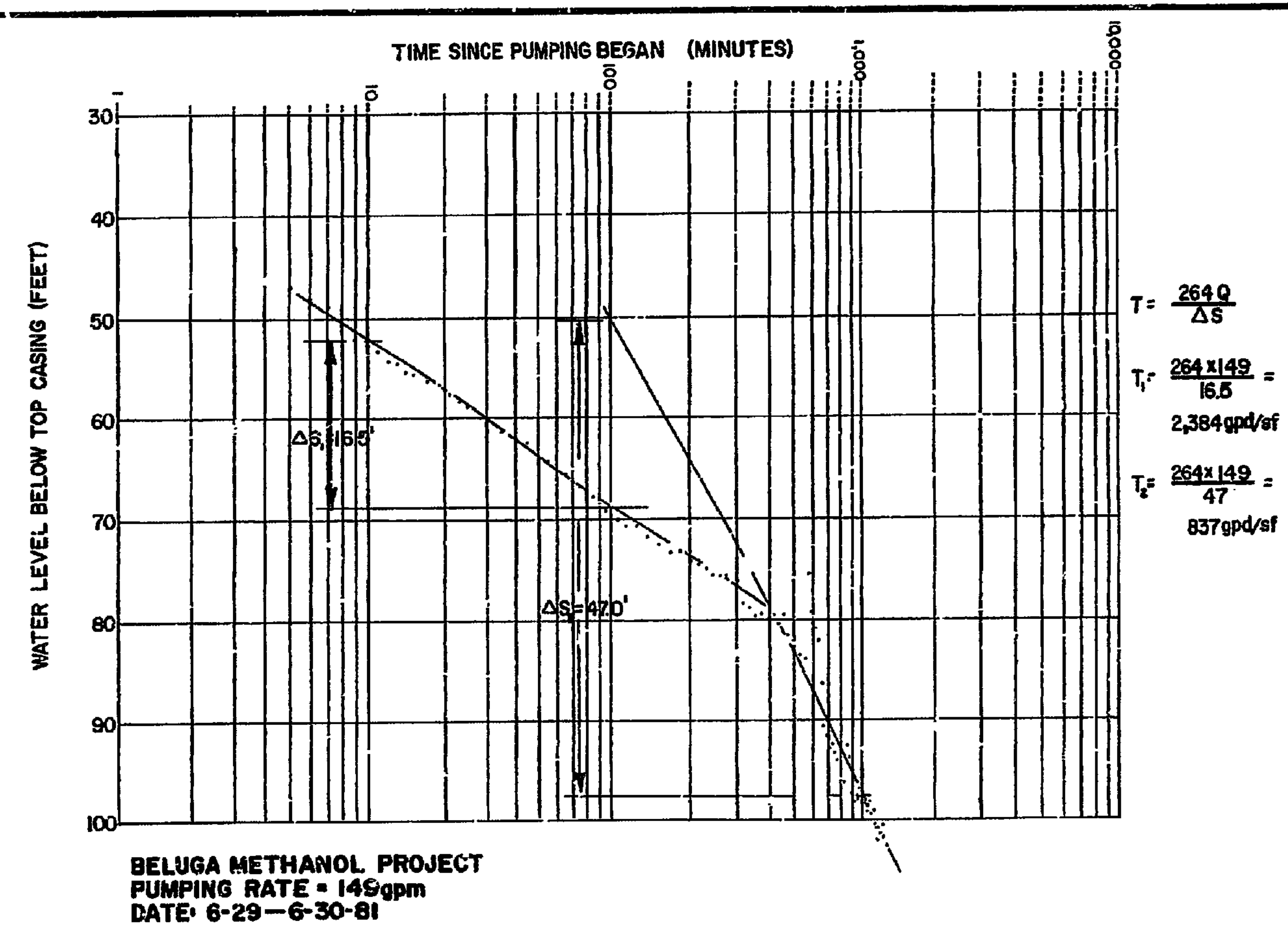


FIGURE 4.4 PUMP TEST OF WELL #2

Table 4.3

LAKES OF THE BELUGA REGION

Name	Location	Area (mi.^{2})	Area (Acres)	Chemical & Physical Characteristics: Date	Temp (°C)	pH	DO mg/ℓ	CaCO mg/ℓ	Secchi depth	Test Netting Results		Other
Ashley Lake	61°8', 151°11'	00.07	44.8									
Beluga Lake	61°24', 151°36'	16.97	10,860.8									
Bishop Lake	61°19', 151°25'	00.18	115.2	6/12/75	11	6.7	17	17.1	12.5'	Rainbow Dollies	3 1	
Bunka Lake	61°4', 151°10'	00.06	38.4									
Chuitbuna Lake	61°7', 151°9'	00.18	115.2									
Cindy Lake	61°8', 151°12'	00.06	38.4									
Congahbuna Lake	61°4', 151°25'	00.40	256.0	7/18/81	15.2	6.2	10.0					
Denslow Lake	61°14', 151°21'	00.03	19.2									
Erin Lake	61°13', 151°19'	00.07	44.8	7/18/81	15.4	6.4	9.4					Depth 3.2 feet
Fell Lake	61°16', 151°18'	00.20	128.0									
Guy Lake	61°10', 151°17'	00.05	32.0									
Jean Lake	61°17', 151°21'	00.08	51.2									
Kaldachbuna Lake	61°3', 151°14'	00.21	134.4									
Lower Beluga Lake	61°21', 151°21'	01.88	1,203.2									
Mad Lake	61°7', 151°34'	00.04	25.6									

Table 4.3
Continued

LAKES OF THE BELUGA REGION

Name	Location	Area (mi.^{2})	Area (Acres)	Chemical & Physical Characteristics: Date	Temp (°C)	pH	DO mg/ℓ	CaCO mg/ℓ	Secchi depth	Test Netting Results	Other
Priscilla Lake	61°20', 151°27'	00.09	57.6								
Roberta Lake	61°5', 151°31'	00.12	76.8	7/18/81	15.1	6.0	9.0				Depth 3.0 feet
Scott Lake	61°7', 151°12+'	00.05	32.0								
Second Lake	61°5', 151°9+'	00.07	44.8								
Theresa Lake	61°10', 151°17'	00.05	32.0								
Third Lake	61°5', 151°10+'	00.03	19.2								
Tukallah Lake	61°8', 151°7'	00.14	89.6								
Viapan Lake	61°7', 151°6'	00.30	192.0								
Vicky Lake	61°3', 151°24'	00.13	83.2	7/18/81	15.8	6.2	9.2				Depth 5.5 feet
Marie Lake		00.06	38.4								

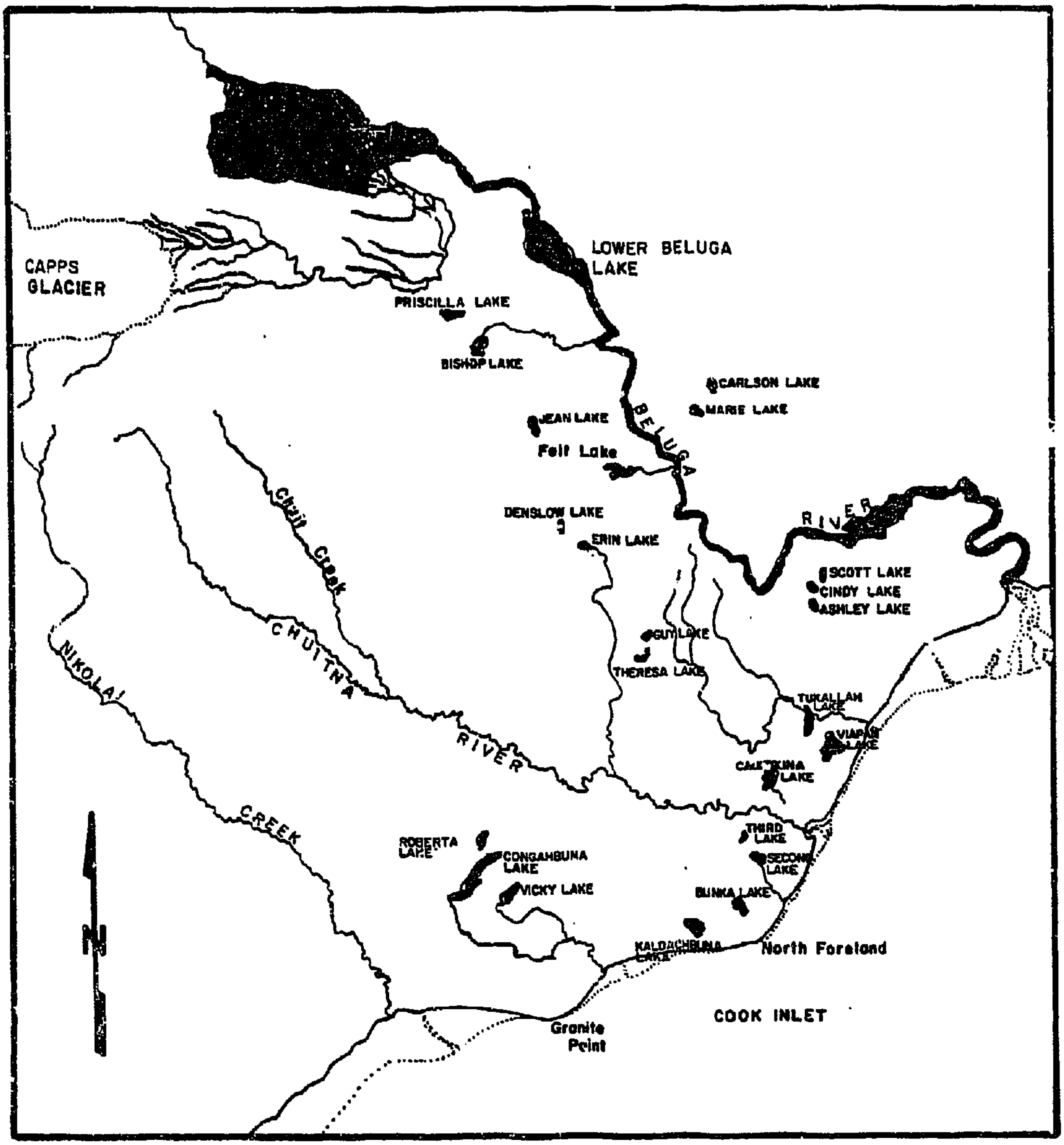


FIGURE 4.5	LAKES OF BELUGA AREA

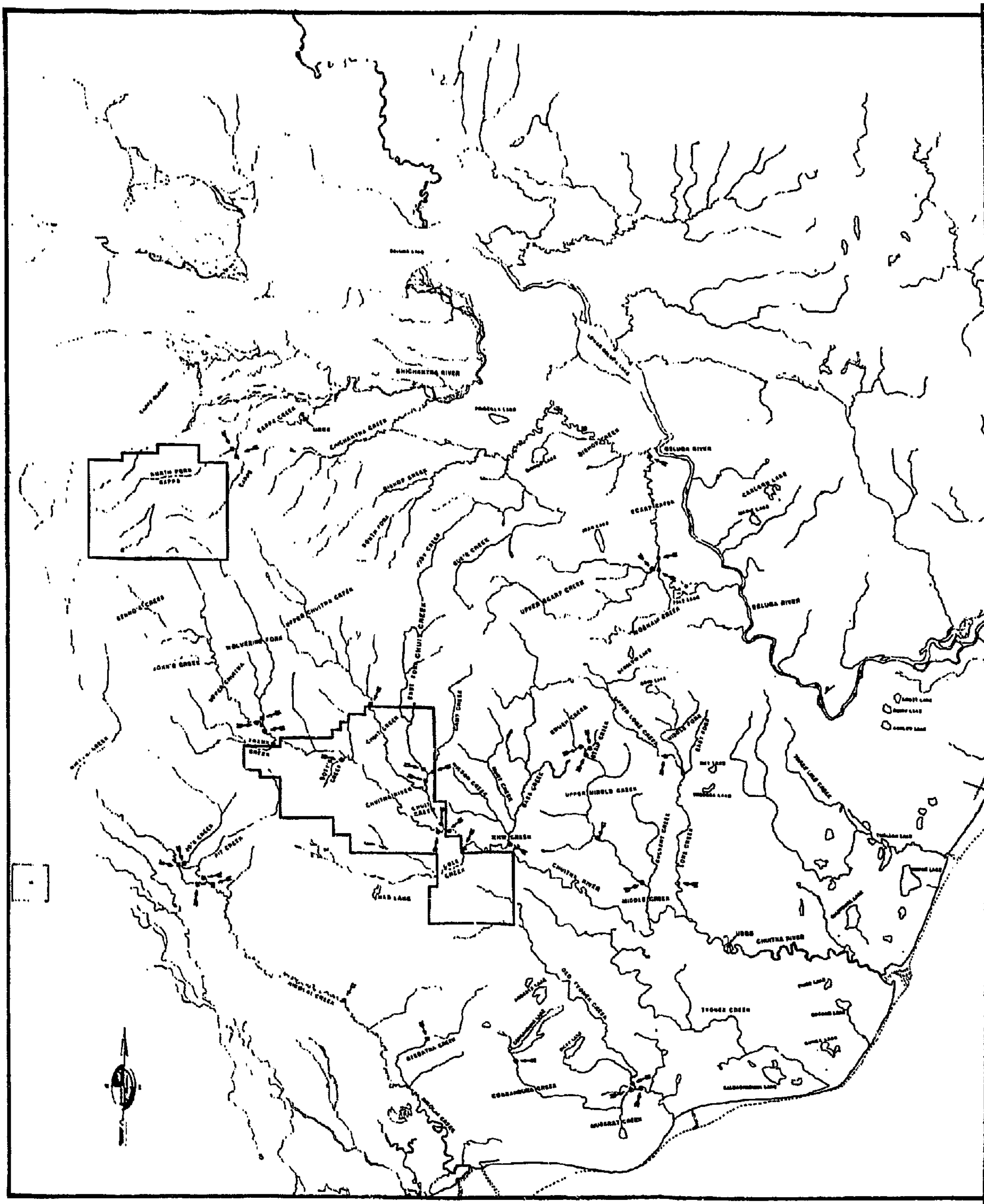
- ## Streams and Rivers

The most important properties of surface water are amount, chemical quality, suspended sediment content, and temperature. With few exceptions, data on surface water in the region is generally sparse.

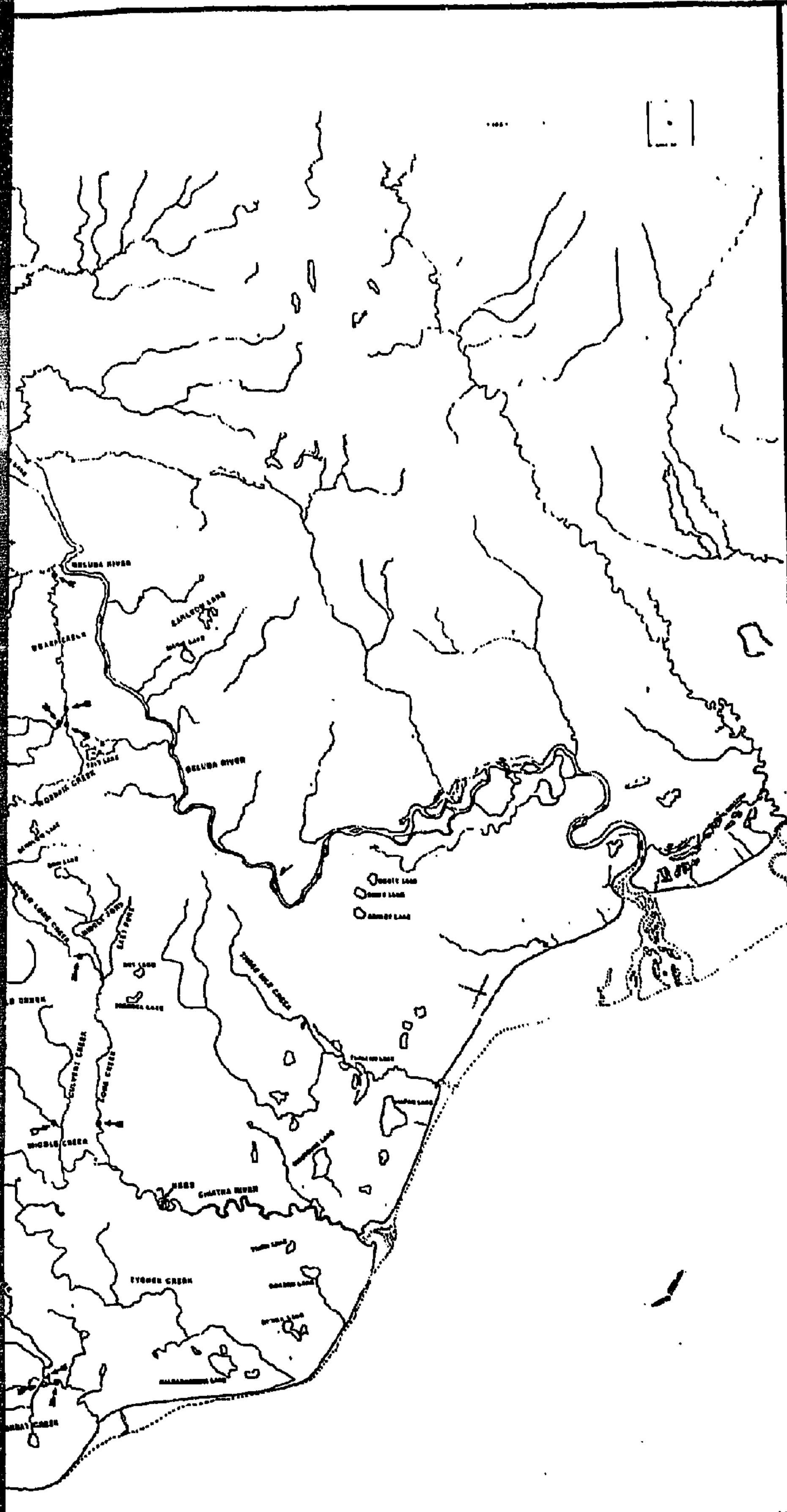
While it is the Chuitna River that most likely would be directly affected by the project, the total project area includes several drainage systems including the Beluga, Chuitna and Nikolai. As part of the 1980-81 field program, staff gauges have been installed at numerous locations (Figure 4.6) and various measurements have been taken of discharge, water chemistry, and sediment content. Selected data on stream and river systems is shown in Table 4.4; stream flow data is shown in Table 4.5; selected discharge measurements are shown in Table 4.6; summary data on suspended solids is shown in Table 4.7; and selected water quality data is shown in Tables 4.8 through 4.11.

The current field program will permit the generation of rating curves for the various staff gauge locations and provide a first look at overall contributions of tributaries and groundwater flows to major stream courses. An example of such a rating curve for one stream is shown in Figure 4.7. Precipitation data and additional discharge measurements would be required before the hydrology of the region can be more accurately described.

Additionally, two sites (Nikolai Creek and Upper Chuit Creek) are being monitored for stream temperature and flows on an experimental basis using portable data recorders linked to temperature and pressure probes. If successful, this program expanded throughout the area of interest would permit a more detailed assessment of the hydrologic balance since simultaneous measurements throughout each of the drainage areas could be available. An example of the type of data being recovered from this program is shown in Figure 4.8.



BELUGA RIVER
CHICHANTNA RIVER
CHUITNA RIVER
UPPER MIDDLE CREEK
MIDDLE CREEK
TYONEK CREEK
MUSKRAT CREEK



LEGEND

- STAFF GAUGE
- OTHER STATIONS
- USGS

STAFF GAUGE LOCATIONS - BELUGA REGION

FIGURE 4.6

Table 4.4

SELECTED DATA ON STREAM AND RIVER SYSTEMS

NAME	Approximate Drainage Area (sq. mi.)	Approximate Length (mi.)	Estimated Annual Runoff (1000 acre ft.)	Estimated Flow (cu. ft./sec.)	Approximate Slope (ft./mi.)	Point of Discharge	Notes
BELUGA DRAINAGE							
Beluga River		28.8			9	Cook Inlet	
Chichantna River		13.5			23	Beluga River	
Capps Creek		3.5			71	Chichantna River	
North Fork Capps Crk		4 7			410	Capps Creek	
South Fork Capps Crk		5.4			335	Capps Creek	
Chichantna Creek		6.3			167	Chichantna River	
Bishop Creek		9.1			38	Beluga River	
North Fork Bishop Crk		5.0			190	Bishop Creek	
South Fork Bishop Crk		3.0			275	Bishop Creek	
Judy Creek		5.5			137	Sue's Creek	
Sue's Creek		7.6			128	Bishop Creek	
Scarp Creek		7.6			79	Bishop Creek	
Upper Scarp Creek		7.7			156	Wobnair Creek	
Wobnair Creek		4.2			83	Scarp Creek	
CHUITNA DRAINAGE							
Chuitna River		24.5			57	Cook Inlet	
Lone Creek		4.6			43	Chuitna River	
East Fork Lone Creek		2.2			34	Lone Creek	
Middle Fork Lone Crk		3.7			89	Lone Creek	
Upper Lone Creek		6.6			68	Lone Creek	
Middle Creek		1.0			75	Chuitna River	
Culvert Creek		3.6			35	Middle Creek	
Upper Middle Creek		7.4			51	Middle Creek	
Strip Creek		1.4			71	Upper Middle Crk	
Brush Creek		1.7			162	Upper Middle Crk	
BHW Creek		2.2			193	Chuitna River	
Bass Creek		7.2			125	BHW Creek	
Hunt Creek		4.1			146	Bass Creek	
Wilson Creek		2.1			298	BHW Creek	
Cole Creek		5.6			134	Chuitna River	

Table 4.4
Continued

SELECTED DATA ON STREAM AND RIVER SYSTEMS

NAME	Approximate Drainage Area (sq. mi.)	Approximate Length (mi.)	Estimated Annual Runoff (1000 acre ft.)	Estimated Flow (cu. ft./sec.)	Approximate Slope (ft./mi.)	Point of Discharge	Notes
CHUITNA DRAINAGE Cont.							
Chuit Creek		8.6			94	Chuitna River	
Camp Creek		4.0			181	E. Fork Chuit Crk	
East Fork Chuit Creek		6.1			107	Chuit Creek	
Upper Chuit Creek		4.5			22	Chuit Creek	
Bolt's Creek		1.2			375	Chuitna River	
Frank Creek		3.6			139	Chuitna River	
Upper Chuitna River		6.9			29	Chuitna River	
John's Creek		1.9			263	Upper Chuitna Riv	
Benno's Creek		3.6			194	Upper Chuitna Riv	
Wolverine Fork		6.1			98	Upper Chuitna Riv	
NIKOLAI DRAINAGE							
Nikolai Creek		27.9			97	Cook Inlet	
Stedatna Creek		4.6			115	Nikolai Creek	
Pit Creek		4.7			287	Nikolai Creek	
Jo's Creek		5.0			280	Nikolai Creek	
OTHER DRAINAGES							
Old Tyonek Creek		9.9			81	Cook Inlet	
Congahbuna Creek		4.6			69	Old Tyonek Creek	
Muskrat Creek		.8			94	Congabuna Creek	
Tyonek Creek		12.9			54	Cook Inlet	
Indian Creek		1.4				Cook Inlet	
Three Mile Creek		7.7			52	Cook Inlet	
S. Fork Three Mile Crk		8.8			34	Three Mile Creek	

Table 4.5

STREAM FLOW DATA (SELECTED STATIONS)
Point Discharge Measurement, Cubic Feet per Second (cfs)

Station No.	Stream Gage Location	Latitude	Longitude	Nov.	May	June	July	Aug.	Sept.	Oct.
1	North Capps	61°19'05"	151°40'54"	17.3		99.9	--			
2	Capps Creek	61°19'00"	151°40'43"	16.4		134.7	--			
3	Chuitna River below Wolverine Fork	61°12'00"	151°39'15"	64.0		375.9	140.82			
4	Wolverine Fork	61°12'05"	151°39'17"	14.8		99.3	27.25			
5	Chuitna River above Wolverine Fork	61°12'03"	151°39'28"	45.1		272.5	100.81			
6	Congahbuna Creek above Old Tyonek Creek	61°02'45"	151°20'27"	10.6	17.2	6.9	32.0			
7	Old Tyonek Creek above Congahbuna Creek	61°02'48"	151°20'27"	21.7	70.4	15.1	79.15			
8	Old Tyonek Creek below Congahbuna Creek	61°02'43"	151°20'21"	33.1	88.9	17.5	121.57			
9	Congahbuna Creek, below Congahbuna Lake	61°03'18"	151°26'53"	5.8	13.1	3.8[1] 2.8[5]	9.97			
10	Stedatna Creek at Culvert	61°04'08"	151°30'59"	5.0	16.7	2.9	28.21			
11	Nikolai Creek at Bridge	61°05'05"	151°35'54"	152.8	136.0 204.7[5]	245.5[1]	--			
12	Upper Chuit Creek	61°12'44"	151°33'54"	27.3		155.3	91.17			

Table 4.5
Continued

STREAM FLOW DATA (SELECTED STATIONS)
Point Discharge Measurement, Cubic Feet per Second (cfs)

Station No.	Stream Gage Location	Latitude	Longitude	Nov.	May	June	July	Aug.	Sept.	Oct.
13	Chuit Creek Mouth	61°09'18"	151°30'11"	42.0	56.4	271.9	58.40			
14	Chuitna River below Chuit Creek	61°09'17"	151°30'06"	116.2	163.1		209.87			
15	Chuitna River above Chuit Creek	61°09'16"	151°30'11"	72.8	100.0 (est.)	500.0 (est.)	167.39			
16	BHW Creek Mouth	61°09'00"	151°26'40"		76.5	24.2	24.28			
17	Lower Lone Creek	61°07'51"	151°17'57" (est.)		275.0	26.8	--			
18	Upper Lone Creek	61°11'15"	151°18'34"		80.2	12.5	12.99			
19	Cole Creek Mouth	61°08'46"	151°29'16"		58.7	9.6	59.46			
20	Pit Creek	61°07'58"	151°42'25"		43.3	12.9	8.75			
21	Nikolai Creek above Pit Creek	61°07'51"	151°42'30"		97.2	45.6	23.35			
22	Nikolai Creek below Pit Creek	61°07'51"	151°42'17"		136.9	57.4	28.94			
23	Jo's Creek	61°08'15"	151°43'33"		19.9	30.3	8.32			
24	Nikolai Creek Above Jo's Creek	61°08'15"	151°43'40"		73.1	18.0	15.99			
25	Brush Creek	61°11'32"	151°22'45"			2.5	4.15			

Table 4.5
Continued

STREAM FLOW DATA (SELECTED STATIONS)
Point Discharge Measurement, Cubic Feet per Second (cfs)

Station No.	Stream Gage Location	Latitude	Longitude	Nov.	May	June	July	Aug.	Sept.	Oct.
26	Strip Creek	61°11'28"	151°22'41"			1.5	1.74			
27	Upper Middle Creek	61°11'24"	151°22'46"			4.2	5.62			
28	East Fork Chuit above Camp Creek	61°10'53"	151°30'29"			68.8	15.57			
29	Camp Creek	61°10'49"	151°30'22"			11.8	5.82			
30	East Fork Chuit below Camp Creek	61°10'45"	151°30'25"			78.3	18.61			
31	Middle Creek near Lease Boundary	61°09'27"	151°22'35"			11.3	16.43			
32	Scarp Creek Mouth	61°19'00"	151°19'33"			46.8	106.18			
33	Wobnair Creek	61°16'03"	151°19'01"			4.8	18.42			
34	Scarp Creek above Wobnair Creek	61°16'03"	151°19'12"			31.2	66.33			
35	Scarp Creek below Wobnair Creek	61°16'07"	151°19'06"			38.2	86.97			
36	Frank Creek	61°11'33"	151°38'55"				67.63			
37	Bolts Creek	61°11'10"	151°25'18"				5.7			

Table 4.6

SELECTED DISCHARGE DATA
Cubic Feet per Second (cfs)

Station No.	Description	Water Year or Date	Drainage Area (sq. mi.)	Total Discharge (cfs)	Mean Discharge (cfs)	Maximum Discharge (cfs)	Minimum Discharge (cfs)	Comment
	Chuitna River (USGS gauge near Tyonek - 160 ft. above sea level)	1979	131	147716	405	2370	45	

From USGS 1980: Period of record from October 1975.

Table 4.7

SUMMARY DATA ON SUSPENDED SOLIDS

Point Sample, Single Day Observation (mg/ℓ)

Station No.	Description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Notes
1	North Capps Creek						41.0	--				2.5		
2	Capps Creek						480.0	--						
3	Chuitna River below Wolverine Fork						11.0	5.0						
4	Wolverine Fork						14.0	1.7 3.3				1.0		
5	Chuitna River above Wolverine Fork						12.0	8.5				21.3		
6	Congahbuna Creek above Old Tyonek Creek					3.2	0.65	3.3				8.4		
7	Old Tyonek Creek above Congahbuna Creek					19.0	2.[illegible]	6.3				4.7		
8	Old Tyonek Creek below Congahbuna Creek					13.0	2.2	7.3						
9	Congahbuna Creek below Congahbuna Lake						4.0	8.5						
10	Stedatna Creek @ Culvert					8.4	1.1	2.2				1.9		
11	Nikolai Creek @ Bridge					19.0	5.9							
12	Upper Chuit Creek						8.2	2.2				2.0		
13	Chuit Creek Mouth					3.6	10.0					3.6		

Table 4.7
Continued

SUMMARY DATA ON SUSPENDED SOLIDS

Point Sample, Single Day Observation (mg/ℓ)

Station No.	Description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Notes
14	Chuitna River below Chuit Creek							18.0						
15	Chuitna River above Chuit Creek						22.0	32.0						
16	BHW Creek Mouth						1.3	3.7						
17	Lower Lone Creek						2.7	2.1						
18	Upper Lone Creek					26.0	1.6	5.9						
19	Cole Creek Mouth						.42	1.3						
20	Pit Creek					180.0	7.5	2.6						
21	Nikolai Creek above Pit Creek				(5/5) (5/4)	36.0 150.0	11.0	8.0						
22	Nikolai Creek below Pit Creek				(5/5) (5/4)	36.0 130.0	13.0	9.8						
23	Jo's Creek					25.0	9.4	3.0						
24	Nikolia Creek above Jo's Creek					49.0	11.0	9.6						
25	Brush Creek							3.1						
26	Strip Creek						72.0	110.0						

Table 4.7
Continued

SUMMARY DATA ON SUSPENDED SOLIDS

Point Sample, Single Day Observation (mg/ℓ)

Station No.	Description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Notes
27	Upper Middle Creek							--						
28	East Fork Chuit above Camp Creek							.8						
29	Camp Creek						2.8	1.4						
30	East Fork Chuit below Camp Creek						1.8	.5						
31	Middle Creek near Lease Boundary							9.1						
32	Scarp Creek Mouth						36.0	71.0						
33	Wobnair Creek						7.7	--						
34	Scarp Creek above Wobnair Creek							6.3						
35	Scarp Creek below							6.0						
36	Frank Creek							8.7						
37	Botts Creek							4.4						

Table 4.8

SELECTED WATER QUALITY DATA, NOVEMBER 1980

Point Sample, Single Day Observation

Station No.	Description	Total Dissolved Solids (mg/ℓ)	Total Suspended Solids (mg/ℓ)	pH	Total Dissolved Iron (mg/ℓ)	Total Manganese (mg/ℓ)
	Capps Creek (South Fork)	27.0	35.0		0.19	<0.05
	Chuitna River (below Wolverine)	28.0	5.4		ND	<0.05

Table 4.9

SELECTED WATER QUALITY DATA, MAY 1981

Point Sample, Single Day Observation

Station No.	Description	Total Dissolved Solids (mg/ℓ)	Total Suspended Solids (mg/ℓ)	pH	Total Dissolved Iron (mg/ℓ)	Total Manganese (mg/ℓ)
	Jo's Creek	50.0	19.0		0.38	<0.05
	Cole's Creek	21.0	16.0		1.10	0.08
	Pit Creek	44.0	46.0		0.46	<0.05
	BHW Creek	29.0	6.6		1.30	<0.05
	Chulitna (below Chuit)	33.0	25.0		1.20	<0.05

Table 4.10

SELECTED WATER QUALITY DATA JUNE, 1981

Point Sample, Single Day Observation

Station No.	Description	Total Dissolved Solids (mg/ℓ)	Total Suspended Solids (mg/ℓ)	pH	Total Dissolved Iron (mg/ℓ)	Total Manganese (mg/ℓ)
	Brush Creek	63.0	2.2		1.7	0.05
	Strip Creek	94.0	45.0		1.6	0.17
	Scarp Creek	54.0	7.3		0.70	0.05
	Beluga River	72.0	34.0		1.9	0.06

Table 4.11

SELECTED WATER QUALITY DATA JULY, 1981

Point Sample, Single Day Observation

Station No.	Description	Total Dissolved Solids (mg/ℓ)	Total Suspended Solids (mg/ℓ)	pH	Total Dissolved Iron (mg/ℓ)	Total Manganese (mg/ℓ)
	Chuitna Creek	27.0	2.2	7.1	.28	<0.05
	Strip Creek	45.0	15.0	7.0	.81	0.07
	Brush Creek	51.0	7.0	6.9	.77	<0.05

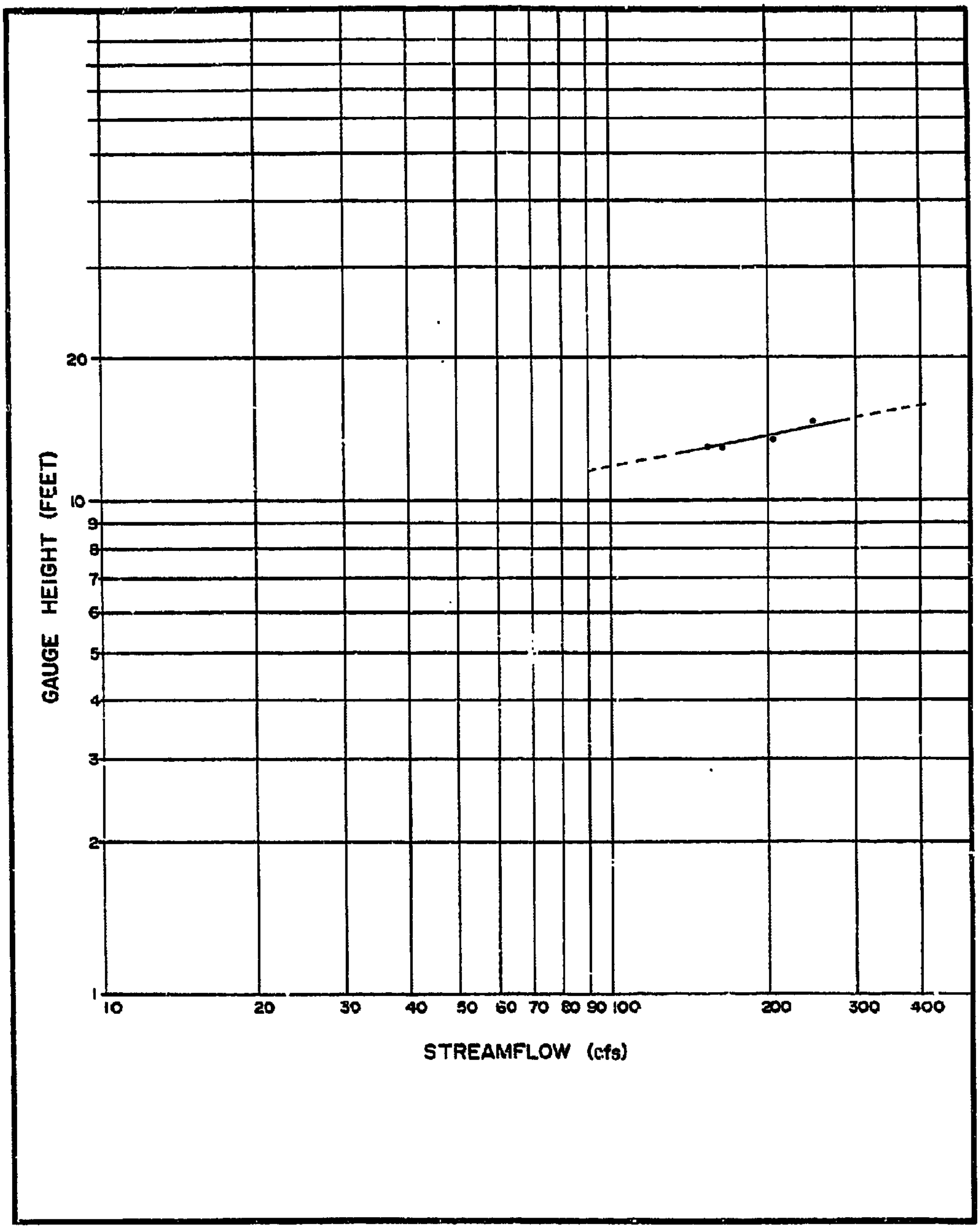


FIGURE 4.7 RATING CURVE FOR NIKOLAI CREEK (BRIDGE)

BELUGA HYDROLOGY STUDY
PREPARED BY DRYDEN & LARUE FOR DOWL ENGINEERS

PAGE 1
10-AUG-81

NIKOLAI CREEK   START TIME 06/03/81 12:00   (NIK064.POD)

DATE	TIME	PRESSURE-INCHES H2O AVG	MIN	MAX	TEMPERATURE-DEG C AVG	MIN	MAX	STREAM GUAGE READING (FT)	FLOW (cfs)
06/03/81	12:00	15.8	0.7	17.5	9.0	6.5	20.5		
06/03/81	16:00	14.4	13.4	15.1	6.5	6.0	6.5		
06/03/81	20:00	12.7	12.0	13.4	6.0	6.0	6.0		
06/03/81	24:00	11.6	11.3	12.0	6.0	6.0	6.0	13.75	205*
06/04/81	04:00	11.6	11.3	12.0	6.0	6.0	6.0		
06/04/81	08:00	12.3	12.0	12.7	6.0	6.0	6.0		
06/04/81	12:00	12.7	12.3	13.0	6.0	6.0	6.0		
06/04/81	16:00	11.6	11.0	12.3	6.5	6.0	6.5		
06/04/81	20:00	10.6	9.9	11.0	6.5	6.5	6.5		
06/04/81	24:00	9.9	9.6	9.9	6.5	6.5	6.5		
06/05/81	04:00	10.3	9.9	10.6	6.0	6.0	6.5		
06/05/81	08:00	11.0	10.3	11.3	6.0	6.0	6.0		
06/05/81	12:00	11.6	11.3	11.6	6.0	6.0	6.0	13.70	205**
06/05/81	16:00	11.0	10.3	11.3	6.0	6.0	6.5		
06/05/81	20:00	9.6	9.3	10.3	7.0	6.5	7.0		
06/05/81	24:00	9.3	8.9	9.3	7.0	7.0	7.0		

* from rating curve
** measured

FIGURE 4.8 TYPICAL DATA RECOVERED FROM *DATAPOD* EXPERIMENT (NIKOLAI CREEK)

The existing field program is being expanded to include more *in situ* water chemistry so that temperature, pH, dissolved oxygen, and conductivity measurements will be made each time a discharge measurement is taken or a stream gauge reading is made. A typical chemical analysis for one station on one day is shown in Figure 4.9.

Following the completion of the 1981 field program an evaluation of the program will be made and a scope-of-work for 1982 will be prepared. This scope-of-work will be coordinated with other field programs including the collection of climatic data and the initial analysis of groundwater with particular reference to the proposed mine areas.

Water quality for existing wells has been compared to that of the Chuitna River (Table 4.12). Additionally, sediment samples of numerous alluviums have been analyzed (Table 4.13).

Possible Use of Surface Waters

Congahbuna Lake has a surface area of some 256 acres with an average depth of some 6 feet (maximum depth of 16 feet). The size of this lake suggests that some consideration could be given to using the lake for a cooling pond to provide natural cooling of the thermal discharge from the plant. The impact on existing fisheries would obviously have to be carefully weighed. The lake would provide a holding time of approximately 25 hours assuming a 330,000 gpm discharge from the plant (lake volume is approximately 500 million gallons). The plant discharge would be 95°F. Analysis indicates that the surface area of the lake is not sufficient to provide cooling by natural means comparable to that which can be achieved by cooling towers.

Natural mechanisms that tend to dissipate heat from water surfaces would cool the thermal discharges to only 81°F in the colder winter

CHEMICAL & GEOLOGICAL LABORATORIES OF ALASKA, INC.

TELEPHONE (907) 279-4014 274-3364 ANCHORAGE INDUSTRIAL CENTER 5633 B Street

ANALYTICAL REPORT

CUSTOMER DOWL Engineers SAMPLE LOCATION: Alaska

DATE COLLECTED 5-5-81 TIME COLLECTED: 1315 Hrs.

SAMPLED BY EWT SOURCE Jo's Creek

REMARKS DOWL Engineers - Beluga Methanol Project ATTN: rrd

FOR LAB USE ONLY

RECVD. BY GY LAB # 7432-

DATE RECEIVED 5-6-81

DATE COMPLETED 5-18-81

DATE REPORTED 5-18-81

SIGNED [signature]

	mg/l		mg/l		mg/l
[] Ag, Silver	<0.05	[] P, Phosphorous	<0.05	[] Cyanide	
[] Al, Aluminum	0.33	[] Pb, Lead	<0.05	[] Sulfate	<1
[] As, Arsenic	<0.01	[] Pt, Platinum	<0.05	[] Phenol	
[] Au, Gold	<0.05	[] Sb, Antimony	<0.10	[] Total Dissolved Solids	50
[] B, Boron	<0.05	[] Se, Selenium	<0.01	[] Total Solids	69
[] Ba, Barium	<0.05	[] Si, Silicon	10	[] Suspended Solids	19
[] Bi, Bismuth	<0.05	[] Sn, Tin	<0.10	[] Volatile Suspended Solids	
[] Ca, Calcium	2.5	[] Sr, Strontium	<0.05	[] Hardness as $CaCO_3$	17
[] Cd, Cadmium	<0.01	[] Ti, Titanium	<0.05	[] Alkalinity as $CaCO_3$	18
[] Co, Cobalt	<0.05	[] W, Tungsten	<0.05	[] Beryllium	<0.02
[] Cr, Chromium	<0.05	[] V, Vanadium	<0.05	[]	
[] Cu, Copper	<0.05	[] Zn, Zinc	<0.05	[]	
[] Fe, Iron	0.38	[] Zr, Zirconium	<0.05	[]	
[] Hg, Mercury	<0.001	[] Ammonia Nitrogen-N	<0.05	[] mmhos Conductivity	
[] K, Potassium	<1	[] Organic Nitrogen-N	0.58	[] pH Units	
[] Mg, Magnesium	2.3	[] Nitrate-N	1.8	[] Turbidity NTU	2.2
[] Mn, Manganese	<0.05	[] Nitrite-N	<0.01	[] Color Units	20
[] Mo, Molybdenum	<0.05	[] Phosphorus (Ortho)-P	<0.05	[] T. Coliform/100ml	
[] Na, Sodium	2.4	[] Chloride	<1.0	[]	
[] Ni, Nickel	<0.05	[] Fluoride	<0.10	[]	

FIGURE 4.9 TYPICAL SURFACE WATER QUALITY ANALYSIS

Table 4.12

WATER QUALITY COMPARISON
GROUNDWATER & CHUITNA RIVER

	Parameter	#1 Well Pad	#4 Chuitna River	#3 Beluga Station
		(Concentration mg/ℓ)		
Dissolved Species	Bicarbonate	390.0	77.0	112.0
	Calcium	89.0	6.4	8.9
	Chloride	2.4	0.1	6.3
	Copper	0.001	0.002	0.004
	Fluoride	0.2	0.1	0.2
	Iron	6.2	0.4	1.5
	Lead	0	0.003	0
	Magnesium	16.0	3.8	4.6
	Manganese	1.1	0.09	0.06
	Potassium	7.6	1.5	2.7
	Silica	39.0	18.0	54.0
	Sodium	13.0	15.0	27.0
	Sulfate	2.2	2.9	8.9
	Total Hardness	290.0	32.0	41.0
	Corrosion Index*	0.02	0.05	0.20

*me/ℓ (Cl^- + SO_4^{2-}), Greater than 0.1 indicates corrosive tendency.
me/ℓ (Alkalinity as $CaCO_3$)

Table 4.13

SEDIMENT SAMPLES ANALYSES

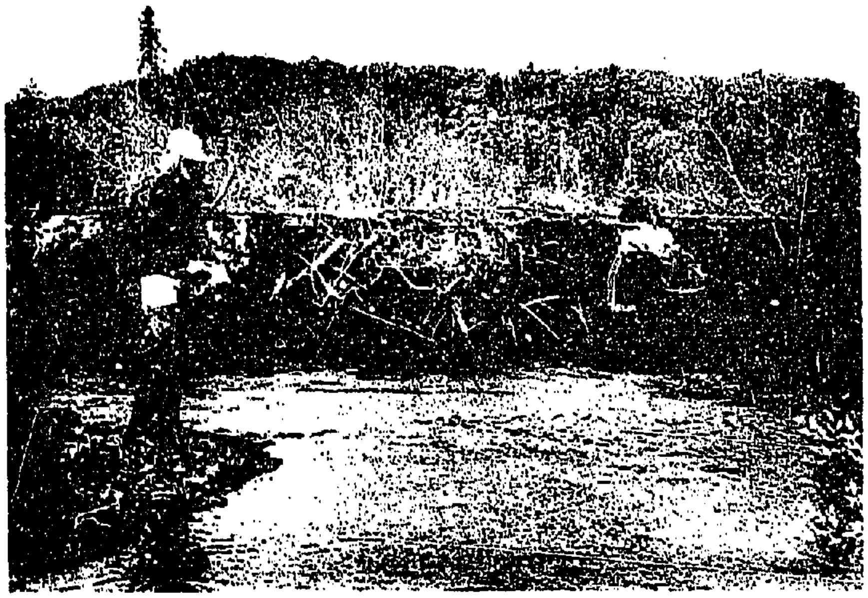
	Coarse Sand %	Medium Sand %	Fine Sand %	Silt %
1. Alluvium, Chultna River, below Wolverine Fork	25	60	10	5
2. Tertiary sediments in valley wall, Chultna River below Wolverine Fork	40	30	25	5
3. Alluvium, Chuit Creek, just above Chuitna coal lease area	40	50	7	3
4. Tertiary sediments in valley wall, Chuit Creek just above lease area	20	20	50	10
5. Alluvium, Chuit Creek, near junction of Chuitna River	65*	30**	4***	1
6. Alluvium, Capps Creek, near junction of North Capps Creek	5	50	40	5
7. Sand dune, above Tertiary sediments in valley wall, North Capps Creek near junction with Capps Creek	30	30	30	10
8. Alluvium, Stedatna Creek, in canyon below logging road	50	20	25	5
9. Unconsolidated deposits, valley wall above Stedatna Creek in canyon	20	15	50	15
10. Alluvium, Congahbuna Creek, at logging road crossing below lake	60	20	17	3
11. Alluvium, Congahbuna Creek, near junction with Old Tyonek Creek	50	30	15	5
12. Alluvium, Old Tyonek Creek, near junction with Congahbuna Creek	40	25	32	3
13. Alluvium, Nikolai Creek, at logging road bridge	55	30	14	1
14. Beach sand, Nikolai Creek, at logging road bridge	--	10	80	10

Coarse Sand = 0.02 - 0.08 inches diameter
Medium Sand = 0.01 - 0.02 inches diameter
Fine Sand = 0.0025 - 0.01 inches diameter
Silt = less than 0.0025 inches diameter

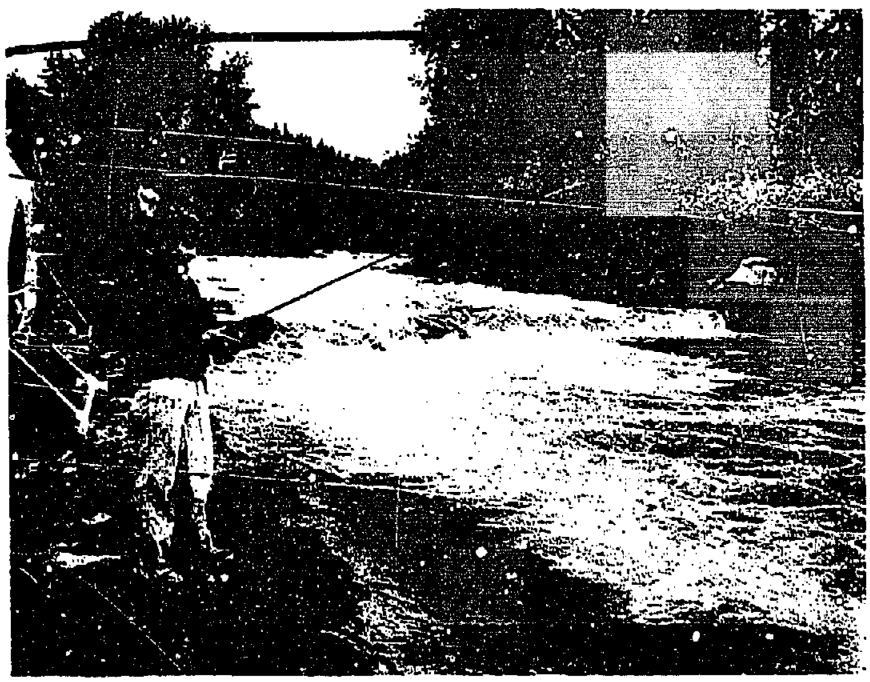
* Mainly quartz, lesser feldspar and dark minerals, angular to subround
** Mainly quartz
*** Mainly quartz and feldspar

months and to only 87°F in the colder winter months and to only 87°F in the warmest months. Spray coolers to provide for additional cooling do not appear to be cost effective when compared to the cooling towers. To provide the same degree of cooling as can be achieved by the proposed cooling towers would require a lake surface area of approximately 1,000 acres, nearly four times the area of Congahbuna Lake.

Further consideration should be given to developing a plant water source from Nikolai Creek in the vicinity of its junction with Stedatna Creek. An infiltration gallery in this location could conceivably provide adequate water to the plant without any impact on the upstream fishery.



Lone Creek



Chuitna River

BELUGA FIELD PROGRAM 1981