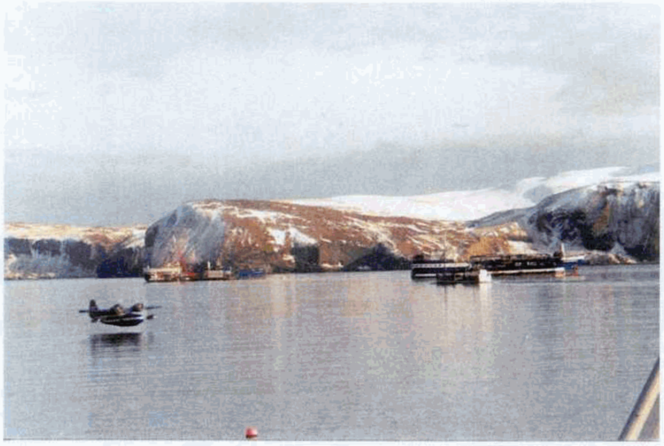
US Army Corps of Engineers
Alaska District

Navigation Improvements Interim Feasibility Report Appendixes

Vol II



Akutan, Alaska

July 2004

APPENDIX A
HYDRAULIC DESIGN
NAVIGATION IMPROVEMENTS
AKUTAN, ALASKA

CONTENTS

INTRODUCTION ---- 4
1.1. Purpose ---- 4
1.2. Project Background/Purpose and Need ---- 4
1.3. Use of English Units ---- 5
2.0 CLIMATOLOGY AND HYDROLOGY ---- 7
2.1. Climatology ---- 7
2.1.1. Precipitation ---- 7
2.1.2. Snowfall ---- 9
2.1.3. Temperature ---- 9
2.1.4. Unalaska Data ---- 10
2.1.5. Wind ---- 11
2.2. Hydrology ---- 13
2.2.1. Tides ---- 13
2.2.2. Storm Surge ---- 14
2.2.3. Wave Setup ---- 16
2.2.4. Design High Water Level ---- 16
2.2.5. Currents ---- 16
2.2.6. Fresh Water Input ---- 17
2.2.7. Icing in the Proposed Harbor ---- 17
3.0 WAVE CLIMATE ---- 19
3.1. Local Wave Generation ---- 19
3.1.1. Analysis by ACES Method. ---- 19
3.1.2. Analysis by STWave Method. ---- 21
3.2. Waves of Non-local Origin ---- 21
3.3. Wave Summary and Design Wave ---- 24
4.0 SEDIMENTATION ANALYSIS ---- 25
4.1. Existing Environment ---- 25
4.2. Longshore Transport ---- 25
4.3. Effects of a Harbor ---- 26
5.0 HARBOR DESIGN CRITERIA ---- 27
5.1. Design Vessel and Design Fleet ---- 27
5.2. Design Basin Area per Vessel ---- 27
5.3. Allowable Wave Heights ---- 28
5.4. Entrance Channel ---- 29
5.4.1. Width ---- 30
5.4.2. Depth ---- 30
5.4.3. Length ---- 31
5.4.4. Alignment ---- 31
5.4.5. Inner Harbor Wave Climate ---- 32
5.5. Circulation and Flushing ---- 34
5.5.1. Design Aspects to Improve Circulation ---- 34
5.5.2. Circulation Modeling ---- 34
5.6. Basin Depths ---- 34
5.7. Wind Protection ---- 35
5.8. Geotechnical Stability ---- 35
5.8.1. Liquefaction ---- 35
5.8.2. Seismic Design Criteria ---- 36
5.8.3. Breakwater Slopes ---- 37
5.8.4. Inner Harbor Slopes ---- 37
5.8.5. Upland Fill Areas ---- 37
5.8.6. Upland Buildings ---- 37

5.9. Moorage Configuration ---------- 37
5.10. Rubblemound Breakwaters/Jetties ---------- 42
5.10.1. Rubblemound Foundation ---------- 42
5.10.2. Stone Weight and Size and Layer Thickness: ---------- 44
5.10.3. Crest Elevation and Overtopping: ---------- 45
5.10.4. Crest Width ---------- 46

6.0 ALTERNATIVES CONSIDERED ---------- 48

6.1. Introduction ---------- 48
6.2. No Action ---------- 48
6.3. Alternative Sites ---------- 48
6.3.1. Akutan Point ---------- 48
6.3.2. North Shore Area 1 ---------- 48
6.3.3. North Shore Area 2 ---------- 48
6.3.4. Salthouse Cove ---------- 48
6.3.5. North Point ---------- 50
6.3.6. Head of the Bay ---------- 50
6.3.7. Whaling Station ---------- 50
6.3.8. South Shore Area 1 ---------- 50
6.3.9. South Shore Area 2 ---------- 50
6.3.10. South Shore Area 3 ---------- 50
6.4. Project Development ---------- 52
6.5. Harbor Alternatives Considered in Detail ---------- 54
6.5.1. Offshore Harbor ---------- 54
6.5.2. Offshore/Onshore Harbor ---------- 57
6.5.3. Inland Harbor ---------- 60

7.0 CONSTRUCTION METHODS AND SEQUENCING ---------- 70

7.1. Construction Methods ---------- 70
7.2. Construction Sequence ---------- 70
7.3. Operation and Maintenance ---------- 71
7.4. Aids to Navigation ---------- 73
7.5. Construction Schedule ---------- 73

8.0 REFERENCES ---------- 74

TABLES

Table 1. Summary of Annual Precipitation at Akutan, 1986–89 ---------- 8
Table 2. Summary of Annual Snowfall at Akutan 1986–89 ---------- 9
Table 3. Summary of Annual Air Temperatures at Akutan 1986–89 ---------- 10
Table 4. Comparison of Unalaska and Akutan Snowfall Data 1986–1987 ---------- 11
Table 5. Mean Speed (kts) and Frequency (%) for Winds From Given Directions for 5° by 5° Rectangular Grid That Contains Akutan Harbor ---------- 12
Table 6. Extreme 1-Minute Winds at Akutan Harbor ---------- 13
Table 7. Extreme Wave Setups for the Head of Akutan Harbor ---------- 16
Table 8. Extreme Waves at the Head of Akutan Harbor (ACES) ---------- 19
Table 9. Extreme Waves at Head of Akutan Harbor (STWave) ---------- 21
Table 10. 50 Year Return Period Waves ---------- 24
Table 11. Akutan Harbor Fleet ---------- 27
Table 12. Design Vessel ---------- 27
Table 13. Design Vessels Per Acre ---------- 28
Table 14. Wave Criteria for Mooring Basin ---------- 29
Table 15. Basin Depths ---------- 34
Table 16. Stone Weights, Sizes, and Layer Thickness ---------- 45
Table 17. Stone Gradation ---------- 45
Table 18. Potential Harbor Sites ---------- 51

Table 19. *Estimated Stockpile Areas and Quantities* ---------- *61*
Table 20. *12-acre Basin Fleet* ---------- *62*
Table 21. *12-acre Basin Depths and Areas* ---------- *62*
Table 22. *15-acre Basin Fleet* ---------- *63*
Table 23. *15-acre Basin Depths and Acres* ---------- *63*
Table 24. *20-acre Basin Fleet* ---------- *64*
Table 25. *20-acre Basin Depths and Acres* ---------- *64*
Table 26. *Reconfigured 12-acre Basin Fleet* ---------- *65*
Table 27. *Reconfigured 12-acre Basin Depths and Acres* ---------- *65*

FIGURES

Figure 1 *Location Map* ---------- *6*
Figure 2. *Akutan Harbor Wind Rose* ---------- *13*
Figure 3 *Wave Fetches ACES Method* ---------- *20*
Figure 4 *STWave Grid* ---------- *22*
Figure 5 *Inner Harbor Wave Climate* ---------- *33*
Figure 6 *Typical Inner Harbor Armored Slope* ---------- *39*
Figure 7 *Typical Rubblemound Breakwater Elevation* ---------- *40*
Figure 8 *Typical Rubblemound Breakwater Section* ---------- *41*
Figure 9 *Rubblemound with Buttress* ---------- *43*
Figure 10 *Akutan Harbor Site Selection* ---------- *49*
Figure 11 *Offshore Harbor* ---------- *56*
Figure 12 *Offshore/Onshore Rubblemound* ---------- *58*
Figure 13 *Offshore/Onshore Wave Barrier* ---------- *59*
Figure 14 *12-acre Alternative* ---------- *66*
Figure 15 *15-acre Alternative* ---------- *67*
Figure 16 *20-acre Alternative* ---------- *68*
Figure 17 *Reconfigured 12-acre Alternative* ---------- *69*
Figure 18 *Drainage Basin* ---------- *72*

INTRODUCTION

1.1. Purpose

This appendix describes the engineering and technical aspects of the proposed harbor and navigation improvements for the head of the bay site in Akutan, Alaska. It includes an examination of several harbor alternatives, sections on existing climatology, the expected wave climate, and design criteria. Also included is an examination of the major construction features including breakwaters, entrance channels, dredging, and operations and maintenance. This appendix provides the background technical data for determining the Federal interest in the project.

Design criteria for this project were developed from published standards and methods as outlined in "*Shore Protection Manual*" (SPM), (USACE, 1984), "*Design of Breakwaters and Jetties,*" EM 1110-2-2904, (USACE 1986), and "*Hydraulic Design of Deep-Draft Navigation Projects,*" EM 1110-2-1613 (USACE 1994).

Other useful channel design criteria are found in:

"*Planning and Design Guidelines for Small Craft Harbors,*" (ASCE, 1994) "*Approach Channels A Guide for Design,*" (PIANC 1997)

1.2. Project Background/Purpose and Need

One of the largest shore based fish processing facilities in the United States (Trident Seafoods) is located in Akutan. Project location and site maps are provided in figure 1. This facility has been in operation since the late 1970s. The primary fleet that supplies the plant consists of commercial fishing vessels working in the Bering Sea. These vessels participate in the crab, pollock, Pacific cod, and halibut commercial fisheries. Most of these vessels are in the 85 to 210 foot length class.

In addition to the Trident plant activity, there are a number of small fishing vessels that are used by the residents of the Native Village of Akutan. Currently, the majority of these vessels are in the 16 to 24 foot length range. The Native village residents have the opportunity to participate in the Bering Sea fisheries under the Individual Fishing Quota (IFQ) and Community Development Quota (CDQ) programs.

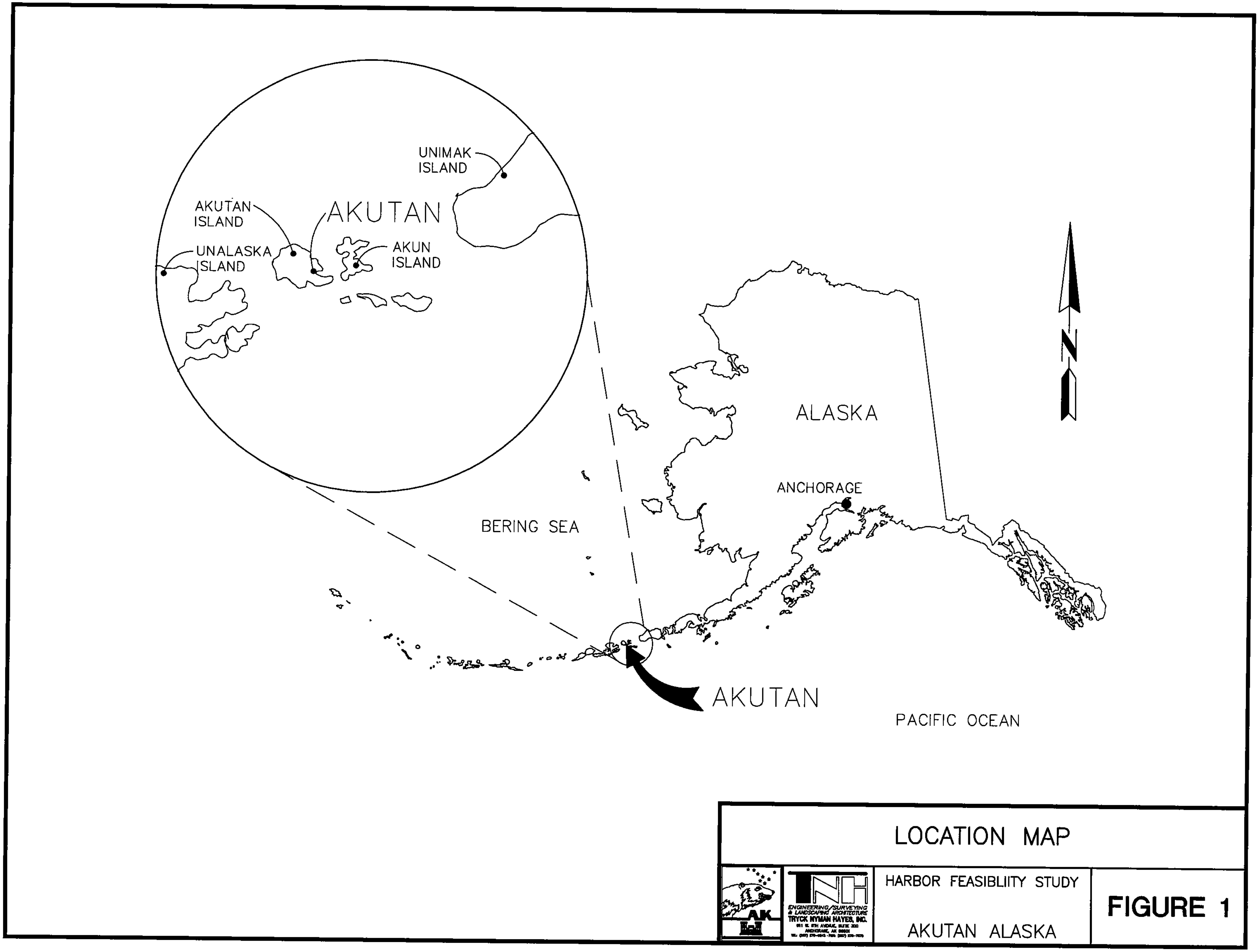
Since the early 1980s, the community of Akutan has been pursuing various means to construct a boat harbor to serve these vessels. Currently, the local fleet finds temporary transient moorage along a somewhat unprotected sheet pile wall adjacent to the Trident plant or elsewhere in the bay. When fishing season is over, many of the larger fishing vessels return to home ports, some as far away as Seattle. Smaller local vessels are pulled out of the water when not in use.

The purpose of this project is to provide a safe and efficient harbor. The harbor must be sized so that it will efficiently serve the existing fleet. The design must provide an economically sound facility with regard to both initial and long-term maintenance costs. In addition, the project must minimize any possible negative environmental impacts.

1.3. Use of English Units

Measurements used in this appendix are English rather than metric units. English units are used because much of the historical data and past studies were recorded in these units, much of the previous survey work was done in English units, and the survey control was based on Alaska State plane coordinates, which are in feet. Conversion of this previous information (especially the contours from the survey) would be laborious.

Therefore, the more cost-effective approach for the current phase of the project was to continue using English units. This allowed for the more seamless use of the past work.


UNIMAK ISLAND
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ENGINEERING/SURVEYING & LANDSCAPING ARCHITECTURE
TRYCK NYMAN HAYES, INC.
HARBOR FEASIBLIITY STUDY
AKUTAN ALASKA
FIGURE 1

2.0 CLIMATOLOGY AND HYDROLOGY

2.1. Climatology

No long term climatological data exists for Akutan. The National Weather Service and National Oceanic and Atmospheric Administration (NWS/NOAA) maintained an automated recording station for precipitation, snowfall, and temperature for Akutan from January 1986 through February 1990. Additional climatic information is taken from the 1988, *NOAA Climactic Atlas, Volume 2, Bering Sea area* (NOAA/CA, V2, 1988); and the *Aleutians East Borough Wave Study—Akutan Alaska, 1995/1996*, prepared by Peratrovich, Nottingham and Drage, Inc. (PN&D). The limited amount of data available and data gaps experienced during the NOAA/NWS data-logging period make developing a comprehensive report of climatological conditions at Akutan difficult. Climate data from nearby Unalaska, which approximates conditions at Akutan and has a longer period of record, will be used as it applies.

2.1.1. Precipitation

Akutan generally experiences mild winters and cool summers characteristic of a northern maritime climate. Cloud cover accompanied by precipitation, usually in the form of drizzle or light rain, is common. According to available NOAA data, the average number of days per year experiencing 0.01 inches or more of precipitation is 277. Days with over 1.0 inch of precipitation are relatively rare, numbering approximately 14 days annually. The mean annual precipitation for Akutan during the NOAA data-logging period was 79 inches. Table 1 provides a summary of annual precipitation at Akutan.

Table 1. Summary of Annual Precipitation at Akutan, 1986–89

	Mean (in)	High (in)	Year	Low (in)	Year	1 Day Max (in)	Date	Avg. # Days >= 0.01"	Avg. # Days >= 0.1"	Avg. # Days >= 0.5"	Avg. # Days >= 1.0"
January	7.35	9.44	1987	4.28	1986	1.76	1/15/1987	25	16	5	1
February	5.98	9.31	1988	3.16	1986	1.20	2/17/1988	22	13	5	1
March	5.09	8.81	1987	3.06	1986	1.30	3/20/1987	23	13	3	1
April	4.93	5.79	1987	4.07	1986	0.90	4/4/1986	22	16	3	0
May	4.14	5.46	1986	2.81	1987	0.98	5/2/1986	18	7	5	0
June	5.33	6.38	1986	4.20	1988	1.50	6/10/1986	21	12	4	1
July	4.77	6.16	1987	3.76	1986	1.10	7/22/1986	19	10	3	1
August	5.50	6.91	1988	4.38	1987	1.70	8/8/1987	20	11	3	1
September	7.36	8.28	1988	6.42	1986	2.00	9/18/1988	23	14	5	2
October	11.26	13.38	1988	10.08	1987	2.04	10/27/1988	28	21	8	3
November	7.34	10.96	1988	5.34	1987	2.25	11/1/1988	28	18	5	1
December	8.90	13.19	1986	4.23	1987	2.03	12/29/1988	28	20	5	3
Annual	79.01	89.32	1988	72.39	1986	2.25	11/1/1988	277	171	53	14
[1]Winter	34.65	44.24	1988	30.79	1986	2.25	11/1/1988	126	79	23	6
[2]Spring	9.07	9.53	1986	8.60	1987	0.98	5/2/1986	40	23	7	0
[3]Summer	15.60	15.96	1987	15.34	1986	1.70	8/8/1987	60	34	10	3
[4]Fall	18.62	21.66	1988	16.73	1986	2.04	10/27/1988	51	35	13	5

Note: Due to the limited amount of available data, some values were derived from 1, 2, or 3 years of data. Some of the data is derived from months with multiple daily data gaps.

[1] November through March

[2] April, May

[3] June through August

[4] September, October

Source: Western Regional Climate Center, NOAA

2.1.2. Snowfall

Monthly snowfall for the Akutan area is shown in table 2. January has the highest mean monthly snowfall of 13.9 inches. The mean annual snowfall is 19.5 inches with a maximum accumulation of 11 inches. Note that snowfall data from the limited period of record may not be representative.

Table 2. Summary of Annual Snowfall at Akutan 1986–89

	Mean (in)	High (in)	Year	Max. Accum. (in)
January	13.90	21.40	1986	10
February	1.25	1.90	1987	5
March	0.63	1.10	1986	11
April	2.60	4.50	1986	5
May	0.00	0.00	-	0
June	0.00	0.00	-	0
July	0.00	0.00	-	0
August	0.00	0.00	-	0
September	0.00	0.00	-	0
October	0.00	0.00	-	0
November	0.80	0.80	1987	5
December	1.50	2.90	1988	8
Annual	19.55	27.70	1986	11
[1]Winter	18.08	10.70	1988	11
[2]Spring	2.60	4.50	1986	5
[3]Summer	0.00	0.00	-	0
[4]Fall	0.00	0.00	-	0

Note: Due to the limited amount of available data, some values were derived from 1, 2, or 3 years of data. Some of the data is derived from months with multiple daily data gaps.

[1] November through March

[2] April, May

[3] June through August

[4] September, October

Source: Western Regional Climate Center, NOAA

2.1.3. Temperature

Temperatures at Akutan are typical of islands in the Aleutian chain with mild winter temperatures and cooler summer temperatures. Average annual temperature is 40.9 °F. The average winter temperature is 34.7 °F. Average summer temperatures reach 49.8 °F. The maximum temperature recorded during NOAA's 4-year monitoring period was 72 °F. The minimum temperature recorded was 8 °F. A summary of annual temperatures at Akutan is supplied in table 3. The PN&D report gives a higher summer average temperature of 55 °F and a winter average temperature of 35 °F.

Table 3. Summary of Annual Air Temperatures at Akutan 1986–89

	Averages			Daily Extremes		Monthly/Yearly Extremes			Max Temp	Min Temp	
	High (F)	Low (F)	Mean (F)	High Date	Low Date	Highest Mean	Lowest Year Mean	Avg. # Days >= Year 90 F	Avg. # Days <= 32 F	Avg. # Days <= 32 F	Avg. # Days <= 0 F
Jan	36.8	29.7	33.3	46.0 1/4/87	17.0 1/9/87	34.9	1987 30.5	1986 0.0	6.0	19.7	0.0
Feb	37.1	29.8	33.4	46.0 2/13/86	15.0 2/20/88	33.1	1988 32.8	1986 0.0	4.7	16.0	0.0
Mar	38.5	29.9	34.2	57.0 3/12/89	8.0 3/10/88	37.2	1987 31.0	1988 0.0	4.5	17.5	0.0
Apr	40.8	31.9	36.3	49.0 4/14/86	19.0 4/18/86	37.4	1987 35.2	1986 0.0	1.5	14.5	0.0
May	45.7	36.5	41.1	56.0 5/10/86	25.0 5/5/87	41.2	1987 41.1	1986 0.0	0.0	1.5	0.0
June	49.9	42.8	46.4	60.0 6/29/88	38.0 6/11/86	47.0	1987 45.4	1986 0.0	0.0	0.0	0.0
July	54.6	47.3	50.9	66.0 7/20/86	43.0 7/22/87	51.1	1986 50.7	1987 0.0	0.0	0.0	0.0
Aug	56.9	47.1	52.0	72.0 8/14/88	35.0 8/31/88	52.6	1987 51.5	1986 0.0	0.0	0.0	0.0
Sep	53.0	43.6	48.3	64.0 9/16/88	32.0 9/2/88	50.4	1986 47.1	1987 0.0	0.0	1.0	0.0
Oct	47.5	41.5	44.5	57.0 10/13/87	33.0 10/25/87	45.0	1986 44.1	1987 0.0	0.0	0.0	0.0
Nov	41.0	34.4	37.7	52.0 11/13/86	16.0 11/29/86	40.4	1986 36.4	1987 0.0	1.8	11.3	0.0
Dec	39.1	29.9	34.5	45.0 12/2/86	12.0 12/8/87	37.8	1986 30.8	1988 0.0	3.0	16.0	0.0
Ann	44.9	37.0	40.9	72.0 8/14/88	8.0 3/13/86	41.4	1987 40.3	1988 0.0	21.4	97.5	0.0
[1]Win	38.9	30.5	34.7	57.0 3/12/89	8.0 3/13/86	35.4	1987 33.4	1988 0.0	19.9	80.5	0.0
[2]Spr	42.6	34.0	38.3	56.0 5/10/86	19.0 4/18/86	39.3	1987 37.6	1988 0.0	1.5	16.0	0.0
[3]Sum	53.8	45.7	49.8	72.0 8/14/88	35.0 8/31/88	50.1	1987 49.3	1986 0.0	0.0	0.0	0.0
[4]Fall	50.3	42.6	46.4	64.0 9/16/88	32.0 9/2/88	47.7	1986 45.6	1987 0.0	0.0	1.0	0.0

Note: Due to the limited amount of available data, some values were derived from 1, 2, or 3 years of data. Some of the data is derived from months with multiple daily data gaps. The 1989 data set is missing several months of data.

[1] November through March

[2] April, May

[3] June through August

[4] September, October

Source: Western Regional Climate Center, NOAA

2.1.4. Unalaska Data

NOAA has archived climatic data since 1949 from Unalaska, and because of its close proximity to Akutan, some climatic data elements for Unalaska may be useful in estimating conditions at Akutan. The annual average precipitation for Unalaska is listed in NOAA/CA, V2, 1988 as 60.5 inches. Total annual snowfall is listed as 72.2 inches with a maximum accumulation of 25 inches. The mean annual maximum temperature is given as 45.3 °F and the mean annual minimum temperature is 35.9 °F. The maximum-recorded temperature was 80.1 °F and the minimum-recorded temperature was 1.9 °F. Prevailing winds are from the southeast with an average speed of 9.6 knots (11.0 mph). Highest wind speeds are from the east with speeds of 82 knots (94.4 mph).

Differences between Unalaska climatic data and available data from Akutan (particularly for snowfall) may be partially explained by the lack of long-term climatic data for the Akutan area. Personal interviews with Akutan residents have yielded some anecdotal information for precipitation and snowfall for the current year (1999/2000) and recent history (past two decades). According to Akutan residents interviewed, 1999 and early 2000 have had much higher than normal snowfalls (one estimate was over 100 inches) and similar weather patterns occurred in the early 1980s and 1990s. NOAA does not supply climatic data for the periods during which "more extreme" weather conditions are reported to have occurred, indicating that the actual annual snowfall and precipitation values may be greater than those shown in tables 1 and 2.

When Akutan and Unalaska snowfall data are compared for the years 1986 and 1987 (table 4), Unalaska shows an average annual snowfall of 45 inches compared to Akutan's average snowfall of 19.5 inches for the same time period. This indicates that Unalaska may receive more snowfall on average than Akutan.

Table 4. Comparison of Unalaska and Akutan Snowfall Data 1986–1987

	Unalaska		Akutan	
	Average Snowfall (in)	Average Accumulation (in)	Average Snowfall (in)	Average Accumulation (in)
1986	48.3	21	27.7	9
1987	41.7	19	11.4	11
Annual Average (in)	45.0	20	19.55	10
NOAA/CA Listed Average Annual Snowfall (in)	72.2	-	-	-

Source: National Data Center, NOAA

2.1.5. Wind

No long-term wind record data for Akutan Harbor exists. Neither the National Climatic Data Center nor the University of Alaska Environmental Research Institute were able to locate any archived wind data. During 1992, a wind gage was installed at the Trident Fish Processing plant approximately one half mile west of the community. This wind data collection effort was in support of the circulation study done to evaluate mixing efficiency from a submerged discharge. This short record appears to be the most representative local data available.

Because of the topography of the bay, wind directions seem to align with the long axis (east and west) of the bay. On the north and south sides, the terrain directly adjacent to the bay rapidly ascends to about 1,000 feet or more. This severely restricts cross-bay winds except near the bay mouth. Even if cross-bay winds do exist, they would not be effective in generating any appreciable waves because of the very limited fetch in the cross-bay direction.

The monthly mean wind speeds for two NOAA wave buoys, one in the Gulf of Alaska (No. 46003) and the other in the Bering Sea (No. 46035), were available on the World Wide Net. The distances from Akutan to No. 46003 and No. 46035 were about 400 and 500 miles, respectively. Due to their lack of proximity to Akutan and to their non-directional format, it was decided they were not particularly useful to this study.

The nearest long-term wind record was collected at Unalaska Airport. The anemometer there is situated to maximize its use by airplane traffic. As such, it is not well suited for use at Akutan Harbor.

The Climatic Atlas (Brower, et al, 1988) provides wind speed information for 5° latitude by 5° longitude rectangular grids based on ship observations. These were presented as a series of monthly wind roses for each grid. However, instead of sorting on wind speed class, only the mean monthly wind speed for each heading was provided. Table 5 provides this information for the grid that includes Akutan Harbor.

Data was collected from the Trident Fish Processing Plant on the north side of Akutan Harbor for a year and is summarized in compass rose plots for four annual quarters. These quarters were calendar based without regard to season, hence, the periods were for January through March, April through June, etc. These plots were modified to display only eight major compass directions and then combined into a single compass rose. This is presented as figure 2.

The data used to create figure 2 show a definite bi-modal direction pattern from the northwest and the southeast. Such a pattern would be expected given the strongly linear shape of Akutan Harbor and the relatively high elevations that border its north and south shoreline. However, the major wind directions are not aligned with the long east-west axis of the bay. It is possible that 1992 was not a representative year in terms of wind direction. However, it is also possible that the anemometer was placed in such a way that the measurements were biased, perhaps by the local orientation of the coast or due to an obstructing facility. It is also possible that the records were incorrectly recorded or analyzed.

Table 5. Mean Speed (kts) and Frequency (%) for Winds From Given Directions for 5° by 5° Rectangular Grid That Contains Akutan Harbor

Month		N	NE	E	SE	S	SW	W	NW
January	Mean	19	21	22	20	19	19	19	19
	Frequency	13	13	13	13	11	11	15	11
February	Mean	21	20	20	21	19	19	20	20
	Frequency	13	13	15	15	11	11	11	11
March	Mean	18	18	20	19	18	20	19	18
	Frequency	11	11	11	11	11	13	17.5	13
April	Mean	17	17	17	20	19	19	19	19
	Frequency	8.5	6	6	7.5	13	19	20	19
May	Mean	15	14	15	17	15	17	17	16
	Frequency	10	8	8	9	9	18	20	19
June	Mean	12	12	14	15	14	15	14	13
	Frequency	11	7	9	12	13	15	19	15
July	Mean	11	10	12	14	14	15	14	13
	Frequency	5	4	8	10	15	20	21	15
August	Mean	13	13	14	15	15	16	15	14
	Frequency	6	6	8	10	15	20	21	13
September	Mean	16	15	16	16	16	16	17	18
	Frequency	10	8	8	8	10	16	21	19
October	Mean	19	17	19	19	18	19	19	20
	Frequency	12	8	8	8	8	21	21	21
November	Mean	20	19	20	20	20	20	21	21
	Frequency	13	10	10	10	12	15	21	18
December	Mean	19	19	22	21	20	20	21	20
	Frequency	11	11	11	10	11	14	16	16

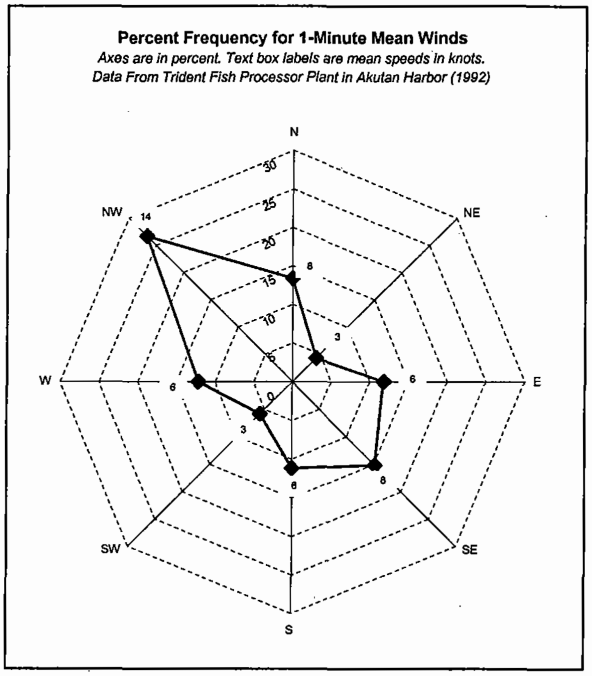


Figure 2. Akutan Harbor Wind Rose

(Trident Processing Plant. Data collected by Jones & Stokes 1993).

This one year of data is far less than is needed to base extreme wind conditions. For extreme wind estimates, the Climatic Atlas (op. cit.) was used. Although the atlas did not have any data for Akutan, it presented results for Cold Bay to the north and Nikolski to the south. Akutan Harbor is roughly equidistant between these two recording stations. Based on extremes at these stations, the extreme 1-minute winds for Akutan are as shown in table 6.

Table 6. Extreme 1-Minute Winds at Akutan Harbor

Probability	Return Period (yr)	Wind Speed (kt)
0.05	20	64
0.02	50	73
0.01	100	79

2.2. Hydrology

2.2.1. Tides

Tides prediction in Akutan is based on a primary National Ocean Service (NOS) station in Unalaska. This information is based on a 15-year period of record from January 1, 1960 to December 31, 1975. It comes from the 1960 to 1978 tidal epoch and is considered "preliminary" data by the NOS. The following tidal statistics apply to Unalaska:

Extreme high water	6.62 ft
MHHW	3.73 ft
MHW	3.46 ft
MTL	2.21 ft
MLW	0.97 ft
MLLW	0.00 ft
Extreme low water	–2.64 ft

The NOS has the following tidal corrections published for Akutan, based on the Unalaska station:

Time Difference		Height Difference	
High	Low	High	Low
–0.17	–0.17	1.08	1.10

Note the time difference values are additive and that the height difference correction is a multiplier.

Based on these published corrections the following tidal information is extrapolated for Akutan:

Extreme high water	7.15 ft
MHHW	4.03 ft
MHW	3.74 ft
MTL	2.41 ft
MLW	1.07 ft
MLLW	0.00 ft
Extreme low water	–2.90 ft

There was some water level information collected in Akutan during 1934 and 1935. This data does not meet NOS criteria for tidal datums. Also, in 1995 PN&D installed and monitored some wave and tide equipment in Akutan Harbor primarily for a wave study. This data has a relatively short period of record (one year) and does not conflict with the above extrapolated tidal data.

2.2.2. Storm Surge

Akutan Harbor is a relatively deep bay; therefore, it is highly unlikely that appreciable storm surges can be generated. To calculate the complete storm surge requires a numerical solution of the horizontal momentum equations. If the equation is simplified so that the wind stresses on the water's surface and at the bottom are used to balance the hydrostatic pressure gradient terms, a form as suggested by Dean and Dalrymple (1984) can be used to approximate the surge. In that reference, one example was presented for a constant depth situation and another for a linearly sloping bottom. These two can be combined to make a surge estimate for Akutan. First consider a region over the majority of the bay where the depth is nearly uniform. This region extends for about 3 miles from the mouth of the bay to near the head of Akutan Harbor; the depth is assumed to be 150 feet. By vertically integrating the simplified momentum equations and combining the ratio of the bottom friction to the surface wind stress into a single coefficient, n, the following expression is produced:

$$n = 1 - \frac{\tau_b}{\tau_s}$$

Where τ is the shear stress and the subscripts b and s refer to the bottom and surface of the water, respectively. The Shore Protection Manual suggests that n varies between 1.15 and 1.3. The more conservative (higher surge prediction) value of 1.3 will be used here. The formula for the surge over that 3-mile zone becomes:

$$\eta = \sqrt{h_o^2 + \frac{2n\tau_s x}{\rho g}}$$

Where η is the surge, h_o is the uniform depth, g is the coefficient of gravity, ρ is the density of sea water, and x is the distance from the mouth of the bay. For the following parameters:

h_0	=	150 feet
n	=	1.3
τ_s	=	$3.1 * 10^{-6} W^2$ (W is the wind speed in fps)
ρg	≈	65 pounds/ft^3
x	=	18,200 feet (3 nautical miles)

The surge is about 0.18 feet.

The second region to consider is the sloping beach from deep water to the shoreline, which can be approximated by a uniform slope. The expression for the surge in this zone cannot be found explicitly, but must be expressed as the implicit relationship:

$$x = l\left[\left(1 - \frac{h+\eta}{h_o}\right) - A\ln\left(\frac{\frac{h+\eta}{h_o} - A}{1 - A}\right)\right]$$

h is the water depth at some distance x, l is the length of the sloping bottom region and A is given as:

$$A = \frac{n\tau_s l}{\rho g h_o^2}$$

For the following parameters:

X	=	l (1,400 feet)
H	=	0: h_o = 150 feet
A	=	9×10^{-5}

The surge is given as 0.05 feet. Combining this with the constant depth zone, the total surge is just over 0.2 feet.

The portion of the surge that results directly from atmospheric pressure differentials is usually an order of magnitude less than that generated by shear stresses. It is not considered except where a region might be under the influence of a tropical storm with extremely high horizontal pressure differential and, therefore, will not be considered further in this case.

From the above discussion, it can be seen that storm surge is not a significant concern in Akutan Harbor. A conservative value of 0.2 feet can be used for design purposes.

2.2.3. Wave Setup

The approach to calculating wave setup uses the concept of radiation stress or excess momentum stress in the surf zone. This approach can be simplified and is a function of the breaking wave height. This has been plotted as a function of the wave characteristics and the beach slope in the SPM using Weggel's 1972 description of the breaking wave criterion. Further, the setup as a function of the breaking wave height and the beach slope also has been plotted in the SPM.

The wave setup can be determined using these tools combined with the wave conditions determined from the STWave model, and the maximum winds for the 20-, 50-, and 100-year return periods (presented in a later section), the wave setups can be determined and are shown in table 7.

Table 7. Extreme Wave Setups for the Head of Akutan Harbor

Probability	Return Period (yr)	Wave Setup (ft)
0.05	20	0.31
0.02	50	0.38
0.01	100	0.41

2.2.4. Design High Water Level

Based on the above discussions, a design high still water level can be taken to be the sum of the tide, wave setup, and storm surge. Using the extreme, 50 year values outlined above, this equates to an elevation of 7.73 feet above MLLW. It is important to note that this number does not take into account the height of the wave or any run up that may occur.

2.2.5. Currents

There is no current data available for Akutan Harbor in the NOAA *Tide Current Tables*. With a mean diurnal tidal range of approximately 3 feet, and with the semi-enclosed shape of the bay, it is highly unlikely that there will be significant current at the head of the bay site.

Akutan Harbor is in communication with both the Bering Sea and the Gulf of Alaska. North of the Aleutians, the Bering Sea current is eastward; south of the chain, the Alaska current flows to the west. In the passes that connect the Bering Sea and the Gulf of Alaska, tidal currents dominate the flows. At higher longitudes, part of the Alaska current flows into and merges with the Bering Sea system. It is probable that the circulation in Akutan Harbor depends very little on these regional current systems.

Jones and Stokes (1992) modeled the bay circulation and found that the currents were predominately driven by local winds. Currents on the order of 15 cm/s or about 0.3 knots were noted in the model, and these were somewhat confirmed by current measurements.

Akutan Harbor appears to have a classic 2-layer current system with flow in the direction of the wind on the surface and a countercurrent (opposed to the wind) near the bottom. It is not clear how these countercurrents are distributed horizontally or vertically. Hence, winds may drag surface water in the same direction near the center of the bay, or along one or both sides, or they may occur only at depth. Countercurrents are required to satisfy continuity.

The freshwater quantity entering the bay is limited and has little effect on bay currents or circulation. Stratification, which might be enhanced by freshwater inflows, would primarily effect how the countercurrents are distributed.

2.2.6. Fresh Water Input

There are two streams that traverse the valley at the head of the bay, one on the north side of the valley and one on the south side. These streams are near the toes of the steep slopes that define the edges of the valley. The stream on the north side of the head of the bay is larger than the one on the south side. This stream is classified by the State of Alaska Department of Fish and Game as an anadromous fish stream and is reported to support pink and coho salmon, as well as Dolly Varden. The stream on the south side of the bay is reported to support pink salmon. Both of these streams have an associated alluvial fan of deposited sediment at their mouths.

Measurements of the flows of these streams have been recorded during several previous studies. In June of 1983, Jones and Stokes estimated the flow in the north side stream at 27 cfs. This appears to be a peak value. In April of 1992, this same company reported a much lower "base flow" of 2.0 cfs for this same north side stream. Winter-like conditions with snow on the ground could have contributed to this low number. In August of 1982, Peratrovich and Nottingham, Inc. recorded a flow of 3.9 cfs in the south side stream and 10.9 cfs in the north side stream. These readings were reported to have been taken after several days of no significant rainfall. Measurements taken at different locations along the streams resulted in different flows, pointing to a high ground water infiltration and influence in the flows.

Also, there is a seasonal drainage near the middle of the beach at the head of the bay. This appears to be an outlet to the wetland impounded behind the berm. There is a small alluvial fan associated with this drainage that is visible in air photographs.

2.2.7. Icing in the Proposed Harbor

Information used for developing an estimate of icing conditions in the proposed Akutan Harbor came from the National Oceanic and Atmospheric Administration (NOAA), the National Oceanic Data Center (NODC), the National Weather Service (NWS), and anecdotal information from local sources.

Local sources interviewed had spent many years in the Akutan and eastern Aleutian area and provided accounts from the past 20 years. Residents from Akutan, Unalaska, King Cove, and Sand Point were interviewed. Most of the individuals interviewed held land-based maritime related positions: either serving as Harbor Master, or employed in the harbor of their community.

Interviews with harbor employees at Unalaska, King Cove, and Sand Point revealed that these harbors all have similar icing conditions. These harbors experience occasional icing, however, the icing only occurs during the coldest winter days and usually consists of a thin slushy layer that does not interfere with boat maneuvering operations. A harbor employee from Sand Point indicated that on one occasion during the last 10 years the ice in the Sand Point Harbor became thick enough to walk on, however, large boat maneuverability was not hampered. All contacts indicated that their respective harbors remained ice-free during most of the winter months.

Air temperatures in the Akutan area remain relatively mild during the winter months with about 100 days per year experiencing minimum air temperatures below 32 degrees Fahrenheit (F). The average January temperature is above the freezing point at 33.3 °F. Cold snaps are usually short lived with no air temperatures below 0 °F recorded in recent history. The coldest seawater temperatures occur in December and January and hover slightly above 32 °F. These climatic and seawater temperature conditions do not favor the development of substantial sea ice.

Long-time Akutan residents who hunt and fish year-round at the west end (near the head of the bay) of Akutan Harbor state that icing does occur near the proposed harbor site. The ice that forms is thin and slushy, easily broken up by wave activity, and does not impede navigation in the area, even for smaller boats such as skiffs.

There are other factors that may add to the potential for ice formation inside the harbor. The harbor is expected to experience some freshwater in-flow from ground water seepage and surface water flow. Freshwater, being less dense than seawater will tend to remain on the surface and, therefore, exposed to ambient air temperatures. Adding to the potential for freezing is the possibility of relatively limited circulation in the harbor due to minimal tidal currents that occur in Akutan Harbor. Both of these factors are difficult to quantify.

Keeping in mind that the west end of Akutan Harbor in its present undeveloped state is experiencing the same fresh water in-flow and tidal currents as would be noted following development of the harbor basin, it can be expected that icing conditions should remain static outside of the dredged harbor basin. Icing conditions inside the harbor basin may be exacerbated by localized higher concentrations of freshwater and retarded circulation inside the basin. It should be noted that the harbors in Unalaska, King Cove, and Sand Point all experience a large amount of freshwater in-flow while remaining relatively ice free.

Based on the above stated information, it is anticipated that the proposed Akutan Harbor will experience some icing during the coldest winter months (November through February). For the most part, icing will consist of a thin slushy layer that will be easily broken up by wave action and should pose no hazard to navigation for both large and small vessels. Occasionally (up to 2 times per year) the harbor may experience heavier icing that may impede smaller vessels. Heavier icing events are expected to be of short duration (1 to 2 weeks per event) and should not prevent larger vessels from maneuvering in the harbor.

3.0 WAVE CLIMATE

3.1. Local Wave Generation

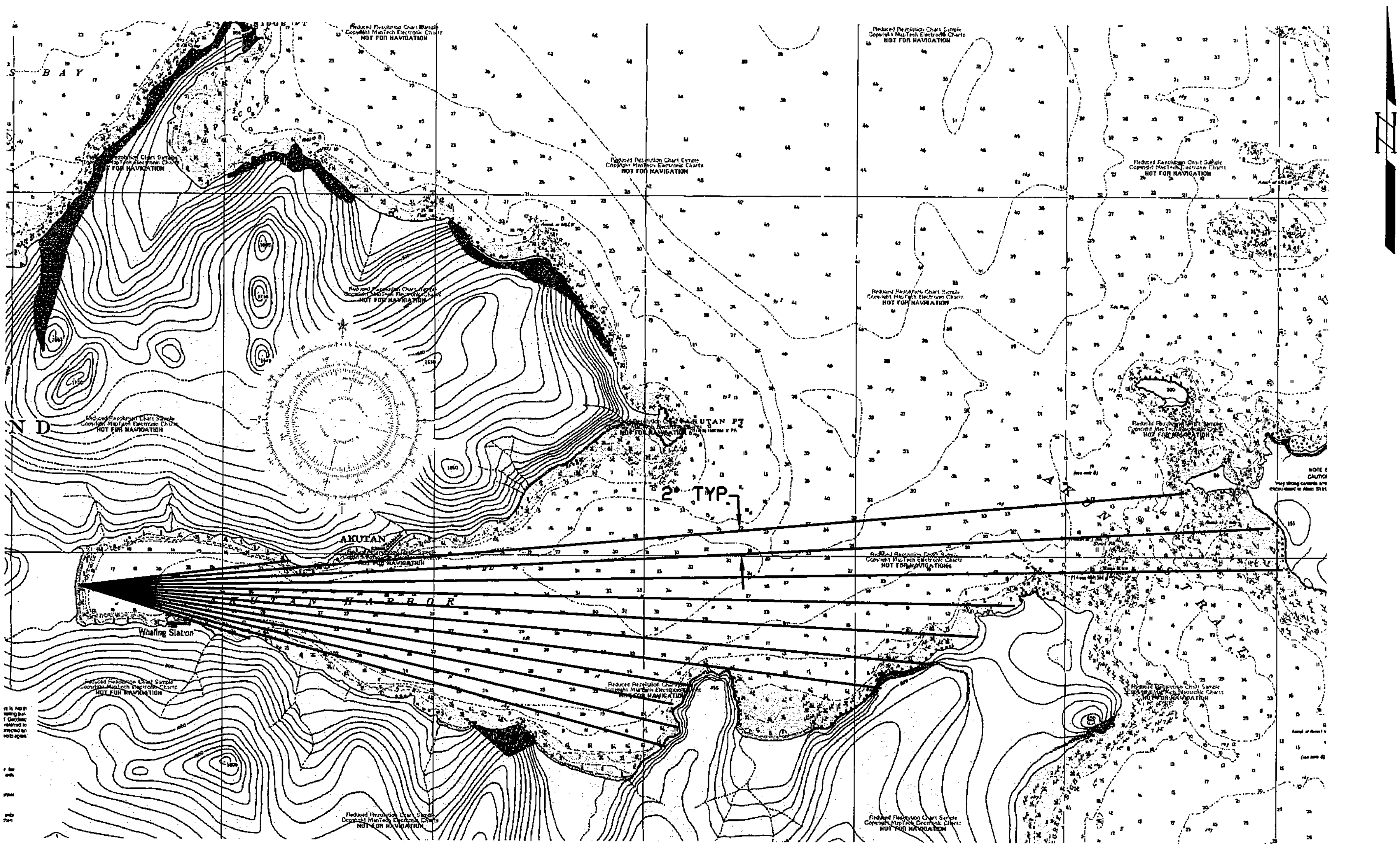
Local winds of any significance must conform to the east-west axis of the bay. Waves, with the potential to impact the project, could be generated only from the east. The fetches would be too limited from any other direction. From the east, fetches could begin far outside the bay and attain lengths of nearly 7 miles. Locally generated waves have been estimated using the restricted fetch method found in the ACES routines and by wave modeling using the steady-state spectral wave model STWave. With the latter, it was determined that the maximum wave-producing wind direction was one directed toward slightly (5 degrees) north of west.

3.1.1. Analysis by ACES Method.

For this method, a series of nine fetches were established radiating eastward from the general location of the potential boat harbor at the head of the bay (figure 3). There is a separation angle of 2 degrees between these radials. The length of the radials varied between 1.42 miles for the northernmost radial to 6.4 miles for the second radial. The average fetch was found to be 5.2 miles. The wind is assumed to be from 095 degrees, which was found from the STWave analysis (table 9) to produce the largest wave. The three extreme wind conditions presented in the wind analysis section were used in the model. The length of time to attain equilibrium wave conditions for the average fetch for this situation and for the three wind conditions presented above is just over an hour. Therefore, the 1-minute winds were transformed to 1-hour winds by dividing by 1.24 (according to SPM). The winds given in table 6 were transformed into hourly values of 64, 59, and 52 knots respectively, for the 100-, 50-, and 20-year return values. For these winds, the duration to attain equilibrium conditions was again checked, and was still found to be close to 1 hour; therefore, no additional adjustments were made. The following wave conditions resulted.

Table 8. Extreme Waves at the Head of Akutan Harbor (ACES)

Probability	Return Period (yrs)	Wave	
		Ht (ft)	Period (sec)
0.05	20	5.4	4.4
0.02	50	6.4	4.8
0.01	100	7.1	5.0



GRAPHIC SCALE

2,500 0 2,500 5,000

(IN FEET)
1" = 5,000'

WAVE FETCHS
ACES METHOD

HARBOR FEASIBLIITY STUDY

AKUTAN ALASKA

ENGINEERING/SURVEYING & LANDSCAPING ARCHITECTURE
TRYCK NYMAN HAYES, INC.

FIGURE 3

3.1.2. Analysis by STWave Method.

Locally generated waves at the head of the bay were also estimated using STWave. The grid consisted of 164 by 56 grid points positioned 200 feet apart (figure 4). Those results are shown in table 9.

Table 9. **Extreme Waves at Head of Akutan Harbor (STWave)**

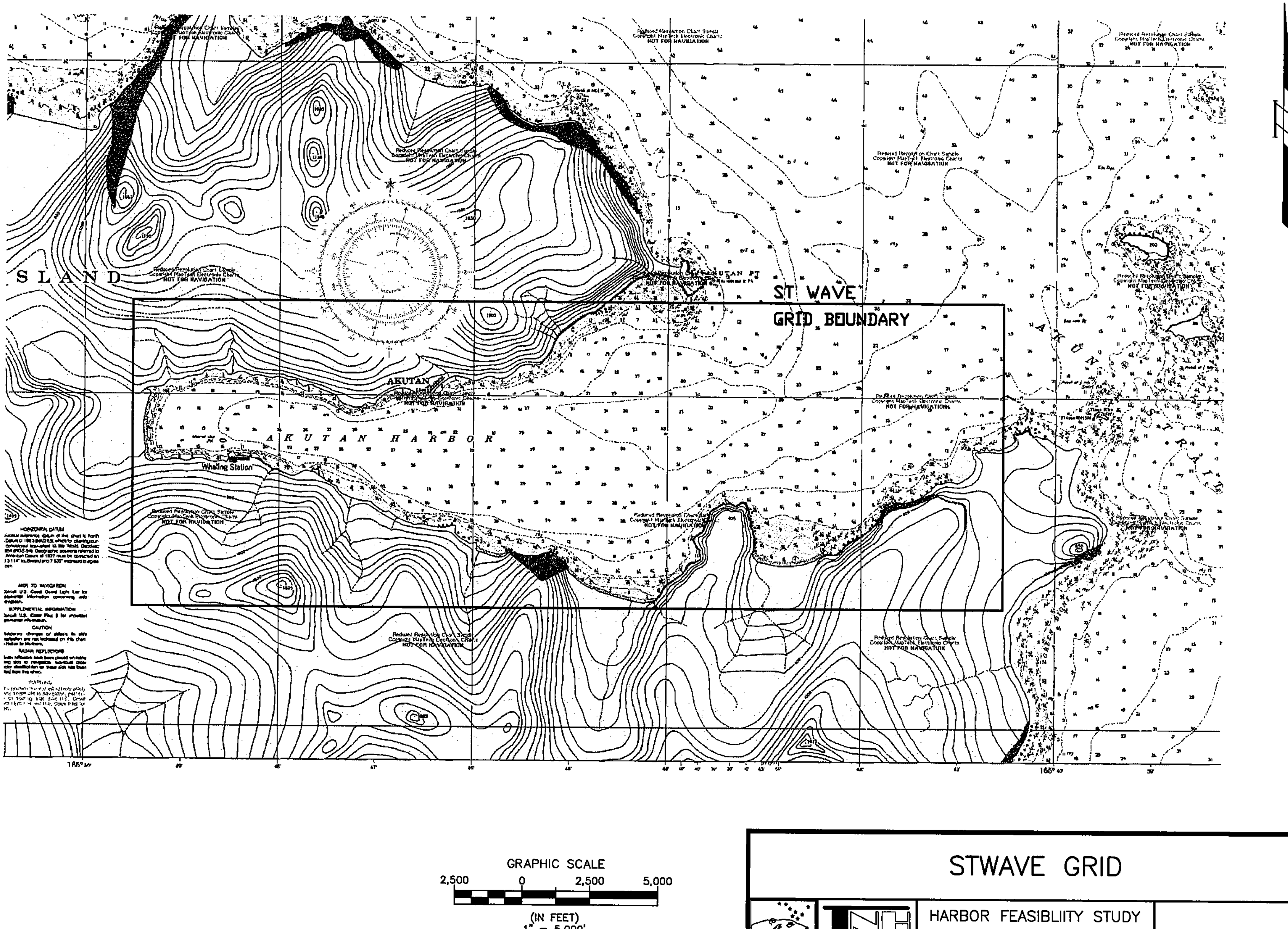
Probability	Return Period (yrs)	Wave	
		Ht (ft)	Period (sec)
0.05	20	2.7	4.4
0.02	50	3.1	4.7
0.01	100	3.3	5.0

Although the periods are nearly identical to the ACES estimates, the wave heights show a marked decrease using STWave. The wave height values tended to increase steadily toward the head of the bay. At a distance of just less than 1 mile from the end, the wave heights began to diminish because of narrowing at the head end. The wave energy is being refracted shoreward along each side, and remaining energy is being redistributed over the wave crest. This effect is not considered in the ACES method.

3.2. Waves of Non-local Origin

Large waves with periods in excess of 8 seconds occur routinely outside the confines of Akutan Harbor. The mouth of the bay is in direct communication with the Bering Sea to the north and the Gulf of Alaska to the south. However, to the east it is protected from direct contact to the Gulf and the Bering Sea by Akun Island. It seems possible that through a combination of wave refraction, diffraction, or reflection some of this wave energy could enter Akutan Harbor.

Waves approaching from the Gulf of Alaska through Akun Strait would encounter shoals and reefs on the western end of this passage that would severely redirect the energy of long-period waves and reduce their total energy through refraction, breaking, and bottom friction. Redirection due to the shoals would severely reduce wave height by refraction. This area should function as a relatively effective filter for long waves and it is doubtful that significant long period wave energy would enter the bay from this direction.



STWAVE GRID

HARBOR FEASIBLIITY STUDY

AKUTAN ALASKA

FIGURE 4

ENGINEERING/SURVEYING & LANDSCAPING ARCHITECTURE
TRYCK NYMAN HAYES, INC.

The passage between Akun and Akutan Islands to the north is exposed to the Bering Sea. It is wide and has deep water throughout. The angular change required by a wave to enter the bay from refraction alone would be well over 90 degrees. Except for isolated situations, angular changes of more than 90 degrees will not permit the propagation of any significant energy. Even situations that might allow larger angular changes at relatively minor loss of energy can be shown to occupy only a small horizontal extent, that is they occupy only a very shortened crest length. If such a crest section is permitted to propagate, diffraction and additional refraction will severely reduce its energy per crest length values. By this reasoning, refraction alone can be eliminated as a mechanism that directs energy into the inner bay. It might appear that a wave approaching from the Bering Sea might be diffracted as it passes Akutan Point (on the northeast corner of the bay). However, the water tends to be relatively shallow south of the point (directly in the lee for a wave from the Bering Sea). Also the bay side of the point is adjacent to a pocket beach. This situation is certain to combine wave refraction to any diffraction that is occurring. Both of these will reduce the bay-directed wave energy per foot of wave crest.

Waves, approaching from the northeast, could be diffracted by Akun Point with some of the energy being redirected into the bay. The angle of this approach would be between 45 and 60 degrees relative to the long axis of the bay. The typical wave diffraction diagrams (figures 2-30 or 2-31 in the Shore Protection Manual) point to diffraction coefficients of less than 0.1. Therefore, it would seem unlikely that appreciable amounts of wave energy could reach the head of the bay by this method and it would seem that diffraction also could be eliminated as a serious source of wave energy at the head of the bay.

Another possible mode of propagating Bering Sea wave energy reasonably far into the bay is by reflection. Evidence exists that waves (possible 2 to 3 feet high with a period of 12 to 14 seconds) do break onto the beach fronting the village of Akutan (VCR tape supplied by Harvey Smith of the State of Alaska Department of Transportation and Public Facilities). Regional winds during this event were northerly, out of the Bering Sea.

The waves would first reflect off the southern shoreline. Then, following a series of successive reflections or by a combination of reflections and refraction, it might be possible for energy to be directed toward the inner bay. This might seem possible, particularly for long-period waves that tend to reflect more efficiently.

Consider a 12-second period wave impinging on a 1 on 10 slope (this slope seems to be about the norm for the southern shoreline). Seelig and Ahrens (1981) developed a relationship between the reflection coefficient (χ) and the surf similarity parameter (ξ) that allows considering the effectiveness of reflection given certain slope and wave conditions. The surf similarity parameter is given in terms of the incident wave height (H_i), the deep-water wavelength (L_0), and the shoreline slope (cot2) as:

$$\xi = \frac{1.0}{\cot\theta\sqrt{H_i / L_0}}$$

For an incident height of 10 feet, ξ is about 0.9 that yields a reflection coefficient of just less than 0.1 on a natural beach and just over that for a plane (smooth) slope. Even a 14-second period wave with the same incident wave height impinging on a steeper 1 on 5 slope has a reflection coefficient of no more than 0.4.

Since several reflections would probably be necessary to propagate this wave energy into the bay, this would not be particularly effective if more than one reflection were required. Only a single reflection is necessary to be directed toward the community.

These reflected waves would tend to develop crests that are essentially parallel to the long axis of the bay and would probably become even more parallel with each successive reflection. Therefore, only diffraction (the crest-parallel propagation of energy) could generate any energy at the head of the bay from these reflected waves. The original reflective surface on the south shore near the mouth of the bay was, at most, only a few hundred feet long. Hence, the reflected wave, in effect, becomes a short-crested wave. To reach the head of the bay through diffraction would require the wave energy from this short-crested wave to travel along its crest a distance of several thousand feet. It is clear that the resulting wave height, if discernable at that distance, would be very small. Therefore, it is unlikely that significant long period wave energy will be reflected to the head of the bay site.

3.3. Wave Summary and Design Wave

It is recommended that the 50-year wave forecasted by the STWave model be adapted as the "design wave" for the project. For purposes of design of structural items it is recommended that the Rayleigh wave height distribution average of the highest 10 percent of all waves be used (H_{10}). The 10 percent wave (H_{10}) is defined in the SPM as the significant wave height (H_S) multiplied by a factor of 1.27. The period remains the same. The design waves are summarized in table 10.

Table 10. 50 Year Return Period Waves

Wave	Ht (ft)	Period (Sec)
H_S	3.1	4.7
H_{10}	3.94	4.7

4.0 SEDIMENTATION ANALYSIS

No site specific sedimentation studies have been performed for the head of the bay. Therefore, sedimentary processes there must be inferred from the beach and nearshore morphology and from the principles of wave propagation and transformation in the coastal zone. It is probably safe to conclude that unless waves are from the east they do not generate any significant transport potential.

4.1. Existing Environment

Field studies conducted in 1998 have confirmed air photo observations that show sediments to be relatively limited and coarse except for at the head of the bay and at the occasional site along the north and south coasts of Akutan Harbor. A large accumulation of relatively fine beach sediments is present only at the bay's head. This accumulation forms a relatively long and narrow pocket beach at the head of the bay that is about 2,500 feet long and 50 to 75 feet wide. This is similar to a typical pocket beach that is formed from sediments becoming trapped between two headlands; however, it differs in that it has two streams that border it on each end. The headlands in this case are the north and south shoreline.

A soils exploration report prepared by Peratrovich and Nottingham, Inc. (now PN&D) in 1982 in support of a then proposed barge landing, described the beach at the head of the bay as a "storm barrier beach." This report describes the typical formation of backwater lakes behind these storm barrier beaches. It describes the beach deposit material as medium to coarse-grained sand and fine gravel with pebbles ranging up to a half inch in diameter. It reported that the thickness of the deposit could be expected to be 90 to 200 feet.

The beach has a somewhat classic shape that contains a berm. This berm has a crest elevation of approximately +10 feet MLLW. Behind the berm there is generally a drop of about 2 feet to elevation +8 feet. Then the terrain gradually slopes upward to the west into the valley. The slope of the beach is approximately 15 to 20 percent.

4.2. Longshore Transport

It is probable that the beach at the head of the bay was formed by the deposit of materials transported up the north and south shores of the harbor from the east to the west. This points to a general along-shore transport down the bay toward the beach at the head.

Undoubtedly, sediment moves along the beach (north and south) in response to relatively small changes in the wind direction. Therefore, it takes only a minor change in the direction of an east wind to switch the dominant shoreline supplying the sediments to the head from the south to the north shoreline and visa versa. There is no obvious indication which shoreline contributes most of the sediment.

It is worth noting that neither stream mouth migrates any appreciable distance along the shoreline. This probably indicates that the north and south longshore transports are nearly equal. As sediment is produced from erosion on the adjacent north and south shorelines, it is transported and deposited at the headland beach and in the nearshore. This probably results in the gradual seaward migration of the stillwater-line and the increased elevations of the backshore. Simultaneously, a small amount of beach sediment is blown further onshore by the wind.

4.3. Effects of a Harbor

Two questions that need to be addressed are:

- How would a harbor and its associated inlet be affected by this beach system?
- How would the system, in turn, respond to the harbor and inlet?

The answer to these questions will probably depend on the extent to which the facilities are built seaward. Ultimately, the tendency will be for the beach to move seaward as it absorbs the sediments transported to it as it has been doing. Any harbor inlet that will be encroached on by sediments being transported alongshore will be subject to shoaling on its harbor end (flood-tide shoals) and on its seaward end (ebb-tide shoals). Clearly, this tendency at Akutan Harbor would be severely reduced by the minimal amount of sediments available for transport and the fact that winds and presumably waves will be approaching the beach nearly head on. Such wave angles tend not to generate much longshore transport. The tendency to build up deposits in the inlet would be further reduced by constructing jetties on one or both sides of the inlet. As sediment begins filling the corners formed where the jetties connect to the beach, sediment fillets will develop and expand. However, these fillets could quite easily be excavated and the sediment mechanically transported back to the beach. This would greatly reduce the amount of sediment that could enter the inlet.

A portion of the sediment that forms the beach is transported from inland sources by the two streams. This material also contributes to the small alluvial fans fronting both streams. There are no particular depositional features that would suggest a strong interaction between the streams and the beach, such as creation of long-shore bars at their mouths. Therefore, it is unlikely that isolating them from the beach sediments through the construction of the harbor facilities would change them appreciably.

Since it appears that only a small amount of sediment participates in the transport processes at the head of the bay, the amount of maintenance dredging will be minimal. Alluvial fans have developed offshore of each stream, and it is suspected that these fans are probably more a result of long-shore sediments being swept offshore by the stream than sediment being transported down the valley by the stream. A third, but considerably smaller (perhaps ephemeral) stream also bisects the northern half of the beach. It appears that this stream may flow only during periods of high runoff, and it has also created a small alluvial fan offshore. It is likely that maintenance dredging would not be required at intervals shorter than 10 years.

5.0 HARBOR DESIGN CRITERIA

As stated in Section 1.0, design criteria for this project were developed from published standards and methods as outlined in *"Shore Protection Manual"* (SPM), (USACE, 1984), *"Design of Breakwaters and Jetties,"* EM 1110-2-2904, (USACE 1986), and *"Hydraulic Design of Deep-Draft Navigation Projects,"* EM 1110-2-1613 (USACE 1994).

Other useful channel design criteria are found in *"Planning and Design Guidelines for Small Craft Harbors,"* (ASCE, 1994) *"Approach Channels A Guide for Design,"* (PIANC 1997).

5.1. Design Vessel and Design Fleet

The typical vessel using Akutan Harbor is a larger sized Bering Sea commercial fishing vessel consisting of trawlers and catcher processors. These vessels range in size from about 80 feet length overall (LOA) to more than 160 feet LOA. Beams range from about 24 to more than 40 feet. Drafts range from about 8 to 16 feet.

The local Village of Akutan fleet consists mainly of vessels under 40 feet in length. Currently, there are about 20 of these smaller vessels used by the locals.

The Akutan Harbor fleet is summarized below.

Table 11. Akutan Harbor Fleet

Length (ft)	0–24	24–32	32–110	110–140	140–160	160–180	Total
Village	10	10	0	0	0	0	20
Trident	0	0	8	22	23	7	60
Total	10	10	8	22	23	7	80

The design vessel is a Bering Sea trawler type vessel. Although there are larger vessels that may use the harbor, such as catcher processors, the design vessel is thought to represent the upper end (in terms of size) of a Bering Sea commercial fishing vessel that might reasonably be expected to use the harbor. Dimensions are summarized in table 12.

Table 12. Design Vessel

LOA (ft)	160
Beam (ft)	35
Draft (ft)	14

5.2. Design Basin Area per Vessel

The amount of published data related to how many vessels of various sizes can be accommodated per acre in a moorage basin is somewhat sparse. One source is *"Marinas and Small Craft Harbors"* by Tobiasson and Kollmeyer (1991). This text has a table that outlines typical boats per acre for vessels up to 60 feet in length. Harvey Smith, State of Alaska Department of Transportation Coastal Engineer, has also developed some criteria for vessels per acre for vessels up to 180 feet in length.

The number of vessels per acre is largely dependent of the moorage arraignment. The moorage arrangement is dependent on fairway width, general float layout, stall or parallel moorage, and whether rafting is allowed.

The design vessels per acre values used for this project are summarized in table 13. The values were compiled and adjusted from the above two referenced sources. They should be used for planning purposes only.

Table 13. Design Vessels Per Acre

Vessel Length (ft)	1.75 LOA Fairway, Stall Moorage, No Rafting Allowed	1.75 LOA Fairway, Parallel Moorage, No Rafting Allowed	1.75 LOA Fairway, Parallel Moorage, Rafting Allowed
20	81		
24	57		
30	43		
40	26		
50	18		
60	13		
70	7.5	9.5	11.75
80	6.5	8.25	10
90	5.5	6.9	8.3
100	5	5.35	5.7
120	3	3.3	5.1
140	2	2.75	4.25
160	2	2.2	3.4
180	2	2	2.5

5.3. Allowable Wave Heights

In general, the disturbance in the mooring basin should not exceed a 1-foot height for a 50-year event. In addition, the final mooring basin design should meet the standards outlined in table 14.

Note that the standards above include a vessel orientation parameter (head or beam seas) and a maximum horizontal motion criterion. These standards were supplied by the State of Alaska Department of Transportation and Public Facilities and are based upon a Canadian study of acceptable wave climates in harbors commissioned by the Canadian Department of Fisheries "*Study to Determine Acceptable Wave Climate in Small Craft Harbours,*" (Northwest Hydraulic Consultants Ltd., 1980). The horizontal motion and vessel orientation criteria are important parameters not accounted for in the maximum one-foot wave height requirement.

Table 14. Wave Criteria for Mooring Basin

Recurrence, Orientation and Period (T in seconds) For Wave Heights (H1/3):	Wave Height (ft)
1 year interval, Beam Sea, T>6	0.50
1 year interval, Beam Sea, 2<T<6	0.50
1 year interval, Beam Sea, T<2	1.00
50 year interval, Beam Sea, T>6	0.75
50 year interval, Beam Sea, 2<T<6	0.75
50 year interval, Beam Sea, T<2	1.00
1 year interval, Head Sea, T>6	1.00
1 year interval, Head Sea, 2<T<6	1.00
1 year interval, Head Sea, T<2	1.00
50 year interval, Head Sea, T>6	2.00
50 year interval, Head Sea, 2<T<6	2.00
50 year interval, Head Sea, T<2	2.00
For Horizontal Motion (ft):	Horizontal Motion (ft)
1 year interval, Beam Sea, T>6	1.00
50 year interval, Beam Sea, T>6	2.00
1 year interval, Head Sea, T>6	2.00
50 year interval, Head Sea, T>6	4.00

5.4. Entrance Channel

The entrance channel to the small boat harbor has four primary design parameters width, depth, length, and alignment. The location for the entrance channel is roughly the same for all the inland harbor alternatives and was chosen for ease of navigation and environmental reasons. During initial study, the entrance channel was aligned with a natural offshore channel near the south side of the head of the bay. This location was thought to be advantageous because of the possibility that shorter breakwaters and jetties could be used due to the wave refraction effect of the offshore channel. Subsequent preliminary environmental studies indicated that this area is frequented by Eiders. For this reason, the entrance channel was moved to the north side of the head of the bay.

During review of the initial draft of this study, concerns were raised about the circulation and flushing within the inland basin. This led to further study and revisions to the entrance channel as well as to the general shape of the basin in an effort to improve circulation and flushing. These improvements are shown on the "Reconfigured 12 acre basin" figures in this document. The revisions include maintaining a rather narrow entrance channel from the bay into the basin in an attempt to maintain the momentum of the tidal prism and hence to increase circulation.

Initially the inland harbor alternatives were depicted with a somewhat "V" shaped entrance channel that opened up into the harbor. The reason for this was so that an adequate turning radius could be maintained for access into the east side of the mooring basin and to floats located along the west side of the basin. To improve circulation, this was later reconfigured into a more traditional parallel bank entrance channel. This required that the access into the float area be along the west side of the basin with floats located along the east side. This resulted in a slightly larger maneuvering channel and slightly larger over all basin area.

5.4.1. Width

Primary factors involved in the design width of the entrance channel include the traffic pattern (one or two lanes), the design ship beam and length, environmental factors such as wind waves and current, and the channel cross section shape. Channel width is defined as the toe-to-toe width measured from the bottom or toe of the side slopes.

Channel width elements consist of a maneuvering lane, bank clearance, and ship clearance if 2-way traffic is anticipated. The width of each of these elements is dependent on the beam of the design ship, the controllability of the vessel, and on the alignment of the channel.

Based on the criteria set forth in EM 1110-2-1613 and EM1110-2-1615, an entrance channel width of 100 feet would meet the criteria for 1-way traffic of a 35-foot wide (beam) design vessel in a straight channel section.

A 100-foot channel width is on the narrower end of the spectrum of "industry standard" entrance channel widths. However, there are several factors that support the use of this width. First, the fleet using the harbor will be less then 200 vessels. This means that traffic into and out of the harbor will be light. Next, the tides at Akutan are quite small and visibility around the entrance channel should be fairly good. This is especially true for the larger commercial fishing vessels that are expected to make up the majority of the fleet. The wheelhouses of these vessels will generally be high enough to see any approaching vessel traffic over the crest of the jetties. Also, the relatively narrow entrance will increase the protection from the ambient wave climate. Finally, the relatively narrow width will maximize flushing of the harbor by increasing the momentum of the tidal current in the basin. Based on the above discussion, a minimum entrance channel width of 100 feet is recommended for this project.

The initial design called for a 100-foot toe-to-toe width at the beginning of the entrance channel (outer entrance) widening to approximately +300 feet at the entrance into the harbor basin. The widening the channel was configured to aid in navigation and maneuvering. Water quality concerns were raised during agency review of the draft report. These concerns led to a numerical model study of the basin and a redesign of the entrance channel in an effort to increase tidally generated momentum in the entrance channel and to thereby increase flushing and improve water quality. The "reconfigured 12 acre basin" design includes a relatively narrow (100' wide) uniform width entrance channel. Navigation and maneuvering are not impacted because the turning basin is not next to the entrance channel in the reconfigured design.

5.4.2. Depth

Primary factors involved in entrance channel depth include the at rest design vessel draft, tide height, vessel squat, vessel heave pitch and roll due to wave action, and a safety margin based on bottom type. For this project the following parameters were used:

a. Design vessel draft: 14.0 feet

b. Tide height (extreme low): 2.9 feet

c. Squat: 0.4 feet

   A ship in motion will cause a lowering of the water surface because of the change in velocity about the vessel. The amount of lowering will be dependent on the speed of the vessel and the characteristics of the channel. For smaller recreational vessels, squat is normally estimated at 0.5 feet. For larger vessels, squat is normally calculated using the procedures outlined in EM 1110-2-1615. This involves determining the "blockage ratio of the submerged cross section to channel cross section," and determining the Froude number for the vessel in the channel. These values are then applied to a table to determine squat.

For this project, the submerged cross-section of the design vessel was found by multiplying the beam times the draft times the midsection coefficient. The midsection coefficient was assumed to be 0.9 (a typical value). This results in a design vessel submerged cross section area of 441 square feet. The channel cross sectional area was found to be 4,000 square feet based on an assumed depth of 20 feet and a width of 200 feet. A ratio of vessel to channel cross section was found to be 0.11.

The Froude number is dependent on the vessel speed and channel depth. Assuming a channel depth of 20 feet and a vessel speed of 8.5 feet per second (about 5 knots), the Froude number was found to be 0.335.

The above discussion leads to the following calculated squat of approximately 2 percent of the channel depth or about:

d. Wave motion (½ 50 year significant wave): 1.5 feet

e. Safety clearance (soft bottom): 2.0 feet

Total Calculated Entrance Channel Depth: 20.8 feet

The above total is predicated on the extreme significant wave event coinciding with the extreme low tide event. The probability of these two events occurring simultaneously is very low. An optimization study was performed and it was found to be cost effective to provide an entrance channel depth of –18 feet MLLW. This was found to be a reasonable value and is recommended for the entrance channel bottom elevation.

5.4.3. Length

The length of the entrance channel will have an effect on the inner harbor wave climate. Generally, longer channels provide more wave attenuation due to refraction and turbulence along the armored channel slopes.

For this project, another consideration is the effect the basin could have on the existing beach. An entrance channel length of approximately 400 feet was chosen for the inland basin option. This allows for the majority of the existing beach to remain unaffected by the harbor basin and provides for an approximate 175 foot separation distance between the harbor and the beach. This channel length also allows a relatively straight approach to the harbor.

5.4.4. Alignment

The entrance channel alignment was chosen because it provided the most direct access possible to the harbor while maintaining an acceptable inner harbor wave climate. As a rule of thumb, the turning radius for the channel should be no less than 2.5 times the length of the design vessel or 400 feet.

The jetties protecting the entrance channel are angled slightly from perpendicular to the beach face. The opening of the channel essentially points directly into Akutan Harbor aiding navigation as no significant turning will be required to enter the channel. However, it also means that approaching waves will be aligned with the entrance channel increasing the wave climate just inside the entrance channel mouth. The entrance channel is designed to decrease wave energy sufficiently prior to entrance into the mooring basin.

5.4.5. Inner Harbor Wave Climate

As stated in the previous section, waves moving westerly inside Akutan Harbor will approach relatively unimpeded into the entrance channel. In order to achieve the desired inner harbor wave climate, the entrance channel must be designed to bleed off wave energy as the wave moves down the channel prior to entering the inner basin. Refraction, shoaling, and turbulence will dissipate a portion of the wave energy as it travels down the entrance channel.

As the wave enters the harbor a portion of the wave is diffracted around the corner of the south breakwater into the harbor basin. Diffraction is the spreading of wave energy from areas of high energy to areas of less energy often behind or around obstructions. An often-used example of diffraction is the reduced wave energy on the lee side of an island. The waves impacting on the windward side expend a portion of their energy effectively leaving a gap in the wave. In this example, at some distance from the island's lee shore, waves again reform and build as wave energy moves along the crests to fill the void. If there were no reforming of waves (diffraction), there would be perfectly calm wave shadow areas extending indefinitely behind islands.

The wave climate for the "reconfigured 12 acre basin" was modeled using REFDIF software. The results of this modeling are included in an appendix to this document and are summarized in figure 5.

As can be seen from figure 5, most of the mooring basin area falls in an area where waves of less than 0.6 feet are expected. There are a few areas where the waves will be 0.8 feet or less and there are no areas where waves of 1.0 feet or larger are predicted during a 50-year event.

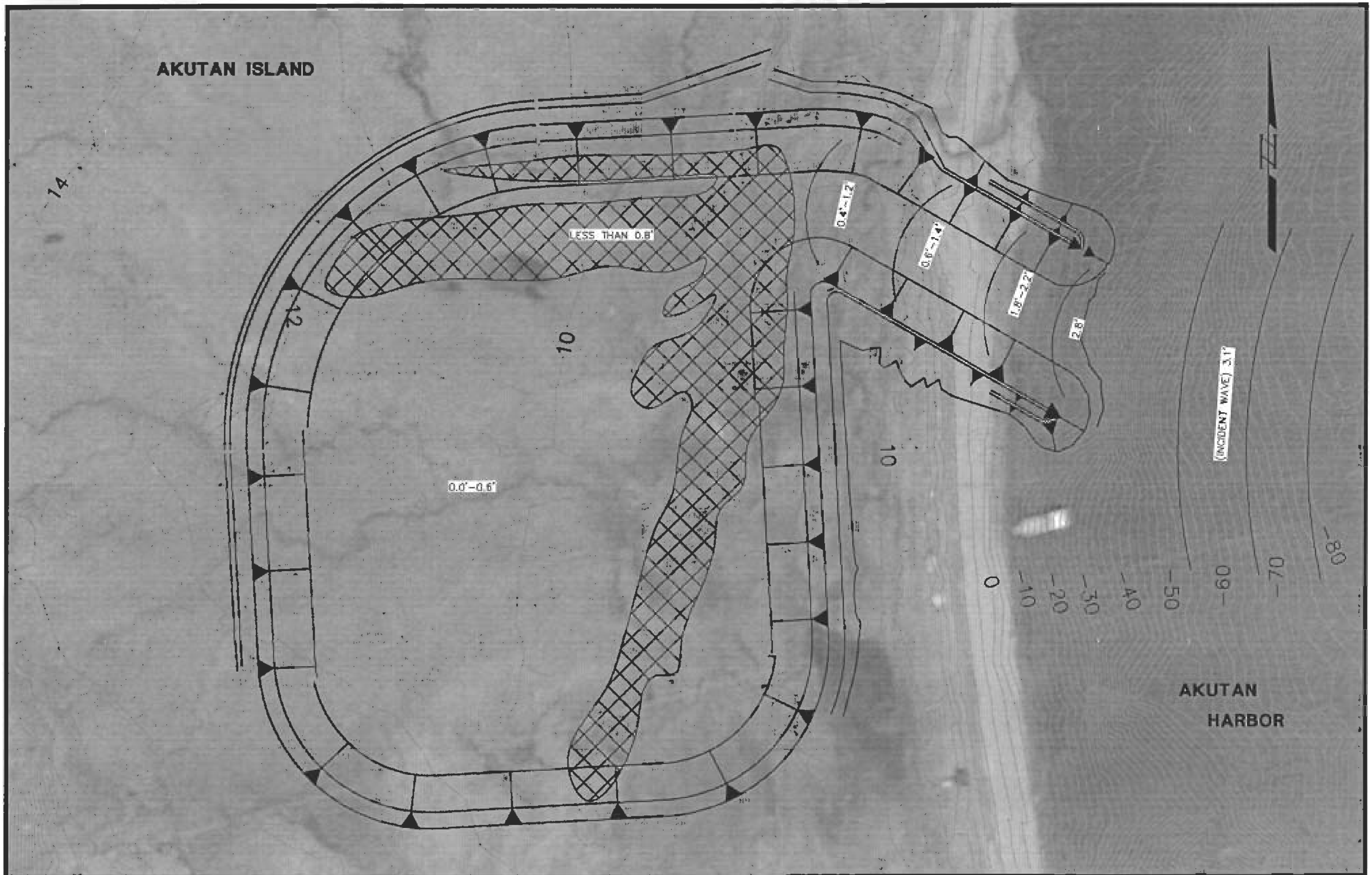
5.5. Circulation and Flushing

Circulation and flushing in the proposed harbor is a design consideration. The Akutan area has relatively low tidal range. As outlined previously, MHHW is about 4 feet. This means there is a relatively small tidal driving force for circulation and exchange in the proposed harbor.

5.5.1. Design Aspects to Improve Circulation

The ratio of length-to-width (aspect ratio) for the basins considered in this report varies from about 1.3 to 1.6. Aspect ratios of 0.5 to 2.0 are generally recommended for adequate harbor circulation and flushing.

The inland basins in this report were configured with large radius corners, about 200 feet. This was done to enhance circulation. The entrance channel was designed with a 100-foot wide section at the mouth. This was done to provide wave protection and to increase the momentum of the tidal exchange and to improve circulation.



NOTES

INCIDENT WAVE HEIGHT = 3.1'
4.7 SECOND WAVE PERIOD
50 YEAR RETURN PERIOD
WAVE CLIMATE BASED ON MODELING BY
"REFDIF" (TRADEMARK) WAVE ANALYSIS SOFTWARE

GRAPHIC SCALE
100 0 50 100 200
(IN FEET)
SCALE: 1" = 200'

INNER HARBOR WAVE CLIMATE

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AKUTAN ALASKA

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FIGURE 5

5.5.2. Circulation Modeling

Circulation in the 12 acre inland basin (described later) was modeled using a three dimensional numerical model as part of this study work. A report entitled "Circulation Modeling in Akutan Harbor and the Potential Impacts by and to the Proposed Small Boat Harbor" is included in a separate appendix to this report. Circulation in the reconfigured 12 acre inland basin was modeled using a three dimensional numerical model. A report entitled "Additional wave and water quality analyses for the potential boat basin at Akutan harbor, Alaska" is include in a separate appendix to this report.

5.6. Basin Depths

The basin design depths were established by considering water levels, wave activity, vessel motions, and safety factors. For this project, due to the wide range in vessel sizes, it will mean a stepped harbor basin.

Vessels from 20 to 120 feet will be moored in an area that has a minimum depth of –14 feet MLLW. Vessels from 120 to 150 feet will have a minimum depth of –16 feet. Vessels over 150 feet will have a minimum depth of –18 feet MLLW. These depth ranges are shown in table 15.

Table 15. Basin Depths

Harbor Area	Depth (ft)
Entrance Channel	18
Vessels > 150 ft	18
Vessels 120–150 ft	16
Vessels 20–120 ft	14

5.7. Wind Protection

As discussed in the previous section on climatology, the local winds are heavily influenced by the local topography. As such, the principal wind directions are east and west. To reduce wind-induced motion as well as to reduce wind loads, the inner harbor floats should be configured to align the long axis of the moored vessels parallel to the wind.

5.8. Geotechnical Stability

Earthquakes are not normally given a great deal of consideration in federally funded USACE projects such as this one. This is due to the generally low statistical probability of a significant event occurring in the fifty-year design life of the structures. Akutan has several significant features that merit seismic consideration, even for a fifty-year design life.

Akutan is located in a very active seismic zone. It is very close to the convergence of the North American and Pacific lithospheric plates in a region known as the Aleutian "megathrust" fault. The State of Alaska Department of Transportation (ADOT) has estimated that an earthquake with a peak acceleration of 0.35 g will have a 90% probability of not being exceeded in 50 years. This level of acceleration represents a large earthquake. Seismic mapping, within 25 miles of the site, has pointed to one recorded earthquake in excess of magnitude 7.1 and two recorded earthquakes of magnitude 6.1 to 7.0.

As stated above, Akutan is located almost directly above the Alaska Aleutian megathrust. According to the "*Probabilistic Seismic Hazard Maps of Alaska,*" (USGS Open File Report 99-36, Wesson et al, 1999):

> *Clearly the majority of the seismicity in the region is associated with the Alaska-Aleutian megathrust fault extending eastward along the Aleutian arc into south-central Alaska. The northwestward – moving Pacific plate is subducted along this megathrust beneath the North American Plate giving rise to the Aleutian trench and islands.*
>
> *The Alaska-Aleutian megathrust has been responsible for several of the largest earthquakes known in instrumental seismology, including the 1964 Prince William Sound (Mw 9.2) and the 1957 (Mw 9.1) earthquakes.*

This seismic activity raises concerns related to slope stability and liquefaction. Seismic conditions in the Akutan area are discussed in more detail in the Geotechnical Section (Appendix C).

5.8.1. Liquefaction

The existing soils at the head of the bay have been found to be only moderately prone to liquefaction. This is due to the existing medium dense, well-graded, coarse, sandy material that is fairly permeable.

In "*Seismic Guidelines for Ports*" by Stuart Werner, (ASCE, March 1998), the following discussion of liquefaction appears:

> *By far the most widespread source of earthquake-induced damage to port and harbor facilities has been liquefaction of the loose, saturated, sandy soils that often prevail at ports. Liquefaction has occurred at ports, even under only moderate levels of ground shaking. It leads to a reduction in stiffness and a loss of shear strength of the liquefied soils which, in turn, induces ground failures and soil settlement as well as increased lateral pressures on retaining walls and a loss of passive resistance against walls and anchors.*
>
> *The liquefaction of a loose, saturated granular soil occurs when the cyclic shear stress/strains passing through the soil deposit induce a progressive increase in the pore water pressure in excess of hydrostatic. In loose to medium dense sands pore pressures can be generated which are equal in magnitude to the confining stress. At this state, no effective stress exists between the sand grains and a complete loss of shear strength is temporarily experienced.*

There are a number of techniques available for mitigating liquefaction hazards. These include:

- Increasing the density of loose soils.
- Providing for higher permeability.
- Confining susceptible soils with a heavy layer of granular material.

- Using less steep slopes where possible.

The density of the soils can be increased by various means including vibrocompaction. Vibrocompaction can be one of the more cost effective soil densification methods. It is technically possible to densify the soils for an increase of about N > 10 (where N = the standard penetration value, a measure of density). An increase such as this can take a loose soil condition and make it medium dense. This can be done to depths exceeding 60 feet. For Akutan vibrocompaction could be achieved for a cost of about $250,000 per acre with a minimum of about 5 acres.

Permeability can be increased through the use of granular fill material and drains. One technique is to place granular fill in vertical "stone columns" that are designed to relieve excess pore water pressure. These columns are placed on a specified grid designed to ensure that the pore pressure never reaches the liquefaction limit.

Confining susceptible soils with a heavy layer of granular or rock fill can result in soil pressures that remain above the liquefaction pore pressure during an earthquake.

Using less steep slopes can lessen the chance of lateral spreading or other slope failure mechanisms.

5.8.2. Seismic Design Criteria

For this project, slopes and structural stability were analyzed using a seismic coefficient of 0.15 g. Note that this is less than the peak value of 0.35 g outlined by ADOT for the Akutan area. Peak seismic acceleration values have been found to poorly represent actual seismic design accelerations as they represent maximum accelerations of generally short duration during a seismic event. Designing to an extreme value of 0.35 g would lead to a prohibitively costly basin. The design seismic coefficient is generally taken to be between ⅓ to ½ of the peak value.

It is likely that during a major earthquake some damage will occur to the harbor slopes. The level of damage to expect during a design size seismic event is difficult to surmise. Many factors contribute to potential damage during an earthquake, such as magnitude, duration, and direction of ground movement. An approximation of damage during various seismic events is shown in the Geotechnical Section provided as Appendix C.

Slope failures would likely begin at the toe of the slope, where the lateral earth pressure is greatest with respect to the confining pressure. Therefore, it is important to carry the riprap down to the reinforced toe structure. It is estimated that under most anticipated seismic events, the majority of slopes would remain intact and slope repair would be limited to dredging of some sloughed materials and patchwork repair of the armored slope. Complete slope failure is possible if the area is subjected to a very large or long duration earthquake.

5.8.3. Breakwater Slopes

Slopes of 2 horizontal to 1 vertical were used during preliminary design of breakwaters and jetties. This slope transitions to a 3:1 inner harbor slope approximately 150 feet into the entrance channel. Slopes of 3:1 for the breakwater were investigated and proved to offer more stability during seismic events. However, armor stone and other breakwater construction materials are an important factor in overall project cost. Therefore, 2:1 slopes were deemed the more economical alternative.

5.8.4. Inner Harbor Slopes

The inner harbor slopes will be set at 3 horizontal to 1 vertical below the water line and at 2 horizontal to 1 vertical above the water line in the harbor basin. These criteria will apply to any slope in the water table area. The slopes will be covered with two layers consisting of 18 inches of 6 to 12 inch diameter armor stone (riprap) placed over 12 inches of filter rock. The rock layers will be underlain with a geotextile filter fabric. Figures 6 shows a cross section of the typical inner harbor slope.

5.8.5. Upland Fill Areas

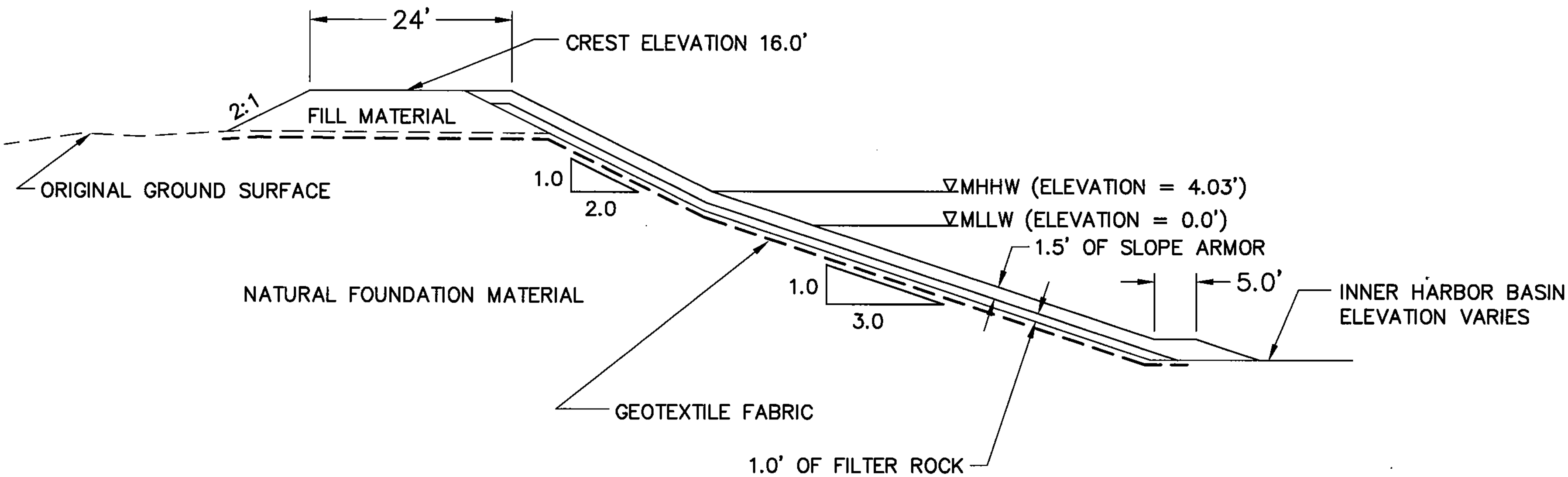
Upland fill areas will be constructed using harbor dredge materials. Slopes of 2 horizontal to 1 vertical above the water table and outside of the basin may be used. Dredged soils will have to be well drained prior to placing. A drainage basin should be prepared during construction to temporarily hold dredged materials and allow them to drain. The drainage basin runoff should be diverted back into the harbor basin. Once drained, dredged materials can be spread out on the uplands areas.

5.8.6. Upland Buildings

Buildings will likely be placed on fill. All buildings should be placed on engineered foundations. These foundations may include piles or compacted base materials.

5.9. Moorage Configuration

The moorage configuration considered for the harbor basin is a rafting type parallel moorage arrangement for the larger vessels. Large vessels are allowed to raft two deep alongside main floats. There would be no individual stall floats for vessels over 40 feet in length. Vessels under 40 feet in length will be berthed in stalls. The rafting parallel float arrangement for larger vessels will allow for more vessels per acre in the harbor. For the larger vessels, the main floats including the marginal float should be a minimum of 10 feet wide. The inner harbor float system should be constructed along the east side of the basin with the turning basin and maneuvering channel located along the west side of the basin.



GRAPHIC SCALE

10 0 5 10 20

(IN FEET)
SCALE: 1" = 20'

TYP. INNER HARBOR ARMORED SLOPE

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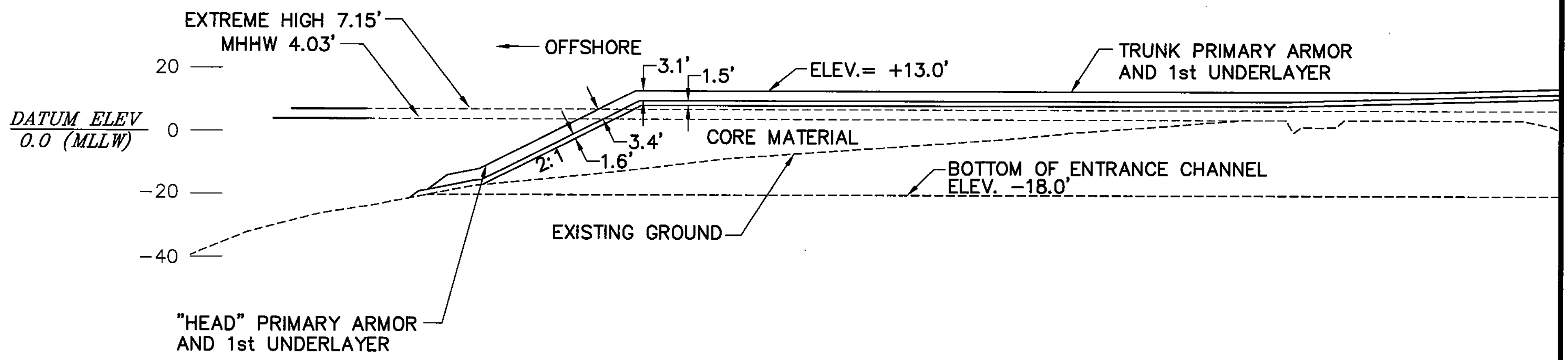
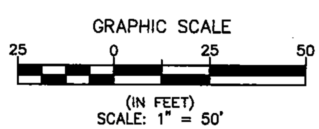
FIGURE 6





TYPICAL RUBBLEMOUND BREAKWATER ELEVATION

ENGINEERING/SURVEYING & LANDSCAPING ARCHITECTURE
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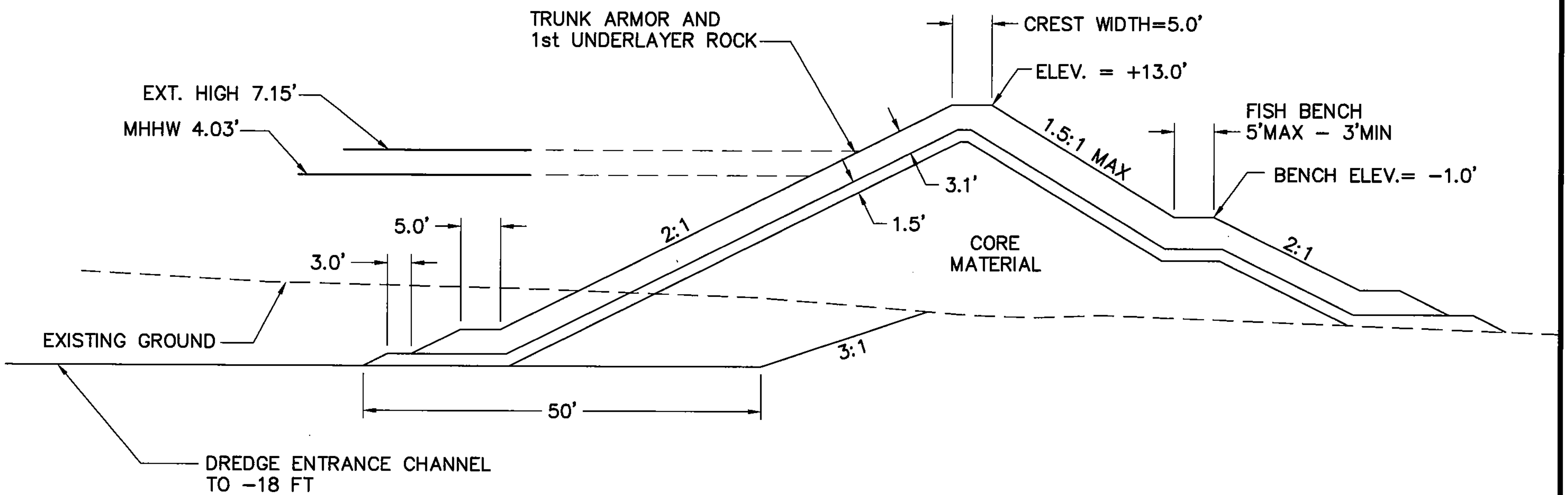
FIGURE 7



GRAPHIC SCALE
10 0 5 10 20
(IN FEET)
SCALE: 1" = 20'

TYP. RUBBLE MOUND BREAKWATER SECTION

NAVIGATION IMPROVEMENTS

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FIGURE 8

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5.10. Rubblemound Breakwaters/Jetties

All the alternatives advanced for further consideration incorporate various rubblemound breakwater components. These rubblemound breakwaters/jetty structures define and protect the entrance channel.

Methods described in the SPM and EM 1110-2-2904 were used to develop values for breakwater primary armor stone weights and dimensions, breakwater crest heights and widths, primary armor stone layer and under layer thickness, and under layer and core material sizes.

5.10.1. Rubblemound Foundation

Two rubblemound foundation design options were explored during the study. The first design places the rubblemound structure directly on existing soils. The second design utilizes an excavated buttress filled with shot rock (core material) as a foundation for the rubblemound structure. The main controlling factors in these designs are the seismic and geotechnical conditions at the site, constructability, and cost.

Rubblemound Structure on Existing Soils. The first design option places the rubblemound structure on top of existing soils. Existing soils may be vibrocompacted to decrease the tendency toward liquefaction and increase stability during seismic events. The channel is dredged an additional 50 feet wider under the breakwater toe so that more core material is placed under the breakwater armor to increase overall stability. Dredge slopes then turn upward at 3:1 to meet the existing ground surface. The advantages and disadvantages of this design are as follows:

Advantages:

- Overall ease of construction.
- Substantial cost savings in dredging and in core materials.

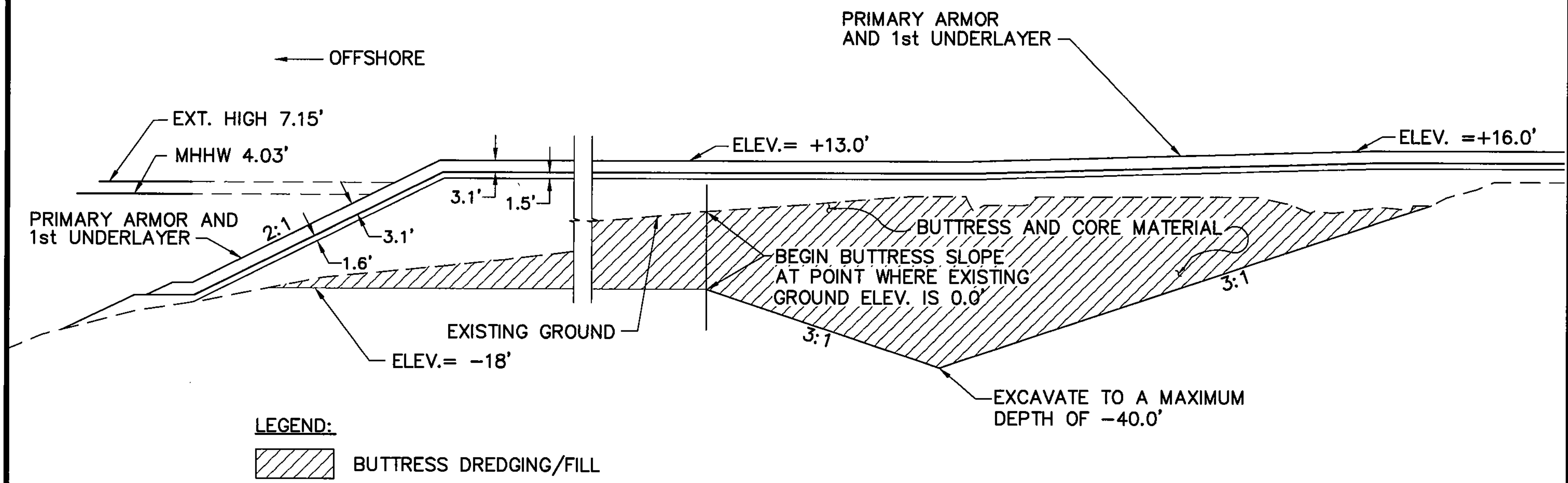
Disadvantages:

- This design is less stable during a seismic event. The seismic factor of safety for this design during the design seismic event is 0.8 (see Appendix C).

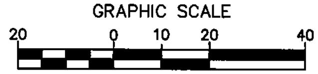
Rubblemound Structure on Excavated Buttress. The second design option calls for the construction of a buttress under portions of both breakwaters. The buttress, as defined for this project, is an excavation under the rubblemound structure that is filled with shot rock. This forms a kind of shear key into the substratum upon which the structures are built. Approximately 50,000 cubic yards of total additional dredging would be required to construct buttresses under both breakwater sections. An equal amount of shot rock/core material would be needed to fill the buttresses. The shot rock material is not susceptible to liquefaction and provides for increased foundation stability. In addition, the weight of this fill adds to the confining stress under the buttress, furthering the resistance to liquefaction. The advantages and disadvantages of this design are as follows:

Advantages:

- Seismically, the design is more stable. This design has a seismic factor of safety of 1.1.



TYP. LONGITUDINAL SECTION THROUGH BREAKWATER AND BUTTRESS



RUBBLE MOUND W/BUTTRESS

NAVIGATION IMPROVEMENTS

AKUTAN ALASKA

FIGURE 9

Disadvantages:

- The design is geometrically complex and difficult to present graphically.
- The design is difficult to construct. This design calls for a large area to be over-excavation under the breakwaters with 3:1 side-slopes. The entire buttress would have to be excavated underwater down to an elevation of –40 feet MLLW.
- The cost of excavation, removal, draining, and storage of extra dredge materials, as well as the cost for extra potentially imported core material to fill the buttress drives up total project costs. A preliminary cost estimate shows the cost for buttress dredging and fill material alone is about $2 million.

Chosen Study Design Option. The design option pursued in detail in this study is option one (without the buttress). The reason is that despite a level of risk in constructing the breakwater with a seismic factor of safety of less than 1.0, the overall cost savings and ease of construction make this option the one most likely to be funded and constructed.

5.10.2. Stone Weight and Size and Layer Thickness:

Primary armor stone weight (W) was calculated using the Hudson Formula.

The Hudson formula is given as

$$W_a = \frac{\gamma_a H^3}{K_D (S_a - 1)^3 \cot \alpha}$$

Where:

W_a = weight of an individual armor stone

γ_a = unit weight of the armor unit

H = design wave height

K_D =stability coefficient

S_a =specific gravity of armor unit relative to the water $(S_a = \gamma_a / \gamma_w)$

; =angle of the structure in degrees from horizontal

Design parameters adopted for Akutan breakwater/jetty calculations include:

- A unit weight for armor stone of 165 lb/ft^3 (γ_a).
- The design wave (H_{10}) equaling 3.94 feet was used as H.
- The stone is assumed to be randomly placed rough quarry stone.
- A portion of the jetty trunk section will be in the breaking wave zone. Therefore K_D = 2.0 for the trunk section.
- The head of the jetty will use K_D = 1.6.
- A side slope of 2 horizontal to 1 vertical.

An average stone layer porosity (P) of 37% (based on randomly placed, rough quarry stone with a primary layer thickness of two armor units; i.e., n = 2) used to calculate layer thickness.

As stated above, portions of the breakwater/jetty are in the breaking wave zone. Therefore, a K_D value of 2.0 (as recommended by the SPM) is used in Hudson's formula for calculations pertaining to the trunk portion of the breakwater. The calculated primary armor stone weight for conditions present at Akutan is 640 pounds with an average stone thickness of 1.95 feet.

The head of the jetty requires special consideration due to the more dynamic wave environment. A K_D value of 1.6 was recommended by the SPM for breaking-wave conditions at the structural head. Using this K_D value, the calculated weight for the primary rock on the head of the structure was found to be 800 pounds. The average stone thickness was found to be 2.0 feet in diameter. This rock is relatively close in size to the trunk portion rock, and is in fact captured by the allowable range of rock sizes for the trunk. Therefore, for simplicity, a separate size of rock is not called out for the head of the breakwater. Special care should be taken to select larger stones within the recommended size range during construction for the head section. Table 16 provides stone weights and diameters, as well as layer thickness. Table 17 provides gradation ranges of stone weights that apply to the project.

Table 16. Stone Weights, Sizes, and Layer Thickness

Layer	Stone Weight Range (lb.)			Average Stone	Layer
	Minimum	Calculated wt.	Maximum	Diameter	Thickness (ft.)
Breakwater Armor Rock					
Primary Armor (W) Layer	480	640	800	1.95 ft.	3.1
Underlayer, Core, Buttress, And Filter Bed					
1st Underlayer (W/10)	45	64	83	10.8 in.	1.5
Core (W/200)	0.96	3.2	5.4	4.5 in.	Varies
Buttress (W/200)	0.96	3.2	5.4	4.5 in.	Varies
Filter	$D_{15\ (filter)}$ [5 x $D_{85\ (foundation)}$			N/A	3.0

Table 17. Stone Gradation

Rock Size	Rock Size Gradation Limits (%)
W	125 to 75
W/10	130 to 70
Core/Buttress	170 to 30
Filter	170 to 30

As shown above, the acceptable gradation for primary armor stone is considered to be ∀25% by weight. Therefore, the structure trunk primary stone may range from 480 lbs to 800 lbs. Other stone weights follow the same range methodology.

5.10.3. Crest Elevation and Overtopping:

Crest height was set to minimize overtopping of the structure by extreme wave events. A small amount of overtopping can be acceptable if it does not cause damage by waves or other effects behind the structure. The crest elevation is dependent upon several factors including; high tide, storm surge, wave setup, and wave runup.

The high tide, storm surge, and wave setup values were previously discussed in relation to the design still high water level. To recap, extreme high tide was found to be 7.15 feet, storm surge was found to be 0.2 feet, and set up was found to be 0.38 feet. These combine to form the design still high water level of 7.73 feet.

Runup is dependent on several factors including wave characteristics, design water level, structure depth, structure slope, and the roughness of the material. Wave runup calculations were performed using methods outlined in the SPM. Calculations were based on the following parameters:

- A deep water wave height (H_o) of 3.94 feet.
- 2 to 1 slopes.
- Randomly placed quarry stone with a roughness correction of 0.55.
- Depth at the toe of the structure (extreme high water) 27.73 feet.

Calculations were performed using several tables in the SPM. The results of the calculations show a wave runup of 4.92 feet from the still water level. Adding the runup value of 4.92 feet to the design high water level of 7.73 feet yields 12.65 feet. This value has been rounded to a practical value of 13.0 feet.

5.10.4. Crest Width

Crest width calculations were determined using methods from the SPM. Crest width is found by applying a formula, which takes into account overlap and meshing of the individual armor units. The SPM states that the minimum crest width should be based on the width of 3 armor stones. With nesting and overlap, the result is a crest width somewhat less than the sum of the individual armor unit widths.

$$\beta = 3k_{\Delta}\left[\frac{W_a}{\gamma_a}\right]^{1/3}$$

Where:

β = The crest width in feet.

k_{Δ}= The layer thickness coefficient, dimensionless.

W_a = Weight of individual armor units, pounds.

γ_a = Unit weight of armor, pounds per cubic feet.

For this project the layer thickness coefficient was 1.0 as outlined in the SPM for randomly placed rough armor stone. The weight of the armor unit was taken to be 640 pounds, and the unit weight of the armor rock was 165 pounds per cubic feet. These values lead to a calculated crest width of 4.7 feet. This value has been rounded up to the reasonable minimum crest width value of 5.0 feet.

Another rule of thumb is that the breakwater crest should be wide enough to allow access for construction equipment if possible. This access does not have to be at the final elevation of 13 feet, but must be set for a reasonable water level condition. Given a 2 to 1 side slope, there would be a useable base approximately 17 feet wide at a construction elevation of +10 feet. This elevation would be well above the high water level for all but the most extreme events.

6.0 ALTERNATIVES CONSIDERED

6.1. Introduction

A wide range of sites and alternatives were considered for navigation improvements in Akutan Harbor. These included many alternatives examined in previous study efforts.

6.2. No Action

Under a no action scenario, there would continue to be no permanent moorage facilities in Akutan. Larger vessels would travel to other areas or ports for long-term moorage. Small vessels would continue to be pulled out of the water when not in use.

6.3. Alternative Sites

Akutan Harbor contains a number of sites that could be potential harbor locations. A site selection drawing for the various sites in Akutan Harbor is presented in figure 10. This drawing basically subdivides and delineates the entire bay into various regions for discussion.

In previous studies, several areas of the bay have been summarily dismissed as potential harbor locations due to high ambient wave climates, steeply sloping upland and/or offshore terrain, difficult access issues, sensitive environmental areas, or other concerns. What follows is a brief narrative description of the site locations. Table 18 outlines the advantages and disadvantages of each of the site locations in Akutan Harbor.

6.3.1. Akutan Point

Akutan Point is located about 1.85 miles east of the community of Akutan. The site contains a small cove just to the southwest of and in the lee of the point. The uplands are steeply sloping and various birds use local sea cliffs for roosting and nesting. The area is used for the placement of subsistence set nets by the locals. A small pocket beach and offshore deposit exists south of the cove. This results in relatively shallow waters in the cove area.

6.3.2. North Shore Area 1

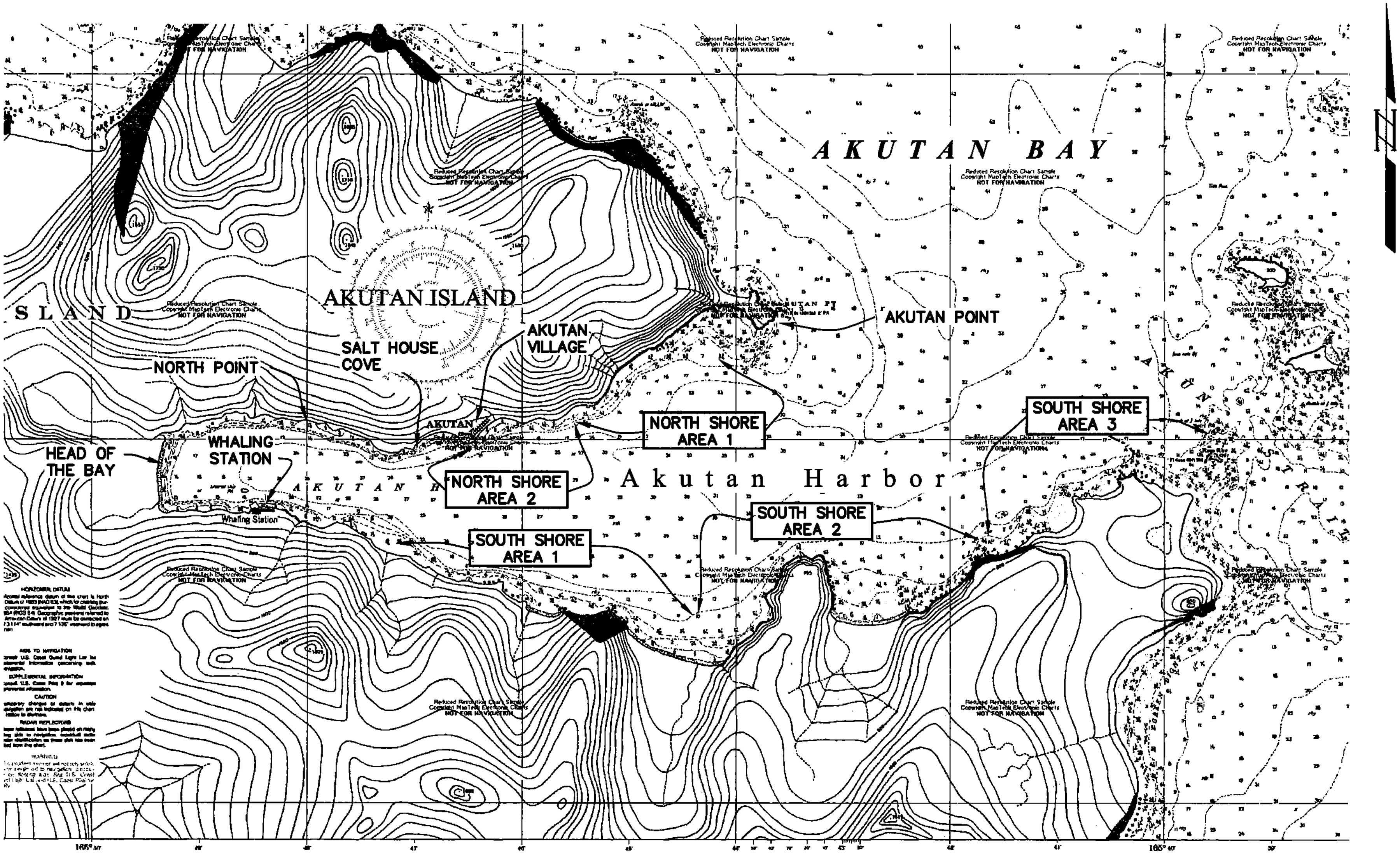
North Shore Area 1 is located about 1.4 miles east of the community of Akutan. The site is bordered by steeply sloping bluffs on the upland side. A relatively shallow bench with depths of about 25 feet extends offshore for approximately 400 feet. From there the bottom drops of rapidly to depths of 60 feet or more.

6.3.3. North Shore Area 2

North Shore Area 2 is located about ½ mile east of the community of Akutan. The site is bordered by steeply sloping upland terrain and relatively deep water (90 feet deep approximately 400 feet offshore).

6.3.4. Salthouse Cove

Salthouse Cove essentially separates the native village of Akutan from the Trident Seafood facility. The Trident facility is located on the western shore of the cove and the native village



GRAPHIC SCALE

2,500 0 2,500 5,000

(IN FEET)
1" = 5,000'

AKUTAN HARBOR SITE SELECTION	
HARBOR FEASIBLIITY STUDY AKUTAN ALASKA	FIGURE 10

ENGINEERING/SURVEYING & LANDSCAPING ARCHITECTURE
TRYCK NYMAN HAYES, INC.

is located of the eastern shore. The eastern corner of Salthouse Cove contains the City dock and seaplane landing facility. This area currently receives regularly scheduled seaplane, state ferry, fuel barges, and other services. A church and gymnasium owned by the Trident facility overlooks the center of the cove.

6.3.5. North Point

The North Point site is located just west of the Trident plant. The site is bordered by steeply sloping upland terrain and relatively deep water (80 feet deep approximately 500 feet offshore). Four submerged HDPE pipelines carry water to the Trident Plant from a dam located high on a hillside. The east end of the site is bordered by a sheet pile wall related to the Trident plant.

6.3.6. Head of the Bay

The head of the bay is characterized by a gently sloping sand beach. It is located about 1.75 miles west of the Trident plant. The beach contains an elevated and vegetated sand berm that separates it from the mostly flat lowland behind it. The uplands extend up into a broad U shaped valley. The valley is defined by steeply sloping uplands with two creeks at the margins. Both these creeks support runs of fish.

6.3.7. Whaling Station

The Whaling Station was constructed in 1912 by the Pacific Whaling Company and was operated until 1942. It is located in the southwest corner of the bay. The land is now privately owned and is used for gear storage by fishermen and the Trident plant. The site has been previously classified as contaminated by the Federal Government and was cleaned up as part of a FUDS program TERC contract.

6.3.8. South Shore Area 1

South Shore Area 1 extends from the area just east of the Whaling Station to a point near the mouth of Akutan Harbor for a distance of about 2 miles. It is characterized by steeply sloping on shore terrain and relatively deep offshore bathymetry. There is a large landslide area near the east end of this section. South Shore Area 1 receives a lot of wave energy from Akutan Bay to the northeast. There is little developable uplands and poor access to the site.

6.3.9. South Shore Area 2

South Shore Area 2 includes the area just west of a small peninsula near the mouth of Akutan Harbor. It is located about 2-1/2 miles from the Whaling Station. The site is characterized by a slight cove like feature that results in an offshore bench. South Shore Area 2 receives a lot of wave energy from Akutan Bay to the northeast. There are some developable uplands, but poor access to the site.

6.3.10. South Shore Area 3

South Shore Area 3 includes the area just east of a small peninsula near the mouth of Akutan Harbor. This area is outside the Akutan Harbor area. The site is characterized by a slight pocket beach resulting in an offshore bench. South Shore Area 3 is exposed to the full fetch and resultant wave energy from outside of Akutan Harbor to the north and east. There are some developable uplands but poor access to the site.

Table 18. Potential Harbor Sites

Location	Advantages	Disadvantages
Akutan Point	Relatively sheltered from north and west storms. Relatively shallow water could accommodate cost effective rubblemound breakwater structure.	Excessive distance from community and Trident facility. Access will require motor vessels for access to and from the community. Exposed to some long period waves from Bering Sea. Facility will be difficult to operate and to maintain due to distance from community. Environmentally sensitive area due to bird habitat, kelp beds, and other marine habitat. May be exposed to large ocean swells from the southerly direction or exposed to reflected waves. Not a local preference.
North Shore Area 1	Relatively sheltered from north and west storms.	Excessive distance from community and Trident facility. Access will require motor vessels for access to and from the community. Exposed to some long period waves from the Bering Sea. Facility will be difficult to operate and to maintain due to distance from community. May be exposed to large ocean swells from the southerly direction or exposed to reflected waves. Relatively deep water offshore, which limits the type of construction and effects cost. Not a local preference.
North Shore Area 2	Relatively sheltered from north and west storms. Relatively close to existing Trident facility and to the community of Akutan.	Exposed to some long period waves from the Bering Sea. May be exposed to large ocean swells from the southerly direction or exposed to reflected waves. Relatively deep water offshore, which limits the type of construction and effects cost. Not a local preference.
Salthouse Cove	Relatively close to existing Trident facility and to the community of Akutan. Relatively good natural wave protection.	Site too close to the existing community, ferry dock and seaplane ramp. Harbor would dominate the bay and adversely impact the quality of life in the community. Exposed to some long period waves from the Bering Sea. Limited potential for upland development. Not locally preferred.
North Point	Relatively close to existing Trident facility and to the community of Akutan. Relatively good natural wave protection. Locally preferred site by Trident and the community of Akutan.	Deep water offshore, which limits the type of construction and effects cost. Limited area for upland development. Access to site from community will have to be through the Trident plant lands. Shallow bedrock near shoreline and in uplands will likely result in rock excavation as part of construction.
Head of the Bay	Good upland area. Shallow water will support efficient and cost effective construction methods. Good natural protection from north and	Uplands contain two fish bearing streams and some wetlands. Relatively long distance from both the community

Location	Advantages	Disadvantages
	south directions. Relatively good natural wave protection. Upland is owned by Akutan Corporation, which may stimulate local economic development. Locally preferred option.	and from the Trident plant.
Whaling Station	Naturally protected from southeast and west directions. Relatively good natural wave protection. Land area classified for industrial use after TERC cleanup is complete. Some uplands development possible. Historical industrial use could mean less challenging environmental concerns.	Long distance from Trident plant and community of Akutan Possible contaminated soils requiring further remediation and cleanup. Relatively deep water offshore, which limits the type of construction and affects cost. Not locally preferred.
South Shore Area 1	Little identified environmental concerns. Probable good water quality and mixing.	Unacceptable wave climate. Limited area for upland development. Long distance from Trident plant and community of Akutan. Relatively deep water offshore, which limits the type of construction and affects cost. Not locally preferred.
South Shore Area 2	Little identified environmental concerns. Some possible upland area. Relatively shallow water will support efficient, cost effective construction methods.	Unacceptable wave climate. Long distance from Trident plant and community of Akutan. Not locally preferred.
South Shore Area 3	Little identified environmental concerns. Some possible upland area. Relatively shallow water will support efficient, cost effective construction methods.	Unacceptable wave climate. Long distance from Trident plant and community of Akutan. Not locally preferred.

6.4. Project Development

A July 1998 preliminary site assessment report ("*Akutan Harbor Feasibility Study, Phase 1, Preliminary Site Assessment Report,*" July 13, 1998) examined five harbor site alternatives as Phase I of this study. These sites were North Point (west of the Trident facility), Akutan Point, Salthouse Cove, head of Akutan Harbor, and the Old Whaling Station. The study recommended that the North Point site and the head of the bay site be considered for further feasibility studies.

In October 1998, after the Phase I report was issued, a field exploration program was undertaken that included upland and bathymetric survey, geotechnical explorations and environmental sampling. This effort focused on the North Point site, which appeared then to be the most economically viable and least environmentally sensitive alternative at the time. A lower priority data collection effort advanced at the head of the bay site.

Subsequent study revealed that the North Point site had limitations because of a steeply sloping onshore and offshore terrain. This constrained the conceptual harbor to a long thin rectangular shape with little uplands. With these constraints, only about a 9-acre basin could be considered for that site. Economic analysis led to the conclusion that the North Point basin was not large enough to accommodate enough vessels to generate sufficient benefits to justify the project. The focus of the project then shifted to the head of the bay site.

Initial examinations of the head of the bay site were focused on three alternatives:

- An offshore harbor.
- An onshore/offshore harbor.
- A dredged inland harbor.

Conceptual designs were advanced for these three alternatives. During conceptual design, a potential problem with earthquake-induced liquefaction was uncovered. This problem was due to the saturated sands present at the head of the bay. Geotechnical engineers suggested several slope stabilization techniques that could be used to deal with this potential problem. These techniques, such as an excavated buttress under the breakwaters, generally increased estimated project costs.

After examining the three design alternatives, conceptual cost estimates and economic evaluation pointed to the dredged inland basin as being the most economically feasible alternative. The design team then advanced several versions of the inland basin. These versions include a 12-acre basin, a 15-acre basin, and a 20-acre basin. By varying the size of the basin, different portions of the overall fleet could be serviced. Also, different overall costs and benefits could be compared.

As the study moved forward, it became apparent that insufficient geotechnical and survey data had been collected at the head of the bay. The reason for this is that initially the head of the bay was not seen as the likely final project location and so data collection there was limited. The soils data collected up to that point consisted of two offshore borings near the head of the bay, but no borings in the upland area where the dredged basin was to go. In addition, survey data extended only a few hundred feet inland and was not sufficient to produce an accurate topographic map of the project site. Offshore bathymetry data was lacking as well.

In order to make an assessment of slope stability and obtain accurate dredge material quantities more geotechnical and survey data would be needed. In August 2000, the U.S. Army Engineer Research and Development Center, Waterways Experiment Station (ERDC-WES) conducted a hydrogeology and wetlands delineation study at the head of the bay in support of the project. This work included some GPS based uplands survey, which was subsequently made available to the study team.

During the ERDC-WES fieldwork, several abandoned 55-gallon drums were discovered near the beach berm. The presence of these drums raised concerns related to possible contaminated soils.

Two reports were produced summarizing the results of these ERDC-WES investigations. These include:

"Delineation of Wetlands on the Proposed Site of the Akutan Harbor Project, Akutan Island, Alaska," by James Wakeley, ERDC May 2001.

"Hydrogeology of Proposed Harbor Site at Head of Akutan Bay, Akutan Island, Alaska," by Joseph Dunbar, Maureen Corcoran, and William Murphy ERDC-WES, July 2001.

Subsequent to the site visit by ERDC-WES, another geotechnical field investigation program was mobilized to the site. This work was done in March 2001. The purpose of this work was to advance geotechnical borings in the upland area of the proposed new basin, and to perform an environmental site investigation.

These site investigations are summarized in the following reports:

"Geotechnical Report, Akutan Small Boat Harbor, Akutan Alaska," by Shannon & Wilson, June 2001 (included in the Appendix)

"Draft Environmental Site Investigation Report, Proposed Harbor Location, Akutan Alaska," by Shannon & Wilson, July 2001 (included in the Appendix)

In September 2002 the draft feasibility reports were released. These reports underwent a thorough agency review and a number of comments and concerns were advanced. Items effecting the design included concerns over circulation and as a result water quality in the new basin, and the overall footprint associated with the stockpile area. In response to comments the study team completed a numerical circulation model of the basin, redesigned the entrance channel and a portion of the harbor perimeter to improve circulation, and reconfigured the stockpile area to minimize impacts. The results of this work are shown in the "reconfigured 12 acre basin" drawing in this report.

6.5. Harbor Alternatives Considered in Detail

As stated previously, three primary alternatives have been advanced for study at the head of the bay including:

- An offshore harbor.
- An onshore/offshore harbor.
- A dredged inland harbor.

These three alternatives constitute the primary alternatives examined in this study.

6.5.1. Offshore Harbor

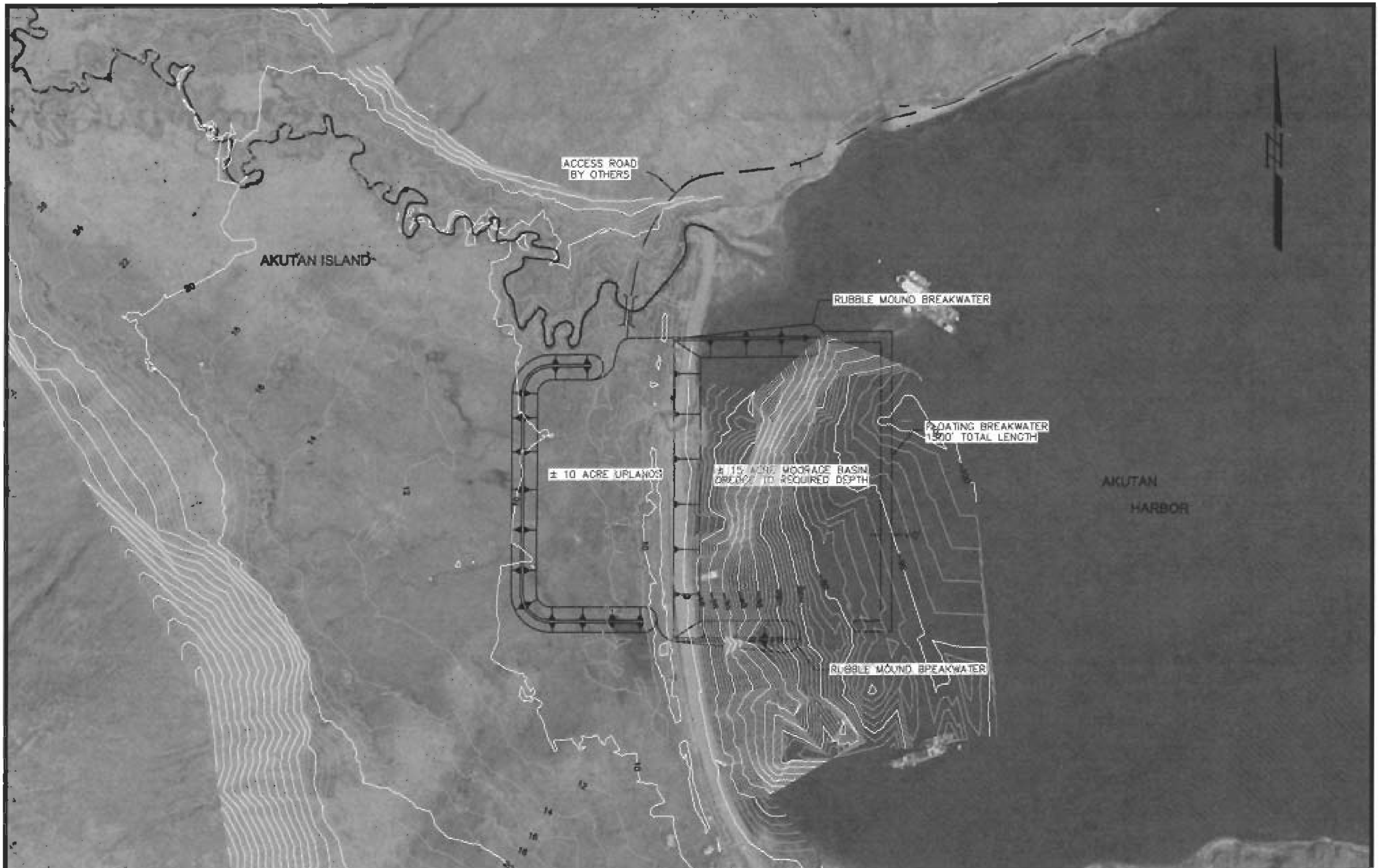
An offshore harbor concept was advanced through the use of a floating breakwater. In this alternative, a floating breakwater, approximately 2,000 feet long, would be anchored near the head of the bay to provide protected moorage. In this alternative, most of the moorage area of the harbor would be offshore with some portion of the existing shoreline area developed for related upland facilities and access. The offshore harbor concept is shown in figure 11.

Floating breakwaters work principally by reflection. They are required to be a significant portion of the incident wavelength in width to be effective. The closer to a width of 50 percent of the incident wavelength, the better the performance will be. Generally, floating breakwaters are used in limited fetch areas that are subjected to waves of less than a 4 second period and a wave height of 4 feet or less. This type of wave climate is generally found in relatively short fetches. The period of the design wave for this project is 4.7 seconds. The height of the design wave (H_{10}) is 3.9 feet. The deep-water wavelength associated with a 4.7 second period is about 113 feet. This points to a floating wave barrier with a width approaching 50 feet.

Conceptually, a barge-like structure with a width of approximately 40 feet could work. A number of these could be linked together and anchored in relatively deep water to form an offshore wave barrier. There are a number of disadvantages associated with this type of structure. Maintenance and inspection could be more frequent and involved than with other structures. This is primarily due to the mooring chain and fixtures that would require frequent periodic inspection.

Another consideration is cost. A steel structure 1,500 to 2,000 feet long, 40 feet wide, and 15 feet deep would cost about $16 million for the fabricated structure alone. There would still be some dredging required and a short breakwater section may have to be constructed. Add to this the costs of towing, moorage chain, anchors, and installation, and the costs for a floating wave barrier alone could exceed $20 million. Another consideration is the risk that a portion of the floating breakwater may come loose from its anchorage due to a broken mooring chain or failed anchor. Because of the remoteness of Akutan Harbor, emergency repairs would be difficult and costly.

Based on the above discussion, a floating breakwater while technically possible is not practically feasible for this project.



OFFSHORE HARBOR

HARBOR FEASIBLIITY STUDY

AKUTAN ALASKA

FIGURE 11

6.5.2. Offshore/Onshore Harbor

A concept was advanced for a harbor basin dredged partially inland. Two alternative methods were examined for the offshore breakwater portion of this concept: a rubblemound structure, and a curtain-wall wave barrier.

Offshore/Onshore Harbor; Rubblemound. The rubblemound version of the onshore/offshore harbor would include a rubblemound as the offshore breakwater component of the basin. The rubblemound would be placed in approximately 25 feet of water and would be approximately 1,100 feet long. This is near the maximum economic practical depth normally associated with this type of structure. (At depths over about 25 to 30 feet the costs of rubblemound breakwaters increase dramatically.) The centerline of this breakwater would be about 100 to 150 feet offshore from the existing beach. Figure 12 shows the conceptual design of the rubblemound option.

As previously discussed, breakwater construction materials are a main component contributing to the total project cost. This alternative greatly increases the amount of armor rock, secondary rock, and core material needed for the project. In addition, the added breakwater length may necessitate the need for a buttress foundation. A conceptual cost of over $4 million was calculated for the buttress alone for this alternative. The costs of this alternative outweigh any anticipated per acre benefits.

Offshore/Onshore Harbor; Curtain-wall Wave Barrier. The curtain-wall wave barrier version of the onshore/offshore harbor would include a curtain-wall wave barrier as the offshore component of the basin. The curtain-wall wave barrier would be placed in about 60 feet of water and would be about 1000 feet long. The wave barrier would be placed about 350 feet offshore from the existing beach. It would be a pile-supported structure consisting of wave barrier panels that extend a distance below the water level but not necessarily all the way to the bottom. There would be a section of rubblemound jetty about 450 feet long that traverses the breaking wave zone and connects the wave barrier to the beach on one side. Figure 13 shows a conceptual design for the offshore/onshore wave barrier option.

OFFSHORE/ONSHORE RUBBLE MOUND

HARBOR FEASIBLIITY STUDY

AKUTAN ALASKA

FIGURE 12

GRAPHIC SCALE

250 0 125 250 500

(IN FEET)
SCALE: 1" = 500'

OFFSHORE/ONSHORE WAVE BARRIER

HARBOR FEASIBLIITY STUDY

AKUTAN ALASKA

FIGURE 13

Curtain-wall wave barriers are similar to floating breakwaters in that they are ideally suited to shorter period, small amplitude waves. They work best in wave periods less then 4 seconds and in wave heights less then 4 feet. Again, the period of the design wave for this project is 4.7 seconds. The height of the design wave (H_{10}) is 3.94 feet.

Using Wiegle's method for power transmission under a wall, a barrier depth of about 30 feet below MLLW would provide an inner harbor wave height of less than one foot at extreme low tides. The panel would be required to extend above MHHW to account for runup. An estimated elevation of +12 feet above MHHW would be required to minimize over topping. At 1000 feet long, the wave barrier would include about 42,000 square feet of panels.

The pile-supported structure could work well in the liquefaction prone soils. The piles could simply be driven deep enough to remain unaffected by any loss of support by the upper layer of soil.

The costs associated with the wave barrier could be about $150 per square foot of barrier panel. This leads to an estimated cost of about $6.3 million for the wave barrier alone. This combined with the rubblemound jetty sections and other structures and features make the cost of this alternative outweigh any anticipated per acre benefits.

6.5.3. Inland Harbor

Initial cost estimates indicate that a dredged inland basin is the most economic alternative. The inland harbor is also among the most environmentally acceptable alternatives. Various layouts and sizes were examined. The same design criteria outlined below was applied to all inland alternatives.

Examining the various basin sizes resulted in an optimization study for the size of the dredged basin at the head of the bay site. The primary factors that entered into the optimization were the following:

- The size of the fleet that could be serviced.
- The benefits that could be generated by the fleet.
- The construction costs.
- The environmental impacts and associated costs.

Orientation. Two primary basin orientations were examined; the long axis of the basin aligned east/west, and the long axis aligned north/south. Orientating the long axis of the harbor basin east/west and centering it in the valley provides for the advantage of maximizing separation distance from the two streams. The disadvantages of this orientation include:

- Alignment of the entrance channel with the long axis of the harbor allowing for more direct communication with the offshore wave environment,
- orienting the basin so that it runs northward into the valley may cause drainage and/or drainage diversion problems due to natural surface drainages concentrated in this area,
- upland areas would likely have to be split north and south of the basin due to the back of the basin butting up against steep inland terrain, and

- the more space-efficient moorage arrangement forces vessels to be moored broadside to the wind under a rafting type moorage arrangement.
- Due to these disadvantages, basins with orientations that aligned the long axis of the harbor north/south were chosen for the alternatives advanced in this study.

Inland Basin Design Alternatives. The inland basin design alternatives that were advanced in this study essentially utilized the same rectangular basin shape with the long axis oriented north/south. The main difference between the alternatives is the size of the basin. The three basin sizes examined were a 12-acre basin, a 15-acre basin, and a 20-acre basin. All the alternatives share the same entrance channel configuration and depth (–18 feet below MLLW). Each of the alternatives will have three primary basin bottom depths of –18 feet, –16 feet, and –14 feet below MLLW to accommodate various vessel sizes. The ratio of length-to-width (aspect ratio) for the basins varies from 1.3 to 1.6. Aspect ratios of 0.5 to 2.0 are recommended for adequate harbor circulation and flushing.

As mentioned previously, the original basin design was modified in response to comments received on the draft report to include features to improve circulation and to minimize the footprint associated with the stockpile area. The modifications include changes to the entrance channel, rounding of the perimeter and steeper inner harbor slopes above the waterline.

Dredging Material Stockpile Area. All of the inland basin alternatives advanced in this study generate a considerable amount of dredge materials. Several local projects may be able to make good use of this as fill. These projects include a currently planned access road and a potential airfield/runway. The potential reuse of the material is dependent on the type of material that exists at the site. Geotechnical data collected at the site indicates that the dredged material would consist mostly of coarse to fine grained sands. This implies that, once drained, the dredged material would be suitable for use in construction of the upland areas and as a sub-base material for an access road or airstrip.

The stockpile areas are located to minimize the environmental impact to natural upland areas and allow access to dredged materials so that they can be used on this and other project sites easily. It should be noted that the size of the stockpile for all the alternatives is significant. Increasing the size of the stockpile may have a direct environmental impact on existing upland areas at the site, and therefore, an impact on associated project environmental and permitting costs. Concept stockpile heights aboveground range from about 25 to 50 feet at the tallest points, this equates to substantial loading on existing subsurface soils. Due to the existing soil being well draining sands, effects should be limited to localized immediate settlement. Estimated stockpile areas and volumes for each of the inland alternatives are shown in table 19.

Table 19. Estimated Stockpile Areas and Quantities

Basin	Stockpile Area (Acres)	Stockpile Quantities (Cubic Yards)
12 Acre Inland	36	850,000
15 Acre Inland	38	990,000
20 Acre Inland	39	1,175,000
Reconfigured 12 Acre	28.5	843,000

Environmental Concerns. Environmental agencies have expressed concerns on the size and location of the stockpile associated with the dredged inland basin. Several suggestions have been proposed to minimize the effect of these areas and the basins on the environment including:

- Place the stockpiles on areas intended for future developed uplands. Typically 40% of the total harbor developed area is dedicated to useable uplands.
- Confine the harbor basin and stockpile area to the southern two thirds of the head of the bay existing uplands. This is the area south of a small drainage that runs through the north valley and effectively separates the northern and southern portions of the uplands.

If the above-mentioned drainage must be affected by construction, its channel must be approximately reconstructed in plan form and cross section to the north of the construction site. It is expected that each of the alternatives will require that the drainage be moved.

All of the inland alternatives attempt to mitigate these environmental concerns.

Alternative 1–12 Acre Dredged Basin. The 12-acre dredged basin alternative is the smallest of the inland alternatives. Approximately 36 acres of uplands can be created with the associated dredge materials. The fleet associated with this harbor is shown in table 20.

Table 20. 12-acre Basin Fleet

Vessel Length (ft)	Number
0–24	10
24–32	10
32–90	0
90–110	8
110–120	15
120–155	13
155–180	2

The 12-acre basin will be dredged to varying depths to accommodate different vessel sizes. These depths, and their associated dredge areas, are outlined in table 21.

Table 21. 12-acre Basin Depths and Areas

Basin Depth (ft)	Acres
–14	2.6
–16	4.0
–18	5.4

As this is the smallest basin alternative, the 12-acre basin has the least environmental impact on the upland area at the head of the bay. The total basin toe-to-toe dredge area, including the entrance channel is 15.3 acres. 79 percent of the total dredge area is dedicated to the mooring basin. The associated concept stockpile covers approximately 36 acres and has a constant crest elevation of +35 feet above MLLW. This equates to a stockpile height above ground of approximately 25 feet at its tallest point. It is likely that some redirection will be required of the small drainage that separates the north and south portions of the uplands. A plan view of the 12-acre alternative is shown in figure 14.

Alternative 2–15 Acre Dredged Basin. The 15-acre dredged basin alternative is the mid-size of inland alternatives. Approximately 38 acres of uplands can be created with the associated dredge materials. The fleet associated with this basin is outlined in table 22.

Table 22. 15-acre Basin Fleet

Vessel Length (ft)	Number
0–24	10
24–32	10
32–90	0
90–110	8
110–120	20
120–155	18
155–180	2

The 15-acre basin will be dredged to varying depths to accommodate different vessel sizes. These depths, and their associated dredge areas, are outlined in table 23.

Table 23. 15-acre Basin Depths and Acres

Basin Depth (ft)	Acres
–14	4.0
–16	5.4
–18	5.6

The total toe-to-toe dredge area is 17.6 acres. 86 percent of the total dredge area is dedicated to the mooring basin. (Note that the percentage of area devoted to the mooring basin increases as the total project size increases. This is due to the fact that the larger mooring areas in the 15-acre and 20-acre alternatives allow for sufficient maneuvering space. The 12-acre alternative includes slightly more additional area to allow extra maneuvering room). As expected, the 15-acre basin has a larger stockpile area than the 12-acre basin and less remaining upland areas to place the stockpile on. The concept stockpile footprint area is 38 acres with a crest elevation increased by 5 feet to +40 feet above MLLW. This equates to a stockpile height aboveground of approximately 30 feet at its tallest point. The 15-acre alternative is shown in figure 15.

Alternative 3–20 Acre Dredged Basin. The 20-acre dredged basin alternative is the largest of the inland alternatives examined. Approximately 39 acres of uplands are covered with the associated dredge materials. The fleet associated with this basin is outlined in table 24.

Table 24. 20-acre Basin Fleet

Vessel Length (ft)	Number
0–24	10
24–32	10
32–90	0
90–110	8
110–120	22
120–155	23
155–180	7

The basin will have three primary depths to accommodate various vessel sizes. These are outlined in table 25.

Table 25. 20-acre Basin Depths and Acres

Basin Depth (ft)	Acres
–14	6.0
–16	6.7
–18	7.3

The total toe-to-toe dredge area of the 20-acre basin is 21.8 acres. This equates to about 92 percent of the total dredged area being devoted to mooring basin. In the case of the 20-acre basin, the basin combined with the stockpile area is large enough, both in volume and plan area, to begin to dominate the topography at the head of the bay and up into the north valley. Under this alternative, the basin and stockpile area will use a significant portion of the available uplands. The stockpile storage area is reduced significantly by the size of the basin. This makes reduced upland storage areas contain larger quantities of dredge material. The result is a stockpile that must now encroach into areas further up the north valley. The footprint area of this concept stockpile is 39 acres and the constant crest elevation is +50 feet above MLLW. This equates to a maximum stockpile height aboveground of 40 feet at its tallest point. The 20-acre alternative has the advantage of being able to service the entire design fleet. However, the size of the project footprint may incur additional environmental and permitting costs. The 20-acre alternative is shown in figure 16.

Reconfigured 12 Acre Dredged Basin. Approximately 28.5 acres of uplands are covered with the associated dredge materials. The fleet associated with this basin is outlined in table 26.

Table 26. Reconfigured 12-acre Basin Fleet

Vessel Length (ft)	Number
0–24	10
24–32	10
32–90	0
90–110	8
110–120	15
120–155	13
155–180	2

The basin will have three primary depths to accommodate various vessel sizes. These are outlined in table 27.

Table 27. Reconfigured 12-acre Basin Depths and Acres

Basin Depth (ft)	Acres
–14	2.6
–16	5.4
–18	2.4

The total toe-to-toe dredge area (mooring basin and entrance channel) of the reconfigured 12-acre basin is 16.2 acres. The footprint area of the stockpile is 28.5 acres and the maximum crest elevation is +50 feet above MLLW. This equates to a maximum stockpile height aboveground of 40 feet at its tallest point. The reconfigured 12-acre alternative is shown in figure 17.

NOTES

TOTAL DREDGE VOLUME = 850,000 CY
BASIN AREA = 12.7 ACRES
ENTRANCE CHANNEL AREA = 2.6 ACRES
(AREA MEASUREMENTS AT TOE OF EXCAVATION)
TOTAL HARBOR PROJECT AREA = 15.3 ACRES

GRAPHIC SCALE
200 0 100 200 400
(IN FEET)
SCALE: 1" = 400'

12 ACRE ALTERNATIVE

HARBOR FEASIBILITY STUDY

AKUTAN ALASKA

FIGURE 14

NOTES
TOTAL DREDGE VOLUME = 990,000 CY
BASIN AREA = 15 ACRES
ENTRANCE CHANNEL AREA = 2.6 ACRES
(AREA MEASUREMENTS AT TOE OF EXCAVATION)
TOTAL HARBOR PROJECT AREA = 17.6 ACRES

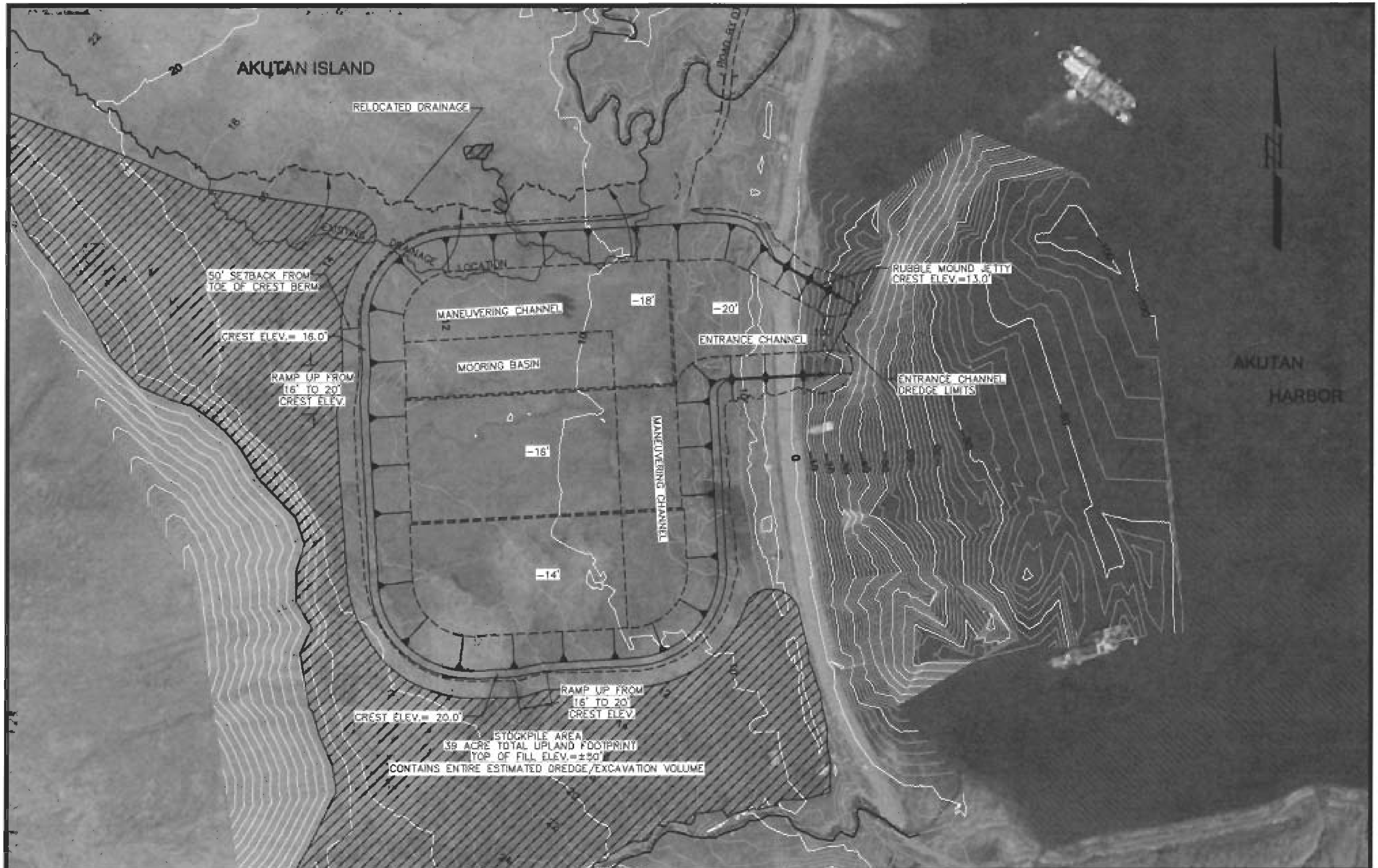
GRAPHIC SCALE
200 0 100 200 400
(IN FEET)
SCALE: 1" = 400'

15 ACRE ALTERNATIVE

HARBOR FEASIBILITY STUDY

AKUTAN ALASKA

FIGURE 15



NOTES

TOTAL DREDGE VOLUME = 1,175,000 CY
BASIN AREA = 19.2 ACRES
ENTRANCE CHANNEL AREA = 2.6 ACRES
(AREA MEASUREMENTS AT TOE OF EXCAVATION)
TOTAL HARBOR PROJECT AREA = 21.8 ACRES

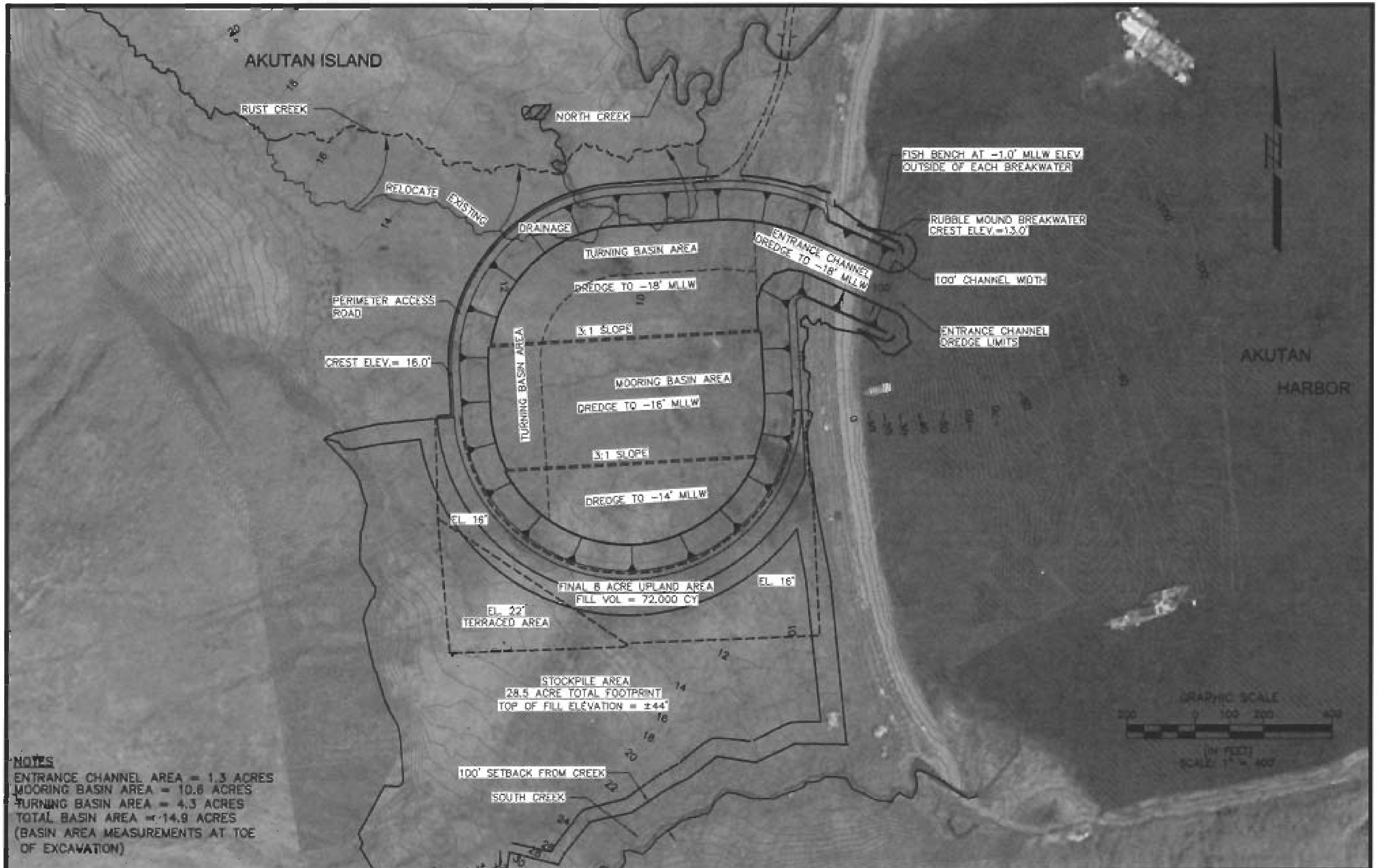
GRAPHIC SCALE
200 0 100 200 400
(IN FEET)
SCALE: 1" = 400'

20 ACRE ALTERNATIVE

HARBOR FEASIBILITY STUDY

AKUTAN ALASKA

FIGURE 16



NOTES

TOTAL HARBOR BASIN PROJECT AREA = 16.2 ACRES (TO TOP OF SLOPE)
TOTAL HARBOR USEABLE UPLANDS AREA = 8.0 ACRES (DOES NOT INCLUDE ROADS AND SLOPES)
TOTAL USABLE HARBOR PROJECT AREA = 28.7 ACRES (INCLUDES PERIMETER ROAD, UPLANDS AND SLOPES)
TOTAL STOCKPILE AREA = 28.5 ACRES (INCLUDES 8 ACRES FOR FUTURE USABLE UPLANDS)
TOTAL HARBOR PROJECT AREA =57.2 ACRES (INCLUDES STOCKPILE FOOTPRINT)
TOTAL DREDGE VOLUME = 843,000 CY
VOLUME REQUIRED FOR USABLE UPLAND FILL = 72,000 CY
TOTAL STOCKPILE VOLUME = 771,000 CY

RECONFIGURED
12 ACRE ALTERNATIVE

TRYCK NYMAN HAYES, INC.

NAVIGATION IMPROVEMENTS

AKUTAN ALASKA

FIGURE 17

7.0 CONSTRUCTION METHODS AND SEQUENCING

7.1. Construction Methods

The choice between dredging by suction, clamshell dredging, or by excavation using a dragline, cat, or large hoe is dependent upon the type of materials being excavated, the water table elevation, and whether the material is to be reused as fill.

If the material is clean sand, as is suggested by the borings, the suction dredging method would be most suitable. This type of dredging has been used successfully on projects that involve the efficient moving of large volumes of materials. A large suction dredge can move uniform small grained material very efficiently.

Excavation can be an attractive method of material removal if the material is drained and reused as local fill. Excavation and onshore handling generally results in less mixing of the water and soil compared to suction dredging making it easier to stockpile and drain the dredged material. The relatively high water table dictates that only a small portion of the overall material can be efficiently excavated in this manner.

It is anticipated that the initial site preparation and excavation will be carried out most efficiently using cats and backhoes. Once the water table is reached, suction dredging will be the most efficient means.

7.2. Construction Sequence

The following general sequence of harbor construction is anticipated:

1. Establish silt fences around local streams. Redirect drainages as required. Establish project limits on the uplands.
2. Work would begin in the inner harbor basin. Blade off the top two or three feet of the vegetative mat of material into the upland stockpile area.
3. Create a stockpile drainage containment berm. The containment may include temporary sub drains that are directed into the harbor basin.
4. Excavate down to the water table using cats and backhoes. Push the material into the upper section of the stockpile area. Saturated material should be drained in the containment area.
5. Once the water table is reached, begin suction dredging of the inner harbor basin. Note that the entrance channel would remain plugged. Pump the material into the bermed stockpile containment area to drain. As the material is drained, push it into the upper sections of the stockpile area.
6. Excavate the basin slopes to grade and lay down the geotextile fabric. Place the slope filter rock and armor.
7. Once the main basin has been dredged, excavate the entrance channel to open the harbor basin to the bay. This work should begin on the basin side to minimize sedimentation getting into Akutan Harbor.
8. Construct breakwater jetties.

9. Construct inner harbor features, such as floats systems, etc. Install aids to navigation.
10. Prepare uplands for intended use.

7.3. Operation and Maintenance

Operations and maintenance of a USACE navigation improvement harbor, such as the proposed basin at the head of the bay requires a division of responsibilities between the local sponsor and the Federal Government. Typically, the operation of the harbor basin along with maintenance of the floats and utilities would be the responsibility of the local sponsor (the City of Akutan).

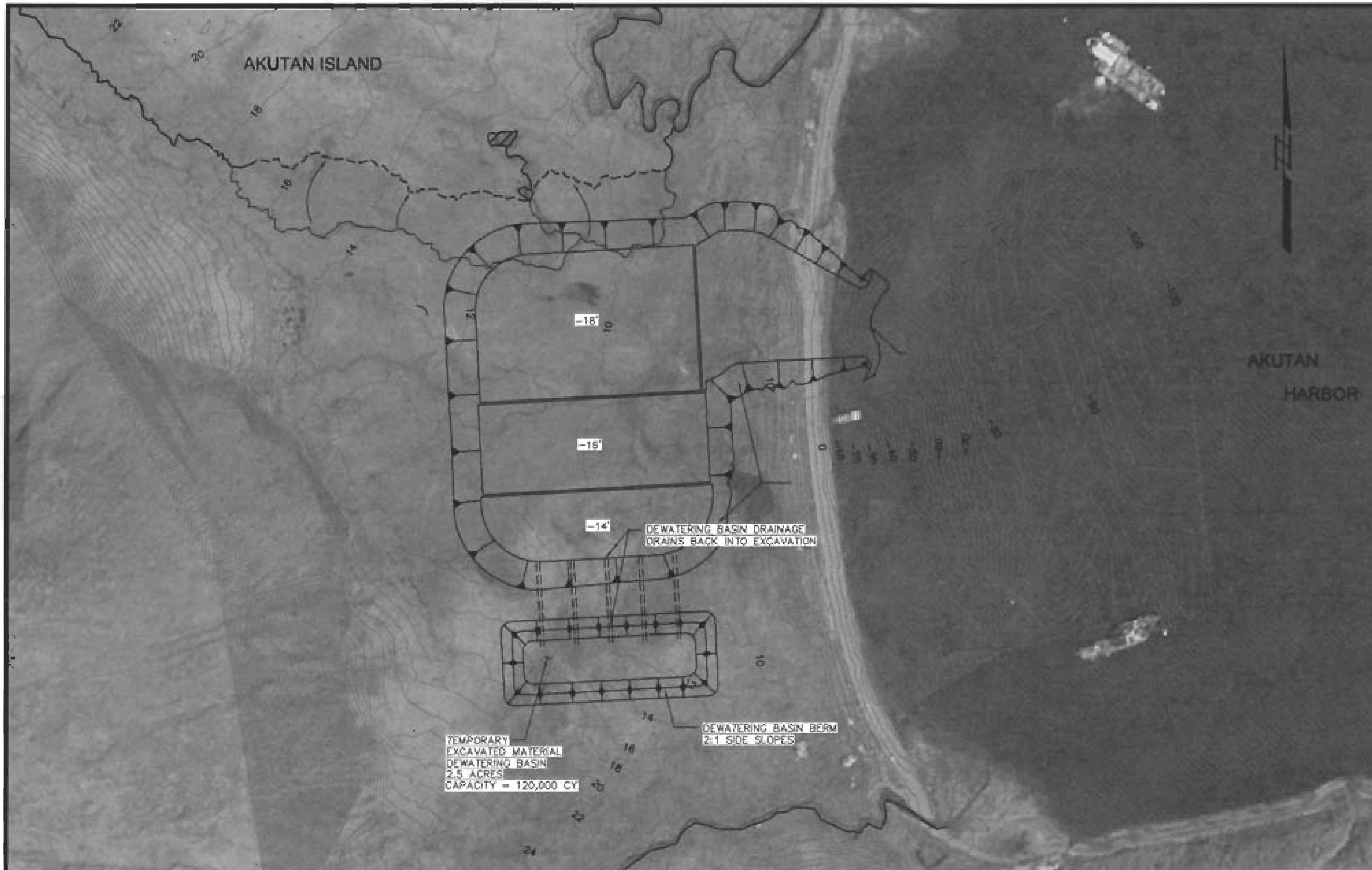
The Federal Government is typically responsible for the maintenance of the breakwaters, entrance channel, and maneuvering basin. This responsibility may entail the periodic hydrographic survey of these areas. Maintenance dredging and repair of the breakwaters may be required periodically. The wave climate at the head of the bay is fairly benign. It is unlikely that the breakwater jetties will be damaged by wave action. It is anticipated that there will be very little sediment transport across the entrance channel. Therefore, it is likely that any type of significant maintenance will be associated with damage due to an earthquake.

For planning purposes the following federal maintenance requirements may apply:

Hydrographic survey every 5 years.

Maintenance dredging (associated with an earthquake) of the entrance channel and maneuvering basin every 25 years. For concept planning purposes, this dredging is assumed to involve a total of 5% of the wetted volume of the harbor basin.

Replacement of 5% of the armor stone on the breakwater jetties every 25 years (again associated with an earthquake).



2:1 SIDE SLOPES

GRAPHIC SCALE

200 0 100 200 400

(IN FEET)
SCALE: 1" = 400'

DRAINAGE BASIN

NAVIGATION IMPROVEMENTS

AKUTAN ALASKA

FIGURE 18

TRYCK NYMAN HAYES, INC.

7.4. Aids to Navigation

It is anticipated that navigation signs and lights will be required on the end of each of the breakwater jetties. A red light (port side when leaving the harbor) will be required on the north jetty and a green light (starboard when leaving the harbor) will be required on the south jetty. Suitable solar powered units are available commercially. Signage may include harbor master call frequencies and identification, as well as no wake zone/harbor speed limit.

The USCG should be notified and consulted with prior to final design and construction.

7.5. Construction Schedule

The construction schedule depends on several factors including the timing of the release of the plan set and on the equipment and techniques used by the contractor. It is possible to work year round at the head of the bay in Akutan. However, overall work efficiency will be reduced in the winter months. In addition, barging in equipment and materials can be more difficult in the winter.

A preliminary estimate of the duration of the major project elements is presented below:

Item	Duration
Bidding and contracting	2 months
Submittals, materials procurement, and shop drawings	3 months
Mobilization	1 month
Basin excavation and dredging	4 months
Breakwater construction	3 months
Inner harbor floats and utilities	3 months
Winter shut down	6 months
Environmental window shutdowns	2 months
Total	**24 months**

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APPENDIX B
ECONOMIC ANALYSIS OF NAVIGATION IMPROVEMENTS AT AKUTAN, ALASKA

Appendix B: Economic Analysis of Navigation Improvements At Akutan, Alaska

Table of Contents

1 OVERVIEW OF REGION AND COMMUNITY 4
1.1 Problem Statement 4
1.2 Akutan 4
1.3 Population 5
1.4 Government 6
1.5 Services 6
1.6 Employment 7
1.7 Trident Seafoods 8
1.8 Community Development Quotas 9

2 MARINE RESOURCE ASSESSMENT 10
2.1 General Overview of Fishery Resources 10
2.1.1 Fisheries 11
2.1.2 Fisheries Resources 15
2.1.3 Management Structure 29
2.1.4 Outlook for Bering Sea Fisheries and Fisheries Resources 35

3 EXISTING CONDITIONS 36
3.1 Existing Marine Facilities 37
3.1.1 Akutan 37
3.1.2 Other Western Alaska Harbors 39
3.2 Fleet Operating Activities 41
3.2.1 Trawl Vessels 42
3.2.2 Pot Vessels 44
3.2.3 Hook-and-line Vessels 46
3.3 Fleet Characteristics 48
3.3.1 Akutan Resident Fleet 48
3.3.2 Akutan Nonresident Fleet 49
3.3.3 Transient Vessels 49
3.4 Moorage Demand 50
3.4.1 Akutan Resident Fleet 50
3.4.2 Akutan Nonresident Fleet 51
3.4.3 Transient Fleet 54
3.4.4 Summary of Moorage Demand 56
3.4.5 Vessel Response to Available Moorage Space 57

4 DESCRIPTION OF ALTERNATIVE PLANS 58
4.1 Non-Structural Alternatives 58
4.2 Structural Alternatives 58
4.3 Summary of Alternatives 58

5 WITHOUT-PROJECT CONDITIONS 59
5.1 Vessel Operating Costs 59
5.1.1 Vessel Travel Costs 62
5.2 Opportunity Cost of Time 63
5.3 Expenses Under Existing Conditions 63
5.3.1 Expenses Related to Rafting and Congestion 63
5.4 Subsistence Activities 64

6 WITH-PROJECT CONDITIONS 64
6.1 NED Benefits for the Proposed Project 64
6.2 Benefits from Dredged Materials 64
6.3 Damage to Vessels 65
6.4 Vessel in-Season Mooring Costs 66
6.5 Pacific Northwest Annual Travel Cost 67
6.6 Subsistence Benefits 69
6.7 Summary of Benefits 71

7 REGIONAL BENEFITS 71

8 SUBSISTENCE 72
8.1 METHOD 73
8.2 SUBSISTENCE IN AKUTAN, ALASKA 73
8.3 EFFECTS OF PROPOSED HARBOR ON AKUTAN SUBSISTENCE ... 76
8.3.1 Boat Season and Use 76
8.3.2 Months Cannot Currently Use Boat 77
8.3.3 Harbor's Influence on Subsistence Activities: – easier access; safer launching; additional trips; bigger boats; hunt other areas further away; increased harvests 78
8.4 Percent Increase in Subsistence Harvests with a Harbor 80

9 SENSITITIVITY ANALYSIS 80

10 SUMMARY 82

11 REFERENCES 83

1 OVERVIEW OF REGION AND COMMUNITY

This report provides background information about the socioeconomic composition of the study area.[1] This information is necessary to enable planners and report reviewers to understand the community infrastructure, the level of economic activity, and the potential of the area to support the project under consideration.

1.1 Problem Statement

Akutan, Alaska is a relatively small, remote community. Although it is one of the most important fishing ports in the United States in terms of volume and value of seafood production, it has very little infrastructure. The community, along with the Aleutians East Borough, has worked for many years to address the need for a small boat harbor in the community. The navigation improvements evaluated in this report are focused on meeting resolving several navigation problems currently facing vessels utilizing Akutan Bay. These problems include: 1) the necessity to travel to other ports in-season in order to secure safe moorage, 2) the necessity of travel to the Pacific Northwest each year, problems associated with the practice of rafting. In addition, residents of Akutan are hampered in their ability to develop a small boat commercial fishery and their subsistence harvests are also being constrained by the lack of available moorage.

1.2 Akutan

In 1878 and 1879, a number of Aleut families from neighboring islands moved to Akutan Island to establish the present community. The Russian Orthodox Church supported this move and immediately built a church and a school. Western Fur and Trading Company built a fur storage and trading post, and its resident agent started a cod fishing business in the village. In 1912, the Pacific Whaling Company built a processing station that operated until 1942, when the Japanese invaded the Aleutians and the Aleuts from Akutan were evacuated to camps in Southeast Alaska.
Akutan's proximity to the rich Bering Sea fishing grounds and the shelter of its deep bay brought the crab and fish processing industry to the community in the late 1940's. At first, the processing companies operated with floating processing ships. This was followed in the early 1980's by construction of a very large processing plant owned by Trident Seafoods. Although the Aleut population of the local village remains at 90 to 100 residents, the processing activity brings the total year-round population of Akutan to over 500, peaking during certain parts of the year at around 1,000 (Aleutians East Borough).

The City of Akutan is a traditional Aleut fishing village on Akutan Island, one of the Krenitzin Islands of the Fox Island group in the Eastern Aleutians. The island is part of the Aleutians East Borough (AEB). Figure A2-1 shows the location of Akutan.

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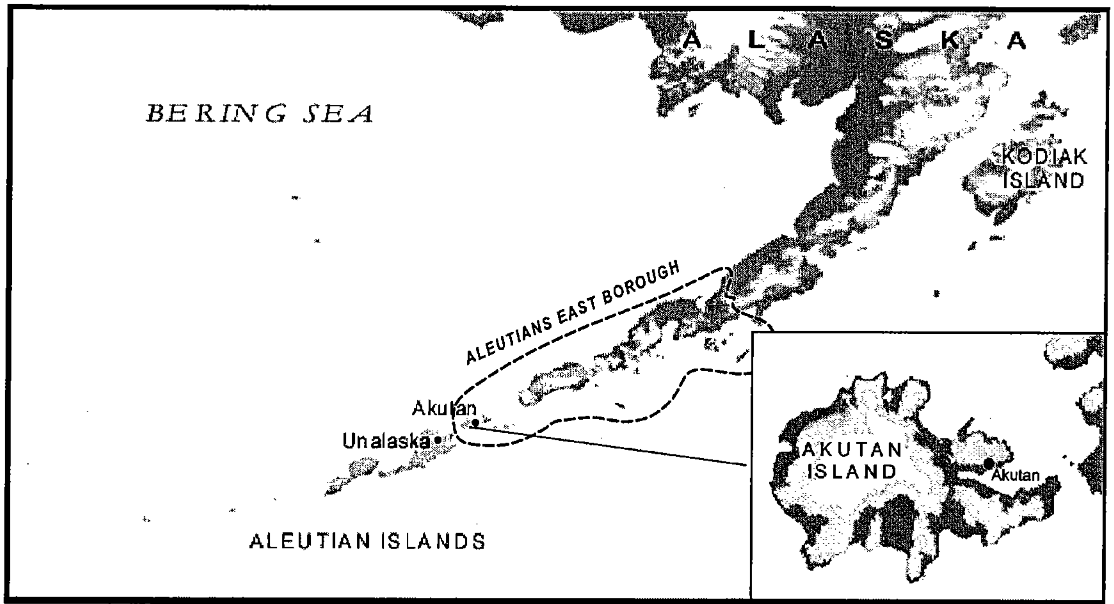
[1] Much of this information is from from a publication from the Aleutians East Borough, as well as information from the Alaska Department of Community and Regional Affairs (DCRA) website. Information was also gathered during a site visit to Akutan in June 1998.



Source: Adapted from Microsoft ExpediaMaps, available online http:\\www.expediamaps.com.

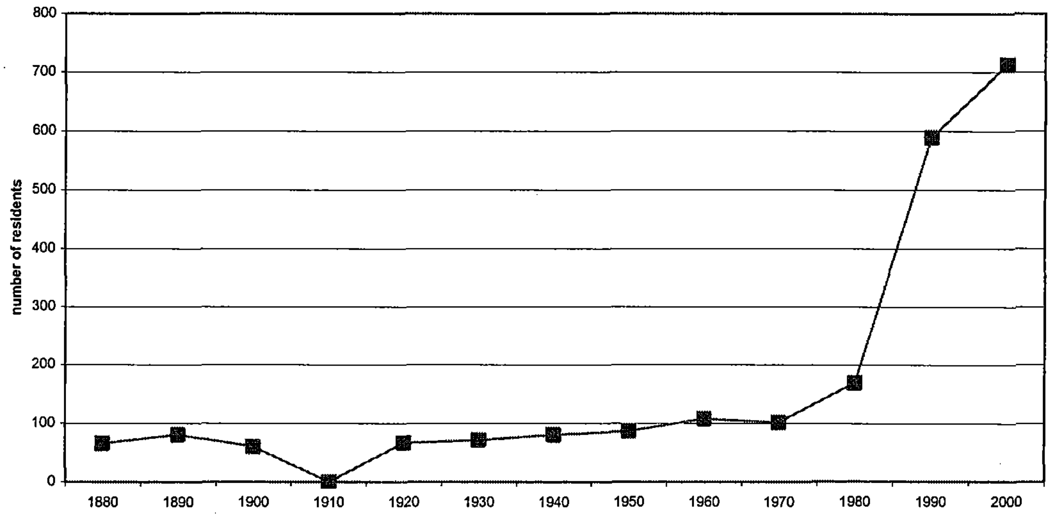
FIGURE A2-1 —*Akutan Vicinity Map*

The city of Akutan is 35 miles east of Dutch Harbor/Unalaska and 766 air miles southwest of Anchorage. The city and the adjacent processing plant owned by Trident Seafoods are on the northeastern corner of the island, on the north shore of a large, well-protected bay that opens to Akutan Bay and the Bering Sea.

1.3 Population

There are two components to Akutan's residents. The traditional village is inhabited predominantly by Aleuts. The 2000 census reported 112 Native residents in Akutan, out of a total population of 713. The majority of the reported population of Akutan is comprised of transient fish processing workers that live in group quarters at the Trident Seafoods facility west of the Aleut village. Figure A2-2 depicts trends for the combined Native and transient populations at Akutan from 1940 through 2000.

Figure A2-2: Population of Akutan: 1880-2000



Sources: Population estimates for 1880–2000 are from the U.S. Census.

The 2000 population of Akutan was 713, a combination of 112 village residents living in 38 households, and 601 workers residing in Trident group quarters. The number of workers varies with the time of year. In recent years, according to Trident, the number of processing workers has rarely been less than 100 and has approached 1,000 during peak processing periods in February, March, and April. Shore plant operations began in 1982; by the late 1980s Trident employed between 600 and 650 people annually, with an average of 400 onsite at any one time.

1.4 Government

Akutan is a second-class city incorporated in 1979. There are seven city council members, including the mayor. There are no sales or property taxes, but the city collects a 1 percent raw fish tax, and the borough collects a 2 percent raw fish tax.

1.5 Services

Utilities. The City of Akutan provides residents with electricity, water, sewage treatment, garbage, and cable television service. The Akutan Electric Utility has a hydropower source with a diesel backup. Generator capacity is 380 kilowatts. The city charges residents 12 cents per kilowatt-hour. Water from a stream and a dam constructed in 1927 is treated and piped into all homes. Sewage is piped to a community septic tank, with effluent discharge through an ocean outfall. Funds have been requested to develop 2 new water sources and construct a new, 125,000-gallon water storage tank and treatment plant. Garbage is burned in an incinerator, and a new landfill site and incinerator are under construction.

Trident Seafoods operates its own electricity and water treatment facility. The city and Trident each own one fuel storage tank, with capacities of 65,000 and 1,666,000 gallons, respectively.

Communication services in Akutan include in-state telephone service by Pacific Telecommunications Inc., long-distance telephone service by AT&T Alascom and General Communications, Inc.; ARCS television programming; and teleconferencing provided by Alaska Teleconferencing Network.

Law Enforcement and Fire Services. One Village Public Safety Officer (VPSO) is provided jointly by the city and state. The city maintains a jail. Fire services are provided by the city, the VPSO, and volunteer firemen.

Health Care. The city-owned Anesia Kudrin Memorial Clinic built in 1991 is operated by the city and the East Aleutian Tribes (EAT), Akutan's Native health organization. Akutan First Responders offers flights to Dutch Harbor/Unalaska or Anchorage for alternative health care. Itinerant employees of the Public Health Service make dental visits. The EAT addresses mental health and substance abuse issues and provides shelters. The Akutan Traditional Council takes responsibility for suicide prevention in the city.

Education. Akutan's one school serves children in preschool through twelfth grade. Akutan School has 20 students, 3 certified teachers, and 5 Advisory School Board members. The Aleutians East School District, operated by the AEB, contains 6 schools.

Transportation. Boats and amphibious aircraft are the only means of transportation into Akutan. There is a dock but no harbor. An Alaska Marine Highway System (AMHS) ferry operates from Kodiak bimonthly between May and October. Cargo is delivered weekly by freighter from Seattle. Akutan has a seaplane base, but no airstrip because of the area's steep terrain. Peninsula Airways provides daily air service from nearby Dutch Harbor/Unalaska, but high waves may limit accessibility, particularly during winter.

Recreation. The City of Akutan provides a youth center and a multipurpose recreation building, and the school gym has basketball courts. The city maintains a public library, and the school library is available to the public. The Akutan Traditional Council sponsors bingo and a museum.

1.6 Employment

Commercial fish processing dominates Akutan's cash-based economy. Eight residents hold commercial fishing permits. The Trident Seafoods plant processes primarily pollock, Pacific cod, and crab. None of the plant workers live in the village: they live in company dormitories and eat in the company mess hall. Although the village and the plant operate independently, it appears that their mutually beneficial relationship is acknowledged. Much of the community's operating budget is supported by fish taxes paid by the processing facility. Other than the processing facility, the village does not have a significant economic engine. Business license data as of January 2001 indicate that there are six small businesses in Akutan.

According to a 1990 study by the Alaska Department of Fish and Game (ADF&G), all village residents used subsistence resources, and 96 percent participated in subsistence harvests. The average gross household income was $37,753, and the average earned household income was $27,807. An estimated 102 jobs were held, and the average number of weeks worked by the 62 adults was 35.8. Local government accounted for 55 percent of the jobs, and 35 percent were in commercial fishing. Only 2.4 percent of jobs worked by villagers were in the fish processing facility.

There are two new areas of the Akutan economy that may be developed if the proposed project is completed. Several residents are interested in developing a small boat commercial fishery to take advantage of the State waters Pacific cod fishery. One quarter of the allowable harvest of Pacific cod is set aside for harvest by small boats. Residents are not able to take advantage of this regulatory advantage because they are unable to moor vessels in their community. Residents are also interested in tourism development and providing services to fishing vessels as areas to add employment opportunities. These options will require the use of a small boat harbor. Potential tourism attractions in Akutan include an active volcano, hot springs, Steller sea lion and seabird rookeries, easily accessible sportfishing for halibut and rockfish, and the natural beauty of the island.

1.7 Trident Seafoods

The Akutan plant is one of Alaska's largest fish processing plants and Trident's largest facility. In 1997 approximately 250 million pounds of pollock, 95 million pounds of Pacific cod, and 60 million pounds of crab were delivered to Trident plants in Akutan, Sand Point, and St. Paul combined; the majority was delivered to Akutan. These 3 plants accounted for approximately 28 percent of pollock and 50 percent of Pacific cod delivered to Bering Sea and Aleutian Islands (BSAI) and western Gulf of Alaska (GOA) inshore plants. Trident also operates several floating processors.

The top five U.S. ports in terms of commercial fishery landings are shown in TABLE A2-1. Trident produced a total of 405 million pounds of fish products in 1997. The majority of the products were produced in Akutan, placing Akutan well within the top five commercial fishing ports in the nation. Akutan is not included in the list of U.S. ports because of restrictions on revealing confidential information.

TABLE A2-1: *Top 5 U.S. ports in terms of commercial fishery landings, 2000*

National Ranking	Port	Commercial Fishery Landings (Millions of Pounds)
1	Dutch Harbor/Unalaska, Alaska	699.8
2	Cameron, Louisiana	414.5
3	Empire-Venice, Louisiana	396.2
4	Reedville, Virginia	366.8
5	Intercoastal City, Louisiana	321.7

Source: National Marine Fisheries Service, *Fisheries of the United States,* 2000.

1.8 Community Development Quotas

The Community Development Quota (CDQ) Program was established by the North Pacific Fishery Management Council (NPFMC) to provide Native communities in western Alaska the opportunity to engage in and profit from commercial fishing and processing for halibut, groundfish, and crab in waters adjacent to their communities.

In 1999, the western Alaska CDQ communities will, for the first time, receive allocations of at least 7.5 percent of all groundfish species managed by the National Marine Fisheries Service (NMFS) and NPFMC. Before 1998, the CDQ program involved only pollock, blackcod, and halibut. In 1998, three percent of the total allowable catch (TAC) for crab was added to the program. In 1999 CDQ pollock allocations were increased from 7.5 to 10 percent of the TAC, and CDQ crab allocations increased to 5 percent of the TAC. With its expanding scope and size, the CDQ program will affect a growing number of western Alaskan residents.

Akutan residents participate in the CDQ program through the community's association with the Aleutian-Pribilof Islands Community Development Association (APICDA). APICDA provides harvesting and processing opportunities on the *F/T Starbound* (a Trident-owned offshore processor) for APICDA community residents. The APICDA community development plan for Akutan is based on development of a harbor in Akutan. In the plan, APICDA has pledged a grant of $1 million to the community for harbor-related economic development.

APICDA is also helping residents of Akutan and other communities through a vessel purchase program. APICDA arranges financing through the program for small but commercially viable fishing vessels that typically range in length from 30 to 58 feet. To date, one Akutan resident has worked with APICDA to purchase and operate a fishing vessel. This 42-foot vessel is too large to operate off the beach (as other Akutan vessels do), but too small to operate in Akutan Bay without a protected harbor. The vessel operates out of Atka, where APICDA has a halibut processing facility. When the vessel is not on the fishing grounds, it uses harbors in Atka or Dutch Harbor/Unalaska. The owner spends much of the year outside Akutan because of the cost of airfare between Akutan and Dutch Harbor/Unalaska.

2 MARINE RESOURCE ASSESSMENT

2.1 General Overview of Fishery Resources

The eastern Bering Sea, from which Akutan draws most of its commerce, is a broad shallow shelf area that is one of the most productive marine areas on earth. The annual harvest of all fish species from the eastern Bering Sea is in excess of 2 million metric tons. (Hiatt and Terry 1999).

The most productive region of the Bering Sea is the southeast Bering Sea-Bristol Bay region, which covers the area from the continental shelf to Bristol Bay between the Pribilof Islands and Unimak Pass. Within this area are the largest fisheries resources in North America. The rivers of Bristol Bay have produced extremely large harvests of sockeye salmon since the mid 1970s. Along the coast of Northern Bristol Bay herring returning to spawn each spring form the basis of the largest herring harvest in Alaska. Small herring populations occur in the bays on the north and south side of the Alaska Peninsula and a summer herring fishery occurs at Dutch Harbor.

In the offshore waters are enormous stocks of pollock, cod, and flatfish. The region produced large harvests of king and tanner crab through the 1960s and 1970s, how ever these species are currently at a very low level of abundance declined through a combination of overfishing and environmental change.

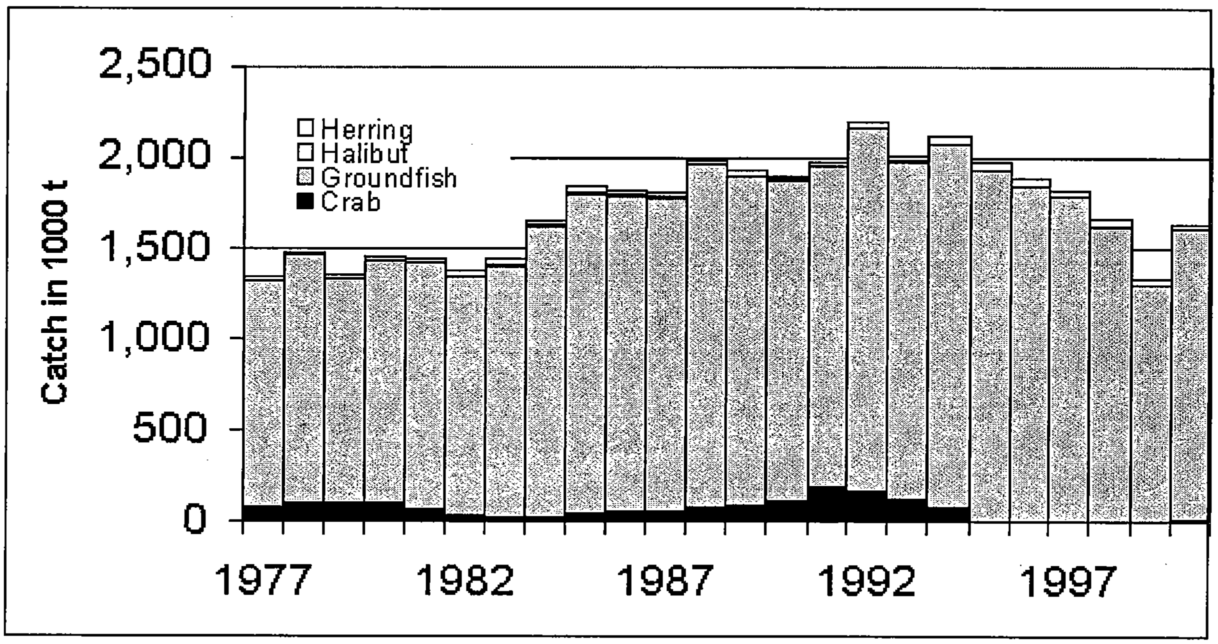


Figure A2-3. Catch history of groundfish, crab, herring and halibut in the eastern Bering Sea (EBS), 1977-2000.

To the north of the Pribilof Islands on the North Bering Sea outer continental shelf occur abundant concentrations of pollock and flatfish, primarily arrowtooth flounder. This area is not as productive as the southeastern Bering Sea, and winter ice cover limits fishing in the area to summer-autumn. In the coastal water from Cape Newenham to Norton Sound occur small spawning stocks of herring, and salmon runs in coastal rivers. The most abundant salmon species is chum salmon, and the largest runs are in the Yukon and Kuskokwim rivers, however, these runs are much less abundant than in other areas to the south. In this region of the Bering Sea an unutilized species, saffron cod, occurs in coastal waters. This species, which is harvested and utilized in Asia, appears to be abundant enough to support a localized fishery centered on Norton Sound.

The Aleutian Islands Region that extends from 170° W to the U.S.-Russian Convention Line has a limited fishery resource. This is likely due to the very narrow shelf surrounding the islands of the archipelago and the steep drop into the abyssal plains of the North Pacific deep. There is very little in the way of salmon or herring through the Aleutian Islands. Groundfish resources are also limited, with relatively low populations of pollock, cod and flatfish. The largest fisheries in the Aleutian Islands region are pollock in the eastern Aleutians, and Atka mackerel in the central and western Aleutians.

Salmon are not major fisheries in the Dutch Harbor area. Sockeye, chum and pink salmon are harvested in relatively low numbers in the Fish and Game Aleutian Islands District, with runs of even year pink salmon accounting for over 90% of the catch.

2.1.1 Fisheries

Alaska has a long history of fisheries exploitation, beginning with the Russian sea otter and fur seal hunts of the early 18th Century. Today, large harvests of salmon, crab, shrimp, herring, and groundfish are taken within the internal waters of the state, and from the U.S. EEZ. Within the past 40 years the greatest developments and changes have been in the groundfish fisheries in the EEZ off Alaska. Pacific cod was the earliest commercial fisheries harvest in Alaska. In 1854, a U.S. sailing brig en route to Russia to trade found large concentrations of cod while anchored of the Alaska Peninsula (Cobb 1928). These fish were salted and taken to San Francisco for sale. In the 1850s, regular annual trips for cod fishing were started by vessels fishing out of San Francisco (Cobb 1922).

The domestic salt cod fishery continued into the 1950s, but was soon dwarfed by the large salmon and herring fisheries that developed in the later part of the 19th century. Halibut became a significant commercial groundfish species in the early part of the 20th century when refrigeration made it possible to bring to market. Salmon, herring and halibut were the mainstay of the Alaska fisheries into the 1950s, at which time crab and shrimp fisheries began to develop and grow. Groundfish, other than halibut, were largely unexploited.

In 1954, this changed as Japan resumed high seas fisheries following the signing of a Peace Treaty with the U.S. High seas salmon fisheries began then, as did Japanese mothership operations began in the eastern Bering Sea targeting yellowfin sole (Bakkala et al 1985). By the late 1960s Japanese operations had expanded, and the first Soviet vessels began operations off Alaska. In the mid 1960s the Japanese and Russian factory trawler fleets moved into the Gulf of Alaska. By the mid 1970s vessels from Korea, Taiwan, and Poland joined the large groundfish fisheries off Alaska (Megrey and Wespestad 1989).

U.S. fishermen were not harvesting groundfish, but were concerned that the foreign groundfish fisheries were effecting the abundance of U.S. target species, such as crab, halibut, and salmon. Efforts were made through negotiations to enforce closed areas and catch restrictions. These measures provided some relief and opportunities to U.S. fishers, and the fishing fleet expanded, primarily larger crab vessels operating from Kodiak and Dutch Harbor.

When the Magnusson Act came into force in 1977, there was little immediate effect on the fisheries off Alaska. Foreign vessels continued to harvest the bulk of the groundfish, and U.S. vessels continued to fish their traditional fisheries. There was increased oversight of the foreign vessels with the placement of catch monitoring observers, and periodic boarding by the Coast Guard and NMFS enforcement.

In the early 1980s traditional crab and shrimp fisheries declined, forcing American fishermen to turn to other species to exploit. Under terms of the Magnusson Act foreign vessels were given favorable access to fish in "joint venture" operations that employed foreign processing vessels and American fishing vessels. Limited operations had started in the 1970s, but joint venture operations accelerated in the early 1980s when a policy of "Americanization" of the fisheries was instituted which reduced access to fisheries of nations not involved in joint ventures.

The policy of "Americanization" also opened up markets, particularly in Japan, that had been controlled by fishing and trading companies. Import restrictions were reduced, and trade was initiated with American companies in order to maintain access to fish products. This opened the door to increased opportunities for American entrepreneurs, who were aided by U.S. loan programs which provided highly favorable guaranteed loans for construction of fishing vessels. In a few short years the groundfish fleet grew from several dozen catcher boats of 105-135' size range to a fleet of nearly 70 large (250-300') factory trawlers.

The "Americanization" program developed much faster than even the most optimistic observer imagined. Directed foreign fishing had been phased out by 1987 and replaced by joint ventures (Figure 3). The joint ventures, which had been expected to continue until near the turn-of-the century by some, were over by 1991. The 1980s were a very profitable period for all segments of Alaskan fisheries, but especially so for groundfish, for which ex vessel values increased from $21.5 in 1982 to $475 million in 1990. The profitability of the fisheries coupled with easy loans, and decreased landings in crab and shrimp lead to an influx of vessels and new companies.

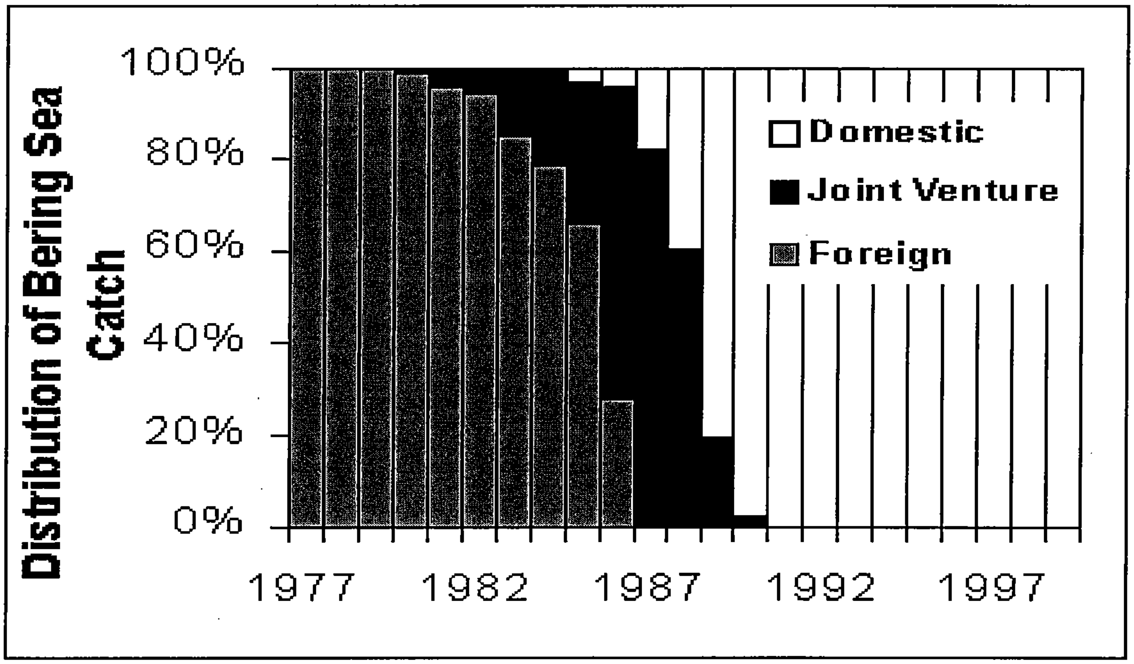


Figure A2-4 Transition of Bering Sea fisheries expressed as portion of the Bering Sea TAC allocated to foreign, joint venture, and domestic fisheries.

By the early 1990s it was clear that the "Americanization" program had been too successful, and there was an excess of capacity. This is clearly illustrated in the eastern Bering Sea pollock fishery, in which catch has averaged 1.2 million metric tons since 1964. While it was foreign dominated the fishery operated year-around, and joint venture fisheries took the harvestable quota in 8-9 months. With the advent of the domestic factory fleet, with tremendous harvesting and processing capacity, the fishing time was reduced to two fishing periods, which by 1997 lasted a total of 55 days in the inshore fishery, and 77 days in the offshore fishery (Table A2-2).

The growth in excess capacity gave rise to a host of management problems, primarily allocative in nature. These have included allocations to gear groups, quota divisions between shore based processors and off shore factory trawlers, by-catch restrictions and area closures to reduce the take of species taken in pre-existing non-trawl fisheries, such as crab, halibut, herring, and salmon; and attempts to develop limited entry programs.

Table A2-2. Fishing periods for eastern Bering Sea pollock and length of periods, 1990-1998.

Year	A Season						B Season					
	Inshore			Offshore			Inshore			Offshore		
	Start	End	Days	Start	End	Days	Start	End	Days	Start	End	Days
1990	1-Jan	15-Mar	74	1-Jan	15-Mar	74	1-Jun	13-Oct	134	1-Jun	13-Oct	134
1991	1-Jan	22-Feb	52	1-Jan	22-Feb	52	1-Jun	4-Sep	95	1-Jun	4-Sep	95
1992	20-Jan	6-Mar	46	20-Jan	6-Mar	46	1-Jun	22-Sep	113	1-Jun	28-Jul	57
1993	20-Jan	24-Mar	64	20-Jan	22-Feb	33	15-Aug	3-Oct	49	15-Aug	22-Sep	38
1994	20-Jan	2-Mar	42	26-Jan	18-Feb	23	15-Aug	4-Oct	50	15-Aug	24-Sep	40
1995	20-Jan	1-Mar	41	26-Jan	21-Feb	26	15-Aug	23-Sep	39	15-Aug	20-Sep	36
1996	20-Jan	2-Mar	42	26-Jan	25-Feb	30	15-Aug	17-Oct	63	30-Aug	17-Oct	48
1997	20-Jan	19-Feb	30	26-Jan	20-Feb	25	1 Sep	16 Oct	45	1-Sep	2 Oct	32
1998	20-Jan	26–Feb	37	26-Feb	20-Feb	25	1-Sep	29-Oct	58	1-Sep	19-Oct	49

The domestic groundfish fishery off Alaska is an important segment of the U.S. fishing industry. With a total catch of 1.8 million metric tons, a retained catch of 1.6 million metric tons and an ex-vessel value of $565 million in 2000, it accounted for 44% of the weight and 16% of the ex-vessel value of total U.S. domestic landings as reported in Fisheries of the United States, 2000. The value of the 2000 catch after primary processing was approximately $1.3 billion (Haitt et al. 2001). In Alaska, groundfish accounted for about half the value of all landings, followed by salmon, shellfish and halibut (Figure A2-5).

The groundfish fishery is currently stable, and economics has begun to remove some of the excess effort, primarily through bankruptcy or transfer to other fisheries. The process of rationalization of fisheries through effort reduction, and/or privatization of fishing rights will be a major feature of Alaska groundfish management for years to come. At the current time the North Pacific Fisheries Management Council is dealing with several issues related to capacity reduction. These issues are discussed further in later sections of this report.

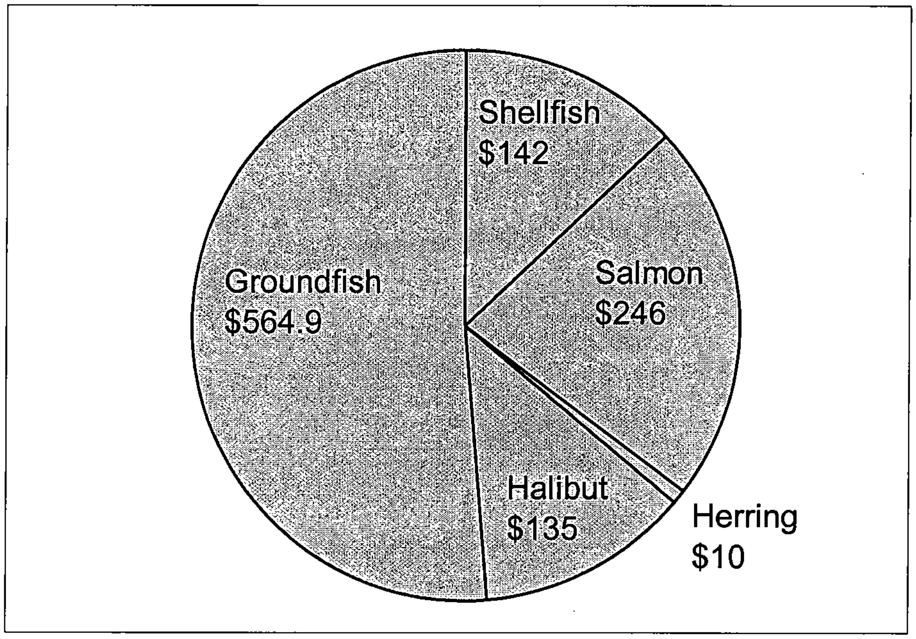


Figure A2-5. Ex-vessel value, in million dollars, of fisheries off Alaska in 2000.

2.1.2 Fisheries Resources

2.1.2.1 Groundfish

The groundfish fisheries accounted for the largest share of the ex-vessel value of all commercial fisheries off Alaska in 2000 (51%), while the Pacific salmon *(Oncorhynchus* spp.) fishery was second with $247 million or 22% of the total Alaska ex-vessel value (Hiatt et al. 2001). The value of the shellfish catch amounted to $143 million or 13% of the total for Alaska.

Walleye (Alaska) pollock *(Theragra chalcogramma*) has been the dominant species in the commercial groundfish catch off Alaska. The 2000 pollock catch of 1.21 million t accounted for 67% of the total groundfish catch of 1.82 million metric tons. The pollock catch was up approximately 11% from 1999. The next major species, Pacific cod *(Gadus macrocephalus*), accounted for 245,600 metric tons or 13.5% of the total 2000 groundfish catch. The Pacific cod catch was up about 1% from a year earlier. The 2000 catch of flatfish, which includes yellowfin sole *(Pleuronectes asper*), rock sole *(Pleuronectes bilineatus*), and arrowtooth flounder *(Atheresthes stomias*) was 228,200 metric tons up over 22% from 1999. Pollock, Pacific cod, and flatfish comprised almost 93% of the total 2000 catch. Other important species are sablefish *(Anoplopoma fimbria*), rockfish *(Sebastes and ebastolobus* spp.), and Atka mackerel *(Pleurogrammus monopterygius*).

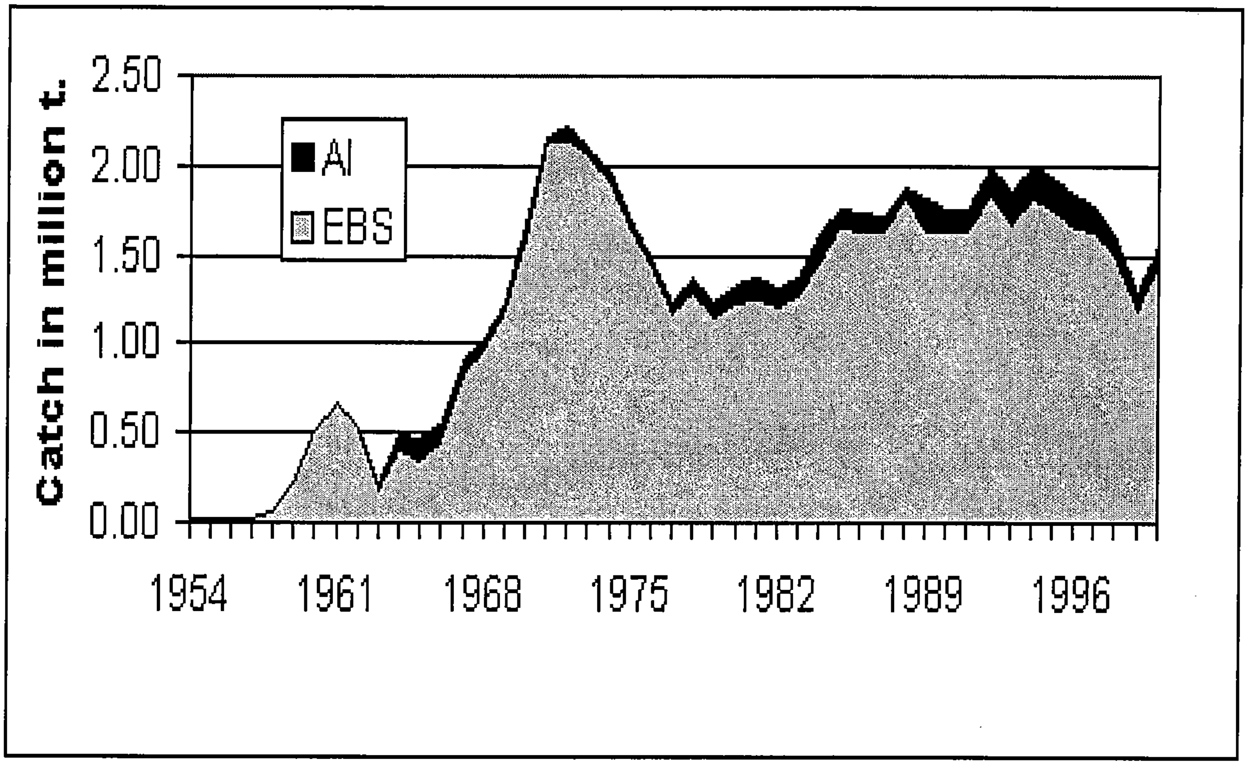


Figure A2-6. Total catch of groundfish in the Aleutian Islands (AI) and eastern Bering Sea (EBS).

Domestic groundfish fish harvesting, which began in the mid 1980's, has grown to be the largest sector of all the Bering Sea fisheries. Since 1988 groundfish landings at Dutch Harbor-Akutan has averaged 304 thousand metric tons with an exvessel value of $66.6 million (Table A2-3).

Table A2-3. Groundfish tonnage and exvessel value of groundfish delivered to Dutch Harbor-Unalaska, 1988-1999. **source: PACFIN**

	Year	Metric tons	Revenue
	1988	170,523.16	$35,465,193
	1989	218,888.27	$43,995,075
	1990	284,431.54	$57,184,372
	1991	320,778.18	$73,055,587
	1992	441,164.04	$124,973,439
	1993	358,317.73	$59,987,702
	1994	390,790.35	$70,171,972
	1995	390,283.70	$95,799,359
	1996	357,812.37	$79,931,854
	1997	249,225.56	$63,469,927
	1998	230,758.55	$40,828,849
	1999	236,734.75	$54,602,004
Average		304,142.35	$66,622,111

The following Information on status and trends of major Bering Sea groundfish resources were taken from NPFMC 2000 and Witherall 2000.

2.1.2.2 Walleye Pollock

Walleye Pollock *(Theragra chalcogramma)* is the most abundant groundfish species in the Bering Sea. The population has varied between 4 and 12 million metric tons. since the mid 1970s, but harvest has remain nearly constant with an average slightly greater than 1 million. The pollock resource supports a large part of the Bering Sea fleet. In 1998 there were 100 catcher vessels and 38 catcher-processors participating in the fishery. However, with the passage of the American Fisheries Act (See Regulatory Issues) and the formation of pollock fishery coops the number of vessels partipating in the fishery has decreased. Under the American Fisheries Act, 50% is allocated to catcher vessels delivering inshore, 40% to catcher processors for processing offshore, and 10% to catcher vessels delivering to motherships. Ten percent of the TAC is allocated to CDQ groups. The remaining TAC has been divided between inshore and offshore harvesters. The pollock quota is apportioned to four seasonal periods to reduce a perceived potential for competition with Steller sea lions through depletion of sea lion forage.

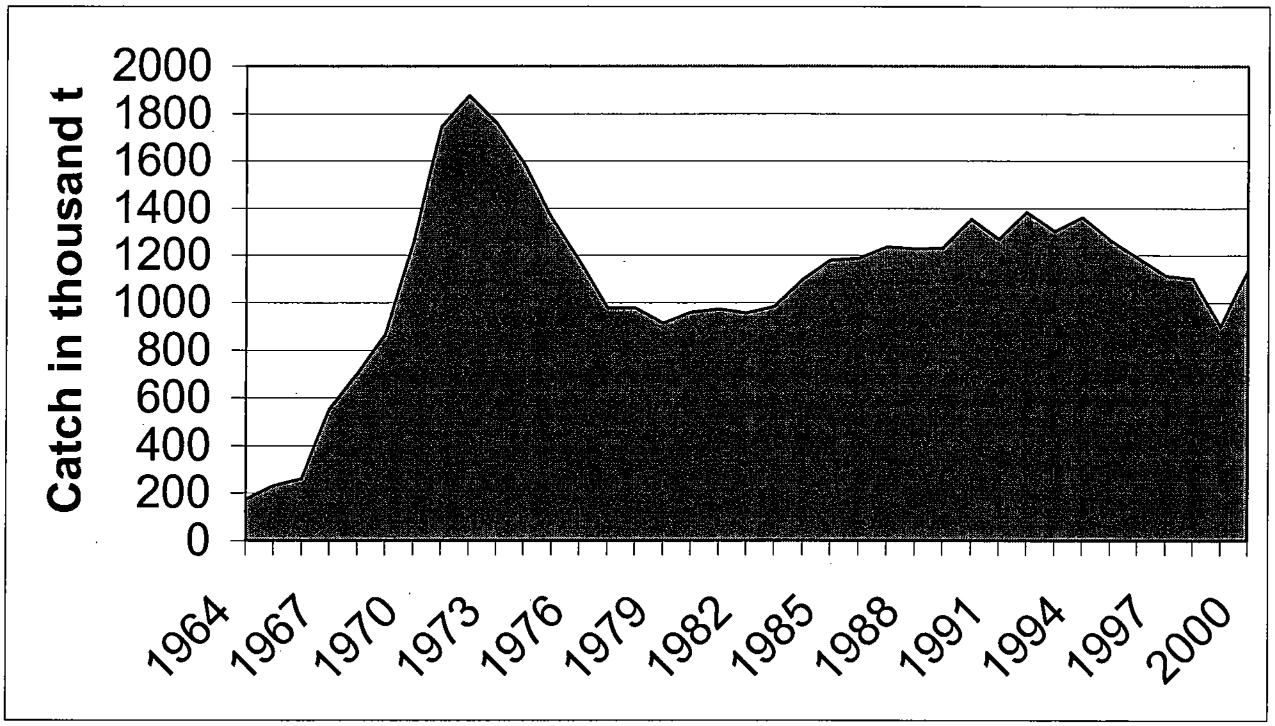


Figure A2-6. Catch of walleye pollock in the eastern Bering Sea, 1964-1999.

The Bering Sea pollock fishery grew in the mid 1960s when at-sea surimi processing was developed (Figure A2-6). Catches increased to over 1 million metric tons from 1970-1976 when Japanese and Russian distant water fleets prosecuted the fishery. By 1991, a domestic fleet phased out joint ventures developed in the early 1980's. Catches have remained relatively stable for the past 20 years. Pollock is primarily utilized for surimi and fillets with mince, roe, and meal as secondary products.

The pollock resource is currently near average levels of abundance. The estimated exploitable biomass in 2001 is about 10 million metric tons. Stocks are expected to stay in this range in the near term with average recruitment expected in coming years. The 2000 catch was 1,132,000 metric tons and it increased to 1,382,417 metric tons. in 2001. Catches are expected to be in the same range for the next several years as good recruitment of pollock passes through the fishery.

Pacific Cod

Pacific cod *(Gadus macrocephalus)* are taken with trawl, longline, pot and jig gear. Most trawling and pot fishing occurs north and west of Unimak Island, whereas most effort by longline vessels occurs along the slope north and west of the Pribilof Islands. In the 1998 fishery cod was harvested by 58 hook and line vessels, 78 pot vessels, and 121 trawl vessels. The Pacific cod TAC is allocated among gear types (51% to longline and pot gear, 47% to trawls, and 2% to jig gear). Of the trawl gear allocation, a 50/50 split is made for catcher vessels and catcher-processors. Seven and one-half percent of the TAC is allocated to CDQ groups.

The ex-vessel value of Bering Sea cod was $137 million in 1997. In 1998, 195,000 metric tons of cod were caught, of which about 98% was retained. Average ex-vessel price was about $0.25 per pound. Primary products produced are H&G and fillets, and to a lesser extent salted, whole fish, and other products (roe, mince, etc.).

Pacific cod is one of the oldest fisheries in Alaska. U.S. dory boat fisheries began in the 19th century that caught and processed salt cod for delivery to San Francisco and Seattle. The dory fishery ended in the early 1950s, but foreign fleets began fishing about the same time. Pacific cod were taken by Japanese longline and trawl operations beginning in the early 1960's. By 1970, catches had reached 70,000 metric tons. Vessels from the USSR entered the fishery in 1971, and together these two countries harvested an average of 50,000 metric tons from 1971-1976. Foreign fisheries were replaced by joint ventures in the early 1980's, which were phased out by domestic fleet by 1988. Catches have fluctuated at about 170,000 metric tons since 1985.

Pacific cod appears to have been at low abundance until the early 1980s when the population increased sharply due to a very strong 1977 year class. Cod abundance has remained high through most of the 1980s and 1990s. The 2000, exploitable biomass was projected to be 1.300 million metric tons. and the TAC set at 193,000 metric tons. The stock has been undergoing a slightly declining trend due to a series of weak year classes in the mid 1990s. An above average 1996 year class has increased the population in the near term. A strong 1999 year class is expected to enter the fishery in coming years and maintain cod production for the next several years.

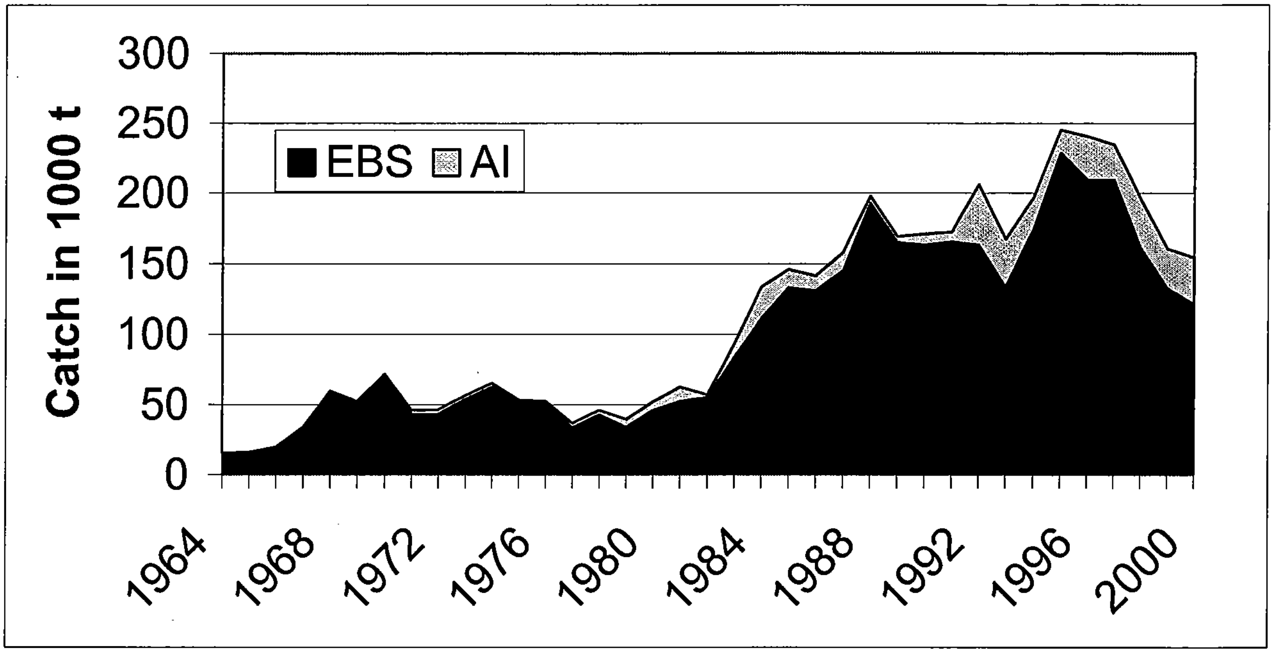


Figure A2-7. Catch of Pacific cod in the eastern Bering Sea (EBS) and Aleutian Islands (AI), 1964-2000.

Flatfish

The Bering Sea contains an enormous flatfish resource with an aggregate biomass of nearly 6 million metric tons. in 1998 (NMFS 1998). The flatfish include the shelf species of which Yellowfin sole (Limanda aspera), Rock sole (Lepidopsetta bilineata), Flathead sole (Hippoglossoides ellassodon) are the most abundant and form the basis of trawl fisheries. Greenland turbot (Reinhardtius hippoglossoides) and Arrowtooth flounder (Atheresthes stomias) occur in deeper water along the continental slope with turbot the target species in the fishery.

The shelf flatfish are harvested by catcher processors. During the winter months roe bearing flatfish are sought, primarily rock sole, and yellowfin sole are harvested during the summer months. Most fishing effort for rock sole occurs in outer Bristol Bay and the area north of Unimak Island. The product form is primarily headed and gutted fish block frozen.

Flatfish harvests produced a total ex-vessel value of $55 million in 1997. In 1999, 67,000 metric tons of yellowfin sole were caught, of which about 55,000 metric tons were retained. Average ex-vessel price for flatfish was about $0.13 per pound.

Greenland turbot has been targeted by trawl and longline gear. The 1997 directed fishery was prosecuted longline vessels from May 1-September 15 in the Bering Sea. Significant amounts are also retained as bycatch in other fisheries. Most fishing occurs along the shelf edge and slope, as well as along the Aleutian Islands.

The flatfish complex of the Bering Sea is lightly exploited; the average harvest since 1980 has been about 209 thousand metric tons per year (Figure A2-8). The average biomass is 4.9 million metric tons and the average TAC has been 407 thousand metric tons. Comparing catch to biomass shows that less than 5% of the resource is utilized, and on average only 50% of the TAC is harvested. The primary reason for the low utilization is that the fisheries for flatfish operate on a bycatch limit for halibut and crab, and when the limit is reached fisheries are terminated.

With the low level of exploitation placed on Bering Sea shelf flatfish the population is expected to remain stable near current levels for the next several years. The aggregate TAC for 2001 is nearly 400 thousand metric tons. Greenland Turbot is the only flatfish that is not productive at the moment, recruitment appears to have been low for a number of years and harvest has been restricted. The 2001 TAC is 8,100 metric tons.

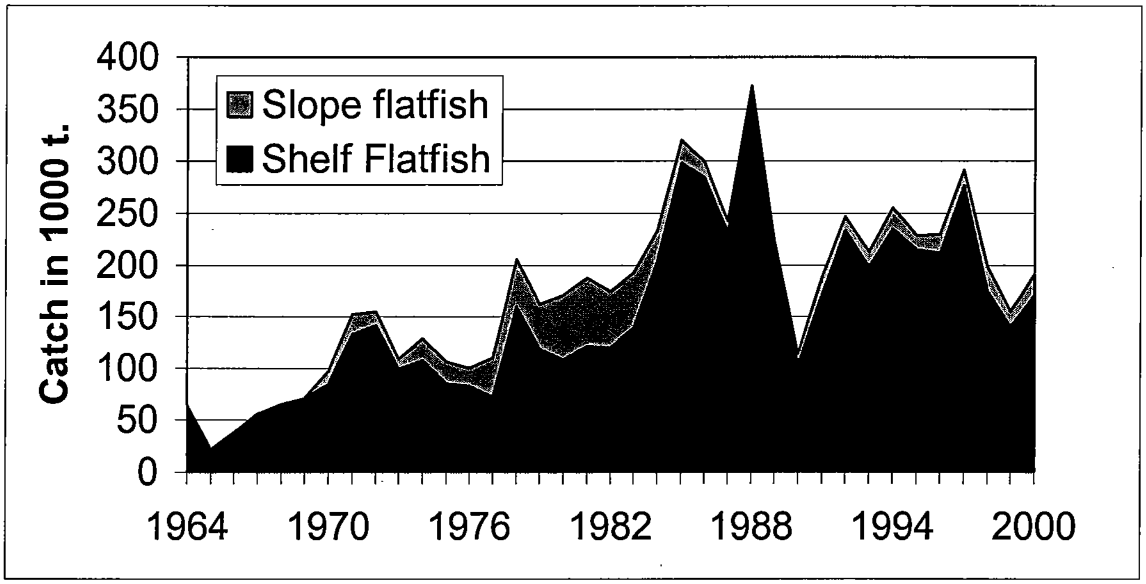


Figure A2-8. Catch of shelf and slope flatfish in the eastern Bering Sea, 1964-2000.

Sablefish

Bering Sea Sablefish is a high valued resource worth $62 million ex-vessel in 2000. In 2000, 1,700 metric tons was caught with an average ex-vessel price was about $2.03 per pound for fixed gear fisheries, and $1.01/lb for trawl fisheries. The primary product produced is fish that are headed, gutted (H&G) and frozen round.

Sablefish are primarily harvest by longline, and pot gear and is fished concurrent with halibut. Twenty percent of the BSAI fixed gear sablefish quota is allocated to CDQ communities.

Sablefish was targeted by Japanese freezer longliners since 1959. Bering Sea catches peaked in 1962 when 28,500 metric tons were harvested. From 1963 to 1972, an average of about 13,000 metric tons of sablefish were caught, with the USSR entering the fishery in 1967.

Catches dropped to less than 5,000 metric tons in 1974. A small peak occurred in 1987 when 8,000 metric tons were landed. Landings have since been reduced.

Exploitable biomass in 2002 is estimated to be 67,000 metric tons in the eastern Bering Sea - Aleutian Islands. The 2000 TAC is 1,930 metric tons in the eastern Bering Sea and 2,550 metric tons in the Aleutian Islands. The stock had declined due to low recruitment from 1982 though the mid 1990's, but now appears to be increasing.

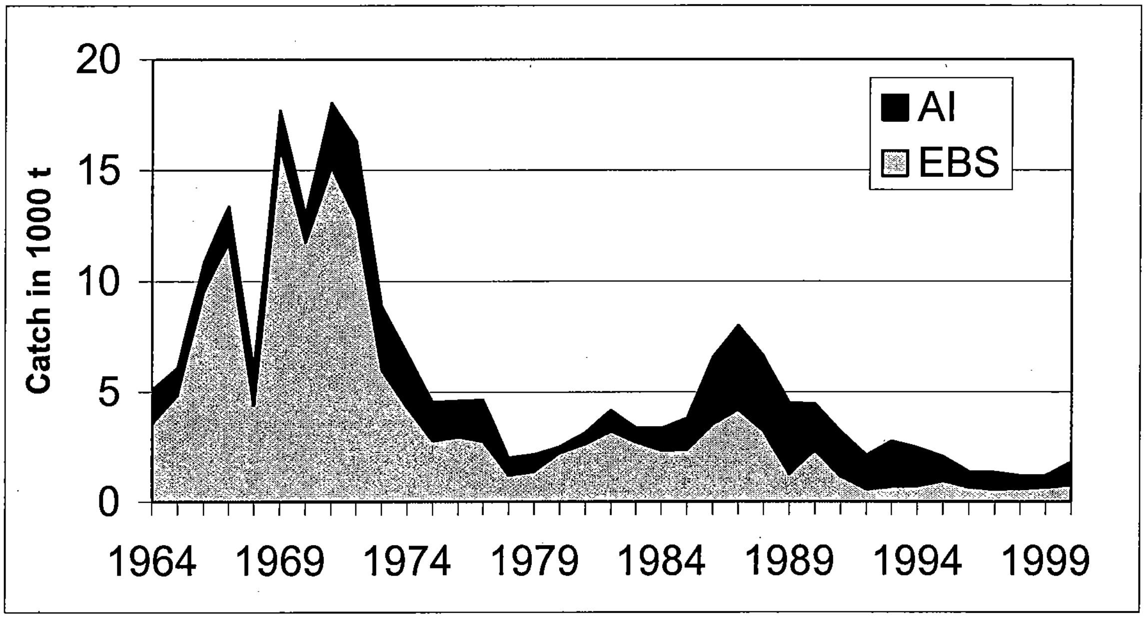


Figure A2-9. Catch of Sablefish in the eastern Bering Sea (EBS) and Aleutian Islands (AI), 1964-2000.

Rockfish

Several species make up the "rockfish complex". The major species is Pacific ocean perch *(Sebastes alutus)* which occurs in deep water along the continental slope and has its greatest abundance in the Aleutian Islands. Other commercially harvested rockfish are northern rockfish, rougheye rockfish, shortraker rockfish and sharpchin rockfish and shorttspine thornyheads *(Sebastolobus alascanus)*, the later species is primarily harvested by longline.. Rockfish are long-lived and have low productivity.

Pacific Ocean perch (POP) and other rockfish are a relatively high-valued resource. In 2000, 15,597 metric tons of POP were caught along with about 840 metric tons of other red rockfish was caught. Average ex-vessel price of rockfish was about $0.18 per pound. Primary products produced are H&G and whole fish.

Major Japanese and Soviet trawl fisheries heavily fished Pacific Ocean perch in the 1960's. In the Bering Sea, catches peaked in 1961 (47,000 metric tons); the Aleutian Islands catch peaked in 1965 (109,000 metric tons). Stocks and catches declined reaching their lowest levels in the mid-1980s. Since 1977, catches have been sharply reduced and maintained near 12,000 - 20,000 metric tons per year to rebuild the stocks.

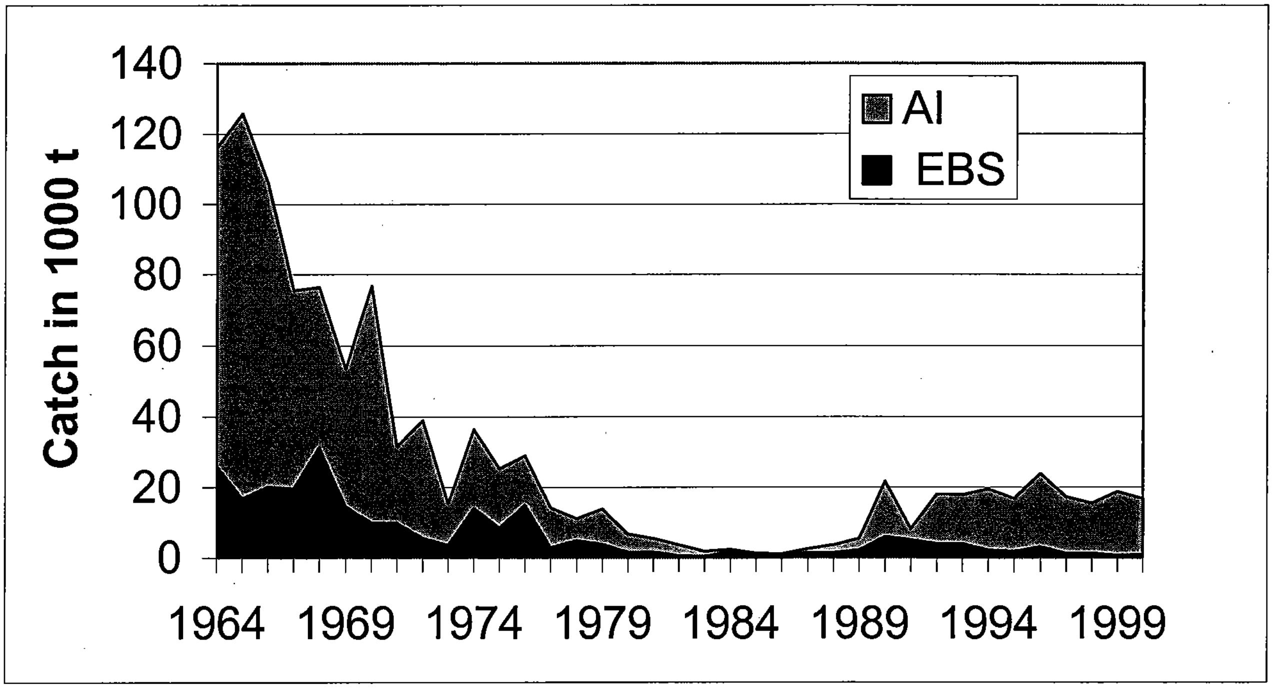


Figure A2-10. Catch of rockfish in the eastern Bering Sea (EBS) and Aleutian Islands (AI) 1964-1996. Pacific Ocean perch (POP) comprised 92% of rockfish catch.

The exploitable biomass of POP in 2002 is 377,000 metric tons in the EBS-AI, and the TAC is 14,800 metric tons. Several above average year-classes were produced during the 1980s that is increasing stock size. For other rockfish the 2002 biomass is estimated at 8,825 metric tons with most of the expected catch from the Aleutian Islands.

Atka Mackerel

Atka mackerel are concentrated on very discrete areas, such as Seguam Bank, Tanaga Pass, Oglala Pass, and Tahoma Reef in the Aleutian Islands. Vessels from USSR, Japan, and Korea targeted Atka mackerel during the 1970's. Catches peaked at 24,000 metric tons during this time period. Foreign fisheries were replaced by joint-ventures during the 1980's. The fishery has been fully domestic since 1990, and catches have fluctuated in response to TACs. Atka mackerel is targeted by catcher processor trawlers. Participants in the 1998 fishery included 14 catcher processors. Since 1994, the TAC has been apportioned among AI subareas. In 1999, as a mitigation measure for sea lions, TAC began to be allocated inside and outside of Steller sea lion critical habitat to reduce potential competition.

In 2000, 47,239 metric tons of Atka mackerel was caught in the EBS-AI area. Average ex-vessel price was about $0.10 per pound. Primary products produced are H&G (headed and gutted) and whole fish.

Biomass of Atka mackerel peaked in 1991, bolstered by strong year-classes produced in 1984-1986 and a very strong 1988 year-class. The most recent assessment indicates that this stock is on a downward trend. The 1992 year class was above average, but more recent year-classes have been small. For 2002, the exploitable biomass was estimated to be 439,700 metric tons and TAC 49,000 metric tons.

Bering Sea Crab

Crab stocks in the Bering Sea and Aleutian Islands are managed by the State of Alaska through a federal king and Tanner crab fishery management plan (FMP). Under the FMP, management measures fall into three categories: (1) those that are fixed in the FMP under the North Pacific Fisheries Management Council's oversight, (2) those that are frameworked so the State can change them following criteria outlined in the FMP, and (3) those measures under complete discretion of the State.

Five types of crab occur in the Bering Sea: Red King crab*(Paralithodes camtshaticus*), Blue King crab*(Paralithodes platypus*), Golden King Crab *(Lithodes aequispinus*), Tanner crab *(Chionoecetes bairdi*), and snow crab *(Chionoecetes opilio*).

Three discrete stocks of red king crab are actively managed in the BSAI region: Bristol Bay, Norton Sound, and Aleutian Islands stocks. The Aleutian Islands stock consists of Adak and Dutch Harbor populations. Two discrete stocks of blue king crab occur: the Pribilof Islands and St. Matthew Island stocks. Golden king crab, or brown king crab, are most abundant in the Aleutian Islands where it is managed as one stock. Tanner crab *(C. bairdi*) are managed into 3 separate stocks: eastern Bering Sea, eastern Aleutian Islands, and western Aleutian Islands. Snow crabs are thought to be one stock throughout the Bering Sea.

Crab harvest is managed under guideline harvest levels established from surveys, or from fisheries performance. A minimum legal size, carapace width exists for each harvested species. Pot limits have been established based on vessel size and guideline harvest level and vary by crab fishery. Observers are required on all vessels processing crab in the Bering Sea and Aleutian Islands area. Season opening dates are set to maximize meat yield and minimize handling of softshell crabs.

Red King Crab

Mean age at recruitment is 8-9 years and the State sets guideline harvest levels of 20% for mature male red king crab. In 1996, the harvest rate for red king crabs was reduced to 10% of the mature males to allow stock rebuilding. A threshold of 8.4 million mature females, equating to an effective spawning biomass of 14.5 million pounds, has been established as a minimum benchmark for harvesting this stock.

The season opening date for Bristol Bay red king crab fisheries is November 1. The Aleutian Islands area (formally Adak and Dutch Harbor) opens September 1.

After declining abundance throughout the 1960s and reaching a low during the years 1970-1972, recruitment to the Bristol Bay red king crab stock increased dramatically in the mid- and late 1970s. Recruitment was much lower during the 1980s and 1990s. By 1994, recruitment was about 1/20th of what it was in 1977. Since then, stock assessments indicate a slight but steady increase in the abundance of small males and females.

At the fishery's peak record landings were established in each year from 1977 to 1980 (peaking at 129.9 million pounds) (Figure A2-11). This was followed by a stock collapse in 1981 and 1982 leading to a total closure of the Bristol Bay fishery in 1983. In 1984, the stock showed some recovery and a limited fishery was reestablished. Between 1984 and 1993, the fishery continued at levels considerably below those of the late 1970s. Annual landings during this period ranged from 4.2 million to 20.4 million pounds.

After 1993, the stock declined again, and no fishery occurred in 1994 and 1995, but reopened in 1996 with a catch of 8 million pounds. The fishery has remained open with catch averaging near 10 million pounds.

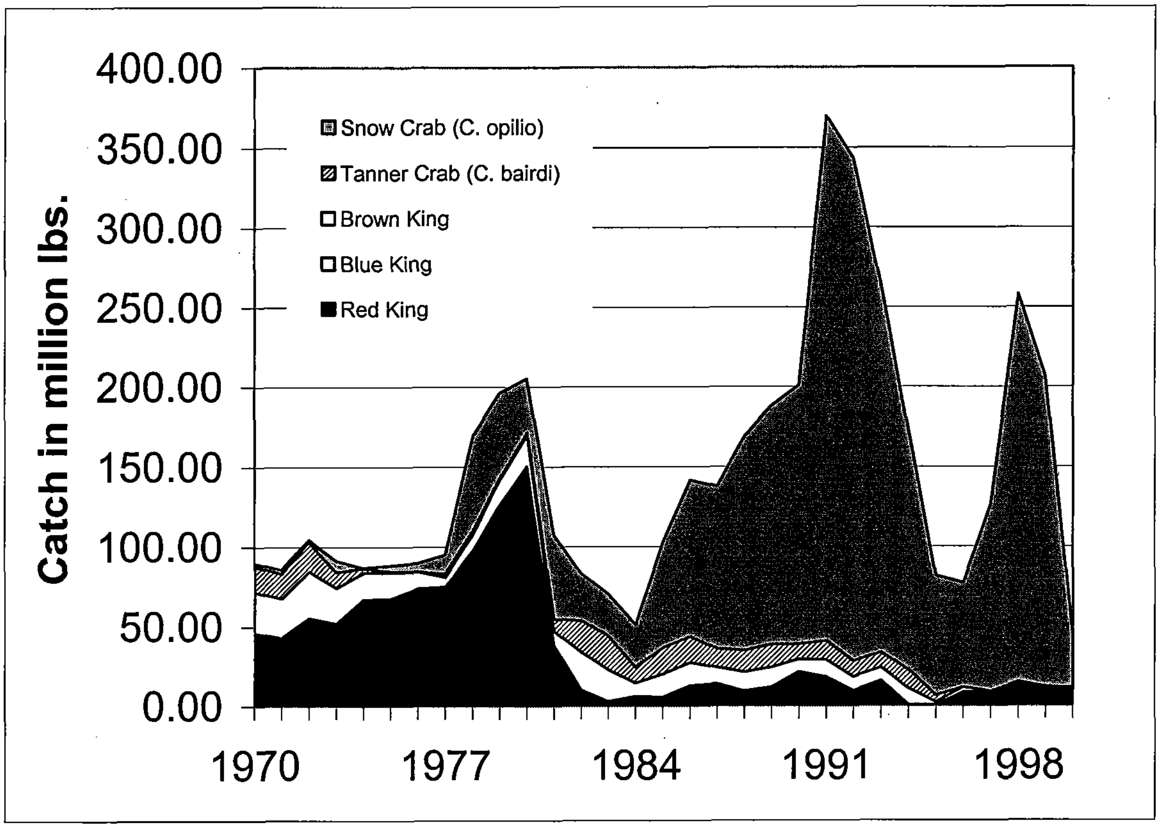


Figure A2-11. Catch of king and tanner crabs in the Bering Sea, 1970-2000.

Over 280 vessels participated in the Bristol Bay red king crab fishery. The season begins on November 1, and generally has lasted less than 10 days in recent years. These crab average about 6.5 pounds and fetch a high ex-vessel price; $3 to $5 per pound was paid during the 1989-1993 fisheries. Total ex-vessel value ranged from $40,000,000 to $100,000,000 in those years.

Red king crab were harvested from the Dutch Harbor area beginning in 1961, and peaked at 33 million pounds in 1966. Thereafter, harvests declined, averaging about 11 million pounds annually through 1976. A secondary peak harvest occurred in 1980 with 17.7 million pounds taken, after which the stock collapsed and has not recovered. No red king crab fishery has been allowed in this area since 1983. A second red king crab fishery occurs in the Aleutian Islands region, the Adak fishery. Began in 1960, it peaked at 21 million pounds in 1964, and continued until 1972 with catches near 16 million pounds. From 1977 to 1993, landings were low (about 1 million pounds annually) but stable. Since then the stock has declined. Currently, red king crab in this area is harvested by golden king crab vessels with single line pots in a directed fishery. The 1995 fishery was prosecuted by 10 vessels, which harvested 36,000 pounds of red king crab with an ex-vessel value of $5.50 per pound. Average weight of landed crab was 7 pounds. No fishery was allowed in 1996 or 1997.

Blue King Crab

The State generally sets pre-season guideline harvest levels for blue king crab based on a mature male harvest rate of 20%. Threshold levels have been established for these stocks, below which a fishery will not occur. A threshold level of 0.77 million crabs >119 mm carapace length has been established for the Pribilof stock; the St. Matthew threshold is 0.6 million males >104 mm carapace length.

NMFS survey data indicate a series of good recruitment in the early 1970s. Recruitment fell off in the early 1980s, but improved signs of recruitment were observed in the early 1990s. Recent survey data indicate that total stock size has generally increased over the past 10 years. During the late 1970s, landings of blue king crab from the Pribilof stock increased to peak at 11 million pounds in the 1980-81 season (Figure A2-11). This was followed by a rapid decline in the early 1980s, leading to a total closure of the fishery in 1988. No fishery occurred from 1988-1994. By 1995, stock conditions had improved such that a combined GHL for red and blue king crab of 2.5 million pounds was established.

In 1995, 119 vessels participated in the Pribilof red and blue king crab fishery. The season began on September 15 and lasted 7 days. Blue king crab fetched $3 per pound exvessel, making the total fishery worth $3.6 million. Average weight of blue king crab harvested was 7.3 pounds. For 1997, 48 vessels, including one catcher-processor, fished Pribilof blue king crabs. The 1997 season lasted 14 days and yielded crabs with an average weight of 7.5 pounds, valued at $2.82 per pound exvessel.

At St. Matthew Island, high numbers of juvenile males crabs recruited to the fishery in the early 1980s. Harvest of blue king crab from the St. Matthew fishery began in 1977, peaking at 9.5 million pounds in 1983. This was followed by reduced harvests in the late 1980s. By the early 1990s, abundance of large males had increased and GHLs were increased to over 3 million pounds. In 1995, a total of 90 vessels (1 catcher-processor, 89 catcher vessels) participated in the St. Matthew blue king crab fishery. The season began on September 15 and lasted 5 days and 3.2 million pounds were landed. Blue king crab sold at $2.32 per pound exvessel, making the total fishery worth $7.1 million. The average crab size was 4.8

pounds. In 1997, 117 vessels participated and harvested 4.6 million pounds in 7 days. Crab averaged 4.9 pounds each and brought $2.21 per pound exvessel, making the total fishery worth $9.8 million.

Golden King Crab

Golden king crab occur at depths from 200 m to 1,000 m primarily in the Aleutian Islands. Pot surveys and fishery performance are utilized as indices of abundance, however. A total of 34 vessels, averaging of 500 pots, participated in the 1994-1995 Adak golden king crab fishery. The fishery lasted 288 days, with a total harvest was 6.4 million pounds. Average weight of golden crab harvested was 4.1 pounds in the Adak area. These crab were worth $3.33 per pound exvessel, for a total season value of $20.3 million. The 1995 Dutch Harbor golden king crab fishery was prosecuted by 17 vessels. The season opened on September 1, and lasted 38 days. A total of 2 million pounds were landed at an exvessel price of $2.60 per pound. Average weight of Dutch Harbor golden king crab was 4.6 pounds.

Tanner Crab

Tanner crab are distributed on the continental shelf of the Bering Sea and concentrated around the Pribilof Islands and immediately north of the Alaska Peninsula

The State sets pre-season guideline harvest levels for Tanner crab based on a mature male harvest rate of 40%. The season opening date for the Bering Sea Tanner crab fishery is November 1. In years when no GHL is established for the Bristol Bay red king crab stock, the Tanner crab fishery is restricted to the area west of 163° W longitude.

The eastern Bering Sea Tanner crab *(C. bairdi)* stock is currently at very low abundance. The 1995 NMFS bottom trawl survey indicated relatively low levels of juveniles, pre-recruits, females, and large males and poor recruitment occurred in following years. The Bering Sea Tanner stock has undergone two large fluctuations. Catches increased from 5 million pounds in 1965 to over 78 million pounds in 1977 (Figure 8). After that, the stock declined to the point where no fishery occurred in 1986 and 1987. The fishery reopened in 1988, and landings increased to over 40 million pounds in 1990. Another decline ensued, and the 1995 Tanner crab season produced only 4.2 million pounds. The 1995 fishery was prosecuted by 196 vessels and lasted 15 days. Average weight of crab landed was 2.3 pounds valued at $2.80 per pound exvessel. Total value of the 1995 fishery was $11.7 million. In 1994 and 1995, fishing was prohibited east of 163° W to reduce bycatch of red king crab. In 1996, 196 vessels harvested 1.8 million pounds of Tanner crab in the directed fishery (12 days) and incidental to a red king crab fishery (4 days). Average weight was 2.5 pounds valued at $2.50 per pound. Due to the depressed nature of the stock and predominance of old shell crab, no fishery has been allowed since 1996.

Snow Crab

Snow crabs are distributed on the continental shelf of the Bering Sea at depths less than 200 meters Abundance of large male snow crab increased dramatically from 1983 to 1991, but has since declined. The 1993 NMFS Bering Sea trawl survey indicated the total abundance of large males (over 4 inches) at 135 million crab, a 48% decrease from 1992. Small (3-4") legal-size males also declined in abundance, consistent with the decline in large males observed since 1991. The 1995 NMFS bottom trawl survey indicated relatively low levels of large male crab. However, the survey indicated an 88% increase in the numbers of pre-recruits, and a 44% increase in the number of large females. These signs of strong recruitment were apparent in the 1996 survey, as survey results indicated the number of large crab doubled.

Catch of Bering Sea snow crab increased from under 1 million pounds in 1974 to over 315 million pounds in 1992. The 1992 peak catch was followed by reduced landings thereafter (Figure A2-11). The 1995 opilio fishery was prosecuted by 253 vessels. The season began on January 15 and lasted 33 days. A total of 74 million pounds were landed. Average weight of crab retained was 1.2 pounds worth $2.43 per pound exvessel. Total value of the 1995 snow crab fishery was $180 million exvessel. Increased landings occurred in recent years due to good recruitment of sublegal males. In 1997, 119.4 million pounds of snow crab were harvested. Average weight of crab taken was 1.2 pounds. A total of 226 vessels have participated. Exvessel price was $0.79/lb, for a total fishery value of $92.5 million. The 1998 fishery opened with a GHL of 234 million pounds, of which 3.5% was allocated as community development quota, CDQ.

2.1.2.3 Pacific Herring

Herring fisheries begin in the Bering Sea in the late 1920s when stock abundance was low in the traditional fisheries of central Alaska. A saltery was developed at Dutch Harbor that operated until the Second World War. In 1959 Russian exploratory fleets located the wintering grounds of herring northwest of the Pribilof Islands and began a winter trawl fishery. In 1968 the Japanese also began fishing for herring on the winter grounds, and developed a gill net fleet that operated in coastal areas harvesting spawning herring. The fishery developed on strong year classes from the late 1970s, and as these year classes died out the catch plummeted.

In the late 1970s, with the establishment of the U.S. EEZ, the foreign fisheries were removed, and domestic roe herring fisheries developed in coastal spawning areas. The largest of the current fisheries is the Togiak fishery in Northern Bristol Bay, followed by Norton Sound (Figure A2-12). Several small fisheries occur along the western Alaska coast between Togiak and Norton Sound.

In 1981 a food and bait fishery redeveloped at Dutch Harbor. This fishery primarily harvests feeding herring migrating from the Togiak spawning grounds to the winter grounds. The herring arrive in the Dutch Harbor area from mid July to early August. By that time they are in good condition and have a high fat content of 16-20%. The quantity of the Dutch Harbor catch is limited because the fishery is operating on Togiak herring. Each year the Dutch Harbor fishery is limited to 7% of the Togiak biomass. The average catch since 1981 has been about 2,700 metric tons.

The Dutch Harbor food and bait fishery usually starts in mid July. The historic record from the old saltery and from foreign fisheries suggests that a herring fishery could be pursued in the Dutch Harbor area from July to late September-early October.

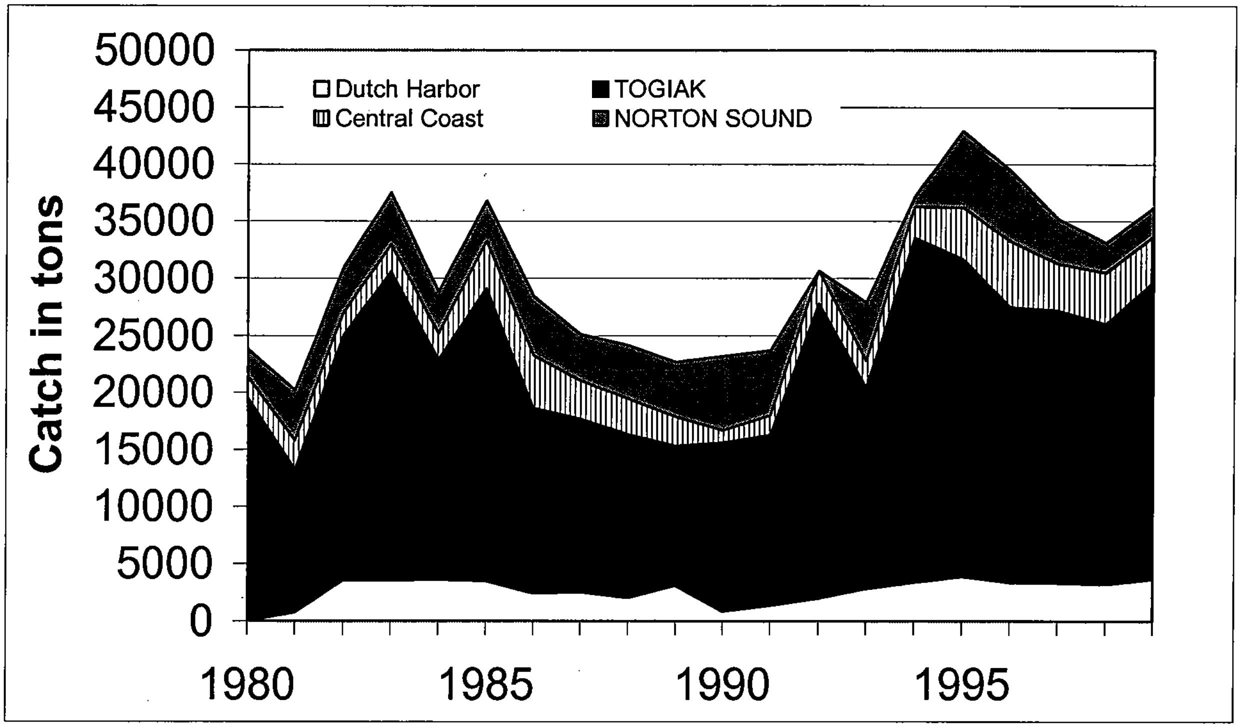


Figure A2-12 Catch of Pacific herring in the eastern Bering Sea by major fishing areas. 1980-1999.

Pacific Halibut

Pacific halibut is found from the Bering Sea to Oregon, though the center of abundance is in the Gulf of Alaska. The resource is considered as one large interrelated stock but is regulated by subareas with catch quotas and time-area closures. The fishery has a long tradition extending back to the late 1800's. There is an active recreational fishery as well. Stock assessment and management advice is provided by the International Pacific Halibut Commission (IPHC) that assesses halibut throughout its range.

The total 1996 Pacific halibut catch in Alaska was 17,064 metric tons. Other catches were 3,106 metric tons taken in the recreational fishery, 103 metric tons taken for personal use, wasted mortality of 480 metric tons due to fishing by lost gear and discard, and incidental catch mortality of 5,719 metric tons by fishermen targeting other species.

The IPHC recently recalculated the exploitable stock of the Pacific halibut. The new calculations indicated that stocks peaked near 275 thousand metric tons in 1992. In recent years the population has shown a slight decline, and a further decline is expected, but halibut numbers are currently high by historical standards.

The catch of halibut is small relative to other groundfish, such as pollock or cod, but it and king crab influence the ground fish harvest greatly. This is because these are species with a long history of domestic utilization. Also they are important species to Alaska small boat fishermen. All through the period of foreign exploitation of groundfish the major effort of government (both State and Federal) was to protect "species of interest to the U.S.", primarily Pacific halibut and king crab. When domestic vessels took over the groundfish fishery the rules of the foreign fisheries were applied to them. A major reason is that most of the trawl fleet is owned by non Alaskans and therefore are viewed as "foreigners".

Halibut bycatch will likely continue to act as a limitation on groundfish development. Recently individual transferable quotas (ITQ) were allotted for halibut. In theory these should be freely transferable and respond to economics. However the NPFMC has limited ITQs to small blocks that can only be harvested by longline. If ITQs were freely transferable, it is likely that trawl vessels would pay the highest value to increase access to groundfish. It is likely that U.S. and Canadian halibut fisherman will increase pressure on the NPFMC to further reduce halibut bycatch since reductions in the trawl catch will accrue to them under the current ITQ structure. According to the IPHC, halibut bycatch is nearly a third of the commercial harvest.

2.1.3 Management Structure

The State of Alaska is responsible for management of fishery resources within the territorial waters (0-3 nm.) of Alaska. The Alaska Board of Fisheries is the policy body that establishes fishery policy, although some aspects of fisheries management is by stature established by the State legislature. The Alaska Department of Fish and Game (ADFG) is the regulatory agency that establishes harvest quotas and regulations for the State managed fisheries.

In the U.S. EEZ (3-200 miles) the North Pacific Fisheries Management Council (NPFMC) is the primary policy and regulatory body. The NPFMC establishes harvest quotas and regulations for the EEZ, which are administered by the National Marine Fisheries Service (NMFS) Alaska Region. Although the NPFMC has jurisdiction over all fish harvests in the EEZ, it has delegated management of species for primary interest to the State of Alaska to ADFG. These species are all species of Pacific salmon, Pacific herring, and shellfish, which includes all crab, shrimp, and scallops. With the delegation of these species the primary focus of the NPFMC and NMFS are the groundfish resources of the Gulf of Alaska and the Bering Sea.

The commercial fisheries management within the State of Alaska is within the Commercial Fisheries Management Division (CFMD) of ADFG. CFMD is organized into four regional offices: Southeastern Alaska, Central Alaska, Western Alaska, and Arctic-Yukon-Kuskokwim. These offices are responsible for the harvest management of resources within their geographic area.

The NPFMC manages through established fishery management plans (FMP's). Two regional groundfish plans are in effect: Gulf of Alaska Groundfish, and Bering Sea Aleutian Islands

Groundfish. The Gulf of Alaska is divided into 3 regulatory areas, southeastern, central, and western. The Bering Sea is subdivided into Aleutian Islands area and eastern Bering Sea management areas. All of these management areas are further subdivided into various regulatory areas.

The NPFMC also have management plans for King Crab, Tanner Crab, and Salmon, but effective management has been delegated to the State.

2.1.3.1 Regulatory Issues

The Bering Sea groundfish fishery has been in a constant state of evolution ever since the passage of the Magnuson Act and institution of the 200 mile EEZ. Through the late 1970s and early 1980s the foreign fishing fleet was restricted and effort placed on utilizing foreign processing capacity in conjunction with U.S. catcher vessels, the so called "joint venture" (JV) fisheries. Joint venture fisheries introduced U.S. firms to processing technology and international marketing of production tied up by foreign firms. Beginning in the mid 1980s U.S. catcher processors began catching and processing fish at sea which began the phase out of the joint ventures, which ended in 1989.

During the 1990s there was a great built up in U.S. catching and processing capacity as entities sought to gain the greatest share of the resource in the then open access fishery. The race for fish caused friction between shoreside processors that were able to employ the catcher vessels that operated in the JV fisheries. The at-sea catcher processors had greater mobility than the shore plants and could fish further offshore than the shorebased vessels. The greatest concentration of groundfish, principally pollock, occurs on the continental shelf edge just north of Dutch Harbor. With all sectors competing for the same concentration of fish there was a strong movement for doing something to separate the shoreside and at-sea sectors. In 1992, The NPFMC instituted what came to be known as "Onshore-Offshore" in which groundfish, primarily pollock, was allocated on a ratio of 35% onshore and 65% offshore.

The NPFMC continued to adjust the percentages and sector participants through the 1990s. The fishery management and development policies for federally managed fisheries off Alaska has shifted from open access to control of effort and minimizing adverse effects of fishing. Programs that have been developed, or under consideration are: the licence limitation program, individual fishing quota (IFQ) program for the fixed gear sablefish fishery, the community development quota (CDQ) program for BSAI groundfish, and the American Fisheries Act (AFA). These programs are eliminating the race for fish as the allocation mechanism and replacing it with a market-based allocation mechanism that decrease harvesting and processing costs, increase the value of the groundfish catch, and, in some cases, decrease the cost of providing more protection for target species, non-target species, marine mammals, and seabirds.

2.1.3.2 License Limitation Program

The Council approved license limitation programs for the groundfish and BSAI crab fisheries under its jurisdiction on June 17,1995.The proposed rule received SOC approval on September 12,1997 and the final rule was published in the Federal Register on October 1,1998.The LLP became effective January 1, 2000, replacing the Moratorium program which expired on December 31,1999.

The LLP limits the number, size, and specific operation of vessels that may be deployed in certain groundfish and BSAI crab fisheries under the Council 's jurisdiction. By limiting the number of vessels that are eligible to participate in the affected fisheries, the LLP limits capitalization in those fisheries.The LLP was intended to identify and limit the number of participants in the groundfish and crab fisheries, as an interim step toward a more comprehensive solution to the conservation, management, and economic problems in an open access fishery,

The American Fisheries Act (AFA)

The American Fisheries Act (AFA) specifies the allocation of the directed pollock fishery annual Total Allowable be divided among the inshore component, the offshore component, and the mothership component at 50%, 40%, and 10% respectively. The Act specified by name 20 catcher processors (offshore sector), owned by nine different companies eligible to continue participating in the pollock fisheries. The Act also removed nine catcher processors from future participation in any US fishery. The Act listed seven catcher vessels eligible to fish and deliver a suballocation within the offshore sector allocation. Three motherships are eligible to process the mothership allocation with 19 catcher vessels eligible to fish and deliver to motherships. For the inshore sector, the Act did not list the eligible plants and catcher vessels by name; rather, it stipulated a landing/processing history necessary for eligibility. For catcher vessels that is >250 metric tons delivered onshore in 1996, or 1997, or 1998 through September 1, or >40 metric tons for vessels under 60'. Approximately 113 catcher vessels eligible in the mothership and inshore categories (92 for inshore delivery, 7 for mothership delivery, and 14 which qualify for both).

A shoreside processor must have processed >2,000 metric tons in both 1996 and 1997 to be eligible, except that processors who did less than 2,000 metric tons in both 1996 and 1997 are eligible, but restricted from processing more than 2,000 metric tons in the future. Eight plants, owned by 7 companies fall under these definitions.

An important aspect of the Act is the provisions for the creation of pollock 'co-ops', or what some refer to as quasi-IFQs. The at-sea catcher-processor sector has formed a cooperative of all the companies known as the Pollock Conservation Cooperative. In it's first year of operation, 1999, the PCC negotiated an allocation of the sectors quota among the member companies. The result of the coop was that the race for fish was over and the vessels could fish slower and achieve a higher product yield and conduct a more targeted fishery with lower bycatch. A secondary result was that fewer boats were needed to harvest and the PCC only operated 16 of the eligible vessels in the first half of 1999 and only 14 in the second half. The 19 vessels eligible to deliver to the at-sea processors also formed a cooperative in 1999, as did motherships and associated catcher vessels fishing. Shorebased processors and catcher vessels formed coops in 2000 among the seven companies authorized to process pollock inshore.

Another aspect of the AFA is the provision for protection of other fisheries (non-pollock sideboards) It was feared that adverse impacts could result from the exclusive rights to harvest and process pollock, coupled with the opportunity to develop co-ops, which could allow co-op harvesters and processors to maximize opportunities in non-pollock fisheries. This would include harvesters and processors of Bering Sea non-pollock groundfish and crab, as well as non-pollock groundfish and pollock harvested or processed in the Gulf of Alaska. Also, the AFA establishments a definition of excessive share limits on harvesters and processors in Bering Sea/Aleutian Islands (BSAI) fisheries, for pollock as well as other groundfish species and crab. The Act specifies pollock excessive share limits for harvest of BSAI pollock (at 17.5%), but does not specify the limits for other species, or for pollock processing; rather, it mandates that the Council establish such caps.

The NPFMC is currently establishing harvester sideboards for AFA qualified vessels that limit their take of non-pollock groundfish. The NPFMC is also addressing the question of excessive shares and attempting to establish definitions of excessive shares for non-pollock species.

Community Development Quota (CDQ)

During the debate over the inshore-offshore allocation, representatives from Western Alaska successfully argued that the evolving division of the resource should consider the interests of the coastal communities of Western Alaska. The result was the allocation of 7.5% of the overall pollock TAC to "community development quotas" (CDQs). This translated into approximately 100,000 tons of pollock in each of the first four years of operation of the CDQ program. To date, 65 eligible communities have organized themselves into 6 regional CDQ Groups. CDQ Groups, incorporated under Alaska law as nonprofit corporations, have formed partnerships with fishing companies that participate in the Bering Sea fishery. The royalties received from these partnerships are the source of funds for the fishery related development projects.

The original program was successful and The NPMFC extended the community development quota to halibut and sablefish in Amendment 15 to the of the Bering Sea and Aleutian Islands Fishery Management Plan for the Groundfish Fishery Area in 1993. In 1995, the Council announced guidelines that would set aside 7.5% of all remaining federal Bering Sea resources, including crab and all remaining groundfish species, for CDQs. Amendments to the Magnuson Act enacted in 1996 require the Council to phase in any crab CDQ over the period 1998 to 2000. And as part of the American Fisheries Act the pollock CDQ portion was increased to 10% of the pollock TAC.

The CDQ program is providing some restructuring of Bering Sea fisheries and providing entry of western Alaskan's into the groundfish and crab fisheries. So far, some CDQ groups have purchased shares of existing fishing companies, while others have invested in small boat fisheries and community fisheries related infrastructure.

Crab rationalization

At its June 2001 meeting, the North Pacific Fishery Management Council (Council)adopted a suite of alternatives, elements and options for analysis of a rationalization program for the Bering Sea/Aleutian Islands (BSAI)crab fisheries for review at the February 2002 meeting.

Crab abundance off Alaska has fluctuated due to natural variation and exploitation. High abundance in the 1970s resulted in good fishing, which brought excess fishing effort into the fishery. With a reduction in abundance and catch many of the vessels entered other fisheries, however, with a resurgence of crab abundance in the early 1990s lead to a doubling of the number of vessels and tripling of the number of pots compared to the numbers employed in 1986 (NPFMC 2001). Access conditions and overcapitalization had also reduced the Bristol Bay king crab season to a mere seven days in 1991.During this period, the number of vessels also increased in the bairdi and opilio Tanner crab fisheries since many crabbers operated in both the king and Tanner crab fisheries.

The NPFMC is examining the potential of reducing crab effort through either coops, similar to the AFA pollock coops, or through an IFQ program. Additionally, under the Consolidated Appropriations Act of 2001 (P.L.No.106-554), congress established a license and vessel buyback program and vessel eligibility criteria in order to reduce fishing capacity in the BSAI crab fisheries. The enactment of the buyback program is, in part, the result of industry-led efforts to provide relief for the crab fleet. An ad hoc industry group considered several approaches to rationalizing the BSAI crab fisheries, including a vessel buyback program, cooperatives, IFQs and the status quo. In order to move more quickly on the development of the buyback program, in early 2000 the industry group split into two smaller ad hoc industry committees, one committee focused on the buyback program and the other focused on cooperatives.

It is too early to determine what the results of on going efforts to control effort in the Bering Sea fisheries will be; however, based on results of the AFA and longline IFQ programs there will likely be a consolidation and net reduction of the number of vessels in the crab fleet.

Steller Sea lions-Fisheries Interaction

The Steller sea lion population of western Alaska has been found to have been in constant decline since the late 1970s. The Steller sea lion was listed as threatened in 1990. The listing followed severe declines of the species throughout the Gulf of Alaska and Aleutian Islands region, which was the center of its range in the North Pacific. In the 1990s,the species has continued to decline and, since the late 1970s, counts of Steller sea lions in this region have dropped by more than 80%. In 1997, NMFS recognized that the Steller sea lion consisted of two distinct populations, split at the 144EW long. line, and reclassified the western population as endangered. The cause of this decline is not clear, but marine mammal biologists have equated the decline with fishing activities, primarily the pollock fisheries of the Bering Sea and the western Gulf of Alaska.

On December 3, 1998, the National Marine Fisheries Service (NMFS) issued a Biological Opinion on the pollock fisheries of Bering Sea/Aleutian Islands. The Opinion found that the fisheries could reduce the survival and recovery of the western population of Steller sea lions in the wild by reducing their reproduction, numbers, and could diminish the value of critical habitat for the survival and recovery of Steller sea lions.

With the "jeopardy" opinion, NMFS developed reasonable and prudent alternatives (RPAs), as required by the Endangered Species Act, which identified ways to modify proposed actions to avoid jeopardizing the species and adversely modifying critical habitat. NMFS developed framework RPAs to concentration of the fisheries over time and space increased the potential for localized depletion of prey relative to the needs of sea lions; i.e., competition. The RPAs excluded fisheries within 10-20 miles of rookeries and major haulouts, set up four fishing periods to disperse the fisheries temporally to avoid locally-depleting the pollock resource, reduced the amount of fishing within "critical habitat" which encompasses most of the southeastern Bering Sea and the major pollock spawning grounds. Also, the RPA's closed the Aleutian Islands to directed pollock trawling.

The Biological Opinion was challenged in the United States District Court for the Western District of Washington. The Court upheld the conclusions of the Opinion, but ruled that the RPAs were arbitrary and capricious, for lack of sufficient explanation. NMFS was instructed to develop revise and resubmit the RPA's to the Court. At the same time several environmental groups filed suit in United States District Court for the Western District of Washington that NMFS had long ignored the decline of the Steller Sea lion and that the environmental impact statement (EIS) for the Bering Sea Aleutian Islands Fisheries Management Plan was inadequate and did not provide for the protection of Stellers. On July 20, 2000, Judge Zilly ruled in favor of the environmental groups and ordered that all trawl fisheries in the Bering Sea be halted in sea lion critical habitat effective August 8, 2000 and continue until NMFS presents the Court with an acceptable EIS.

The issue of fisheries and sea lions is on going. NMFS is allowing the fishery to continue under RPAs for 2001. New research is showing that there is less interaction between fisheries and sea lions than first supposed. NMFS is still preparing a EIS to meet the requirements of Judge Zilly. Environmental groups have told the Court that they will not be challenging the 2002 RPAs that allow the fishery to go forward. The issue of sea lion critical habitat will take several years to resolve. However, the end result of sea lion mitigation measures that will result from the current research appear to be less draconian that earlier measures. It is more likely that restrictions will be largely limited to around rookeries and haul outs, and large area of the Bering Sea north of Dutch Harbor may be delisted as critical habitat. If this occurs there will be only minimal impacts on the Bering Sea trawl and longline fleets, as it has been shown that they can harvest the TAC even under the current more restrictive RPAs.

2.1.4 Outlook for Bering Sea Fisheries and Fisheries Resources

The future of fisheries in the Bering Sea is uncertainty due to the situation of litigation over the impact of fisheries on Steller's sea lion. Until NMFS produces an environmental impact statement that addresses the overall impact of the fishery on the recovery of the sea lion there will continue to be restrictions on the fisheries. However, research has accelerated on this problem with a significant infusion of directed funding from Congress.

The interest of environmental groups in the Bering Sea is growing, with an increasing number of groups entering the management arena. Governor Knowles Chief of Staff recently resigned to head the Alaska office of Oceanus, an environmental group funded by several large foundations (REF). The longline cod fishery is under scrutiny from environmental groups for bycatch of endangered Short-tailed albatross. The World Wildlife Fund, in testimony before the NPFMC, has requested that the Aleutian Islands be set aside as a marine reserve, and that fishing be prohibited. Environmental groups are also challenging the exploitation strategy employed to manage fishery resources, arguing that they are too high and reducing the amount needed to maintain "ecosystem productivity".

The increasing presence of environmental groups and the need to rationalize fishing effort will lead to profound changes in the way Alaska fisheries are conducted in future years. However, the fishing industry has shown it self to be flexible and able to adapt readily to the challenges it is continually being faced with.

Crab fisheries are at all time low levels, and the crab fishing industry is searching for methods to reduce the size of the fleet to maintain economic viability. Proposals have been brought forth to develop crab cooperatives similar to those developed for the pollock fishery, and to institute a vessel buyback program. However, to date these proposals have not been successful.

On a positive note, the fishery resources of the Bering Sea, other than crab, are in good condition and no species of fish is overfished, unlike other major fishing areas of the world. The Bering Sea has maintained a near constant production of fish since the late 1970s. Indications are that this condition will continue into the near future due to the conservative levels of exploitation. The question of crab recovery is an open question. It is not clear whether the decline in crab abundance is due to overfishing, climate change (regime shift), or predation. There is evidence that all factors may in someway be responsible. However, the fact that king crab in the Kodiak region, which were greatly reduced through fishing over 20 years ago, have failed to recover with no fishing since 1982 indicates that long term environmental or ecosystem effects may be operating.

The North Pacific has been in a warm regime since the late 1970s. In this warm regime there has been some significant changes in the survival and growth of various biota. Historically, regime shifts appear to occur at 18 year intervals, and the current warm regime has been anomalously long (Ingraham et al. 1998). There are some indications that we are beginning to enter a cold regime. It this is true then changes should begin to appear in the survival pattern of different species groups. For instance, capelin, which have been in very low abundance, and an important food for Steller's sea lions, should begin to increase. Conversely, salmon abundance may decrease due to colder winters an lower survival in streams, as was apparent in the cold years of the early 1970s. Therefore, it is a strong possibility that crab stocks will begin to recover since historic data indicate that they were more abundant in the years of the previous cold regime.

Assuming that the NPFMC's License Limitation Program and regulatory regime established by the American Fisheries Act continues beyond the 5-year period specified in the Act, then it is likely that there will be no further increases in the number of vessels or plants currently operating at Dutch Harbor-Akutan. If some sort of effort rationalization scheme goes into effect then there will be a reduction in the number of vessels fishing for crab.

The overall outlook is favorable, withstanding short term problems, with a the prospects for continuation of the development of a more efficient fleet size and stable to slightly increasing harvests. Most of the resources are very conservatively managed due to concerns of excessive harvesting capacity and sector allocation of resources. Reduced effort will remove impediments to potential increases in harvests, secondarily the flatfish resources has great capacity for increased harvest. Increases in flatfish could come about in two ways. One, is the development of harvest gear that reduces the bycatch of crabs and halibut that is currently restricting the fishery. Another, is the implementation of fully transferable quotas, which are currently prohibited under the Magnusson-Stevens Act. Halibut and crab have a higher value as bycatch in the trawl fishery since the ration of flatfish to crab/halibut is low and the offsetting costs would make it possible for a trawler to pay a higher price than what a crab or halibut fishermen could get as an exvessel price for these species.

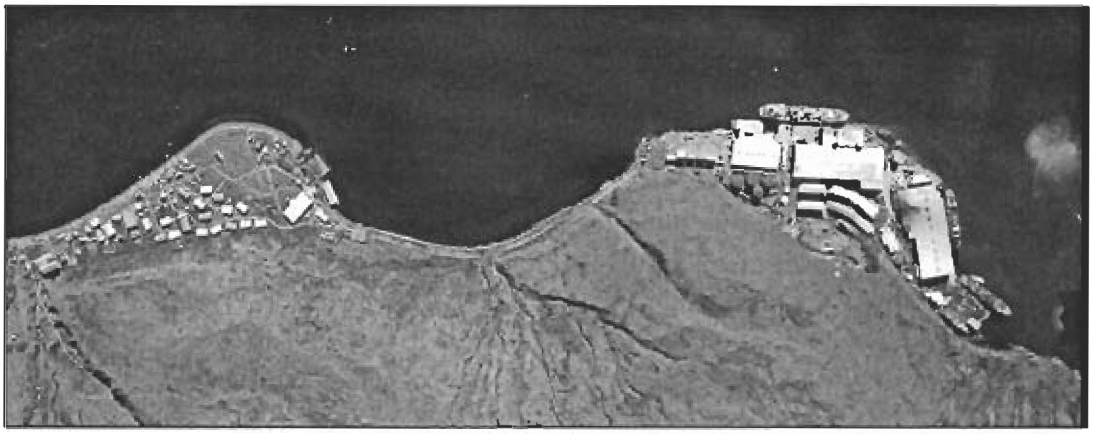
3 EXISTING CONDITIONS

This section describes the existing moorage facilities at Akutan and other western Alaska ports and the vessels that pursue fisheries in the BSAI, some of which will utilize the proposed small boat harbor at Akutan. The section provides a description of the existing marine facilities in Akutan, a brief summary of the moorage available in other ports to the vessels operating in the Bering Sea and Aleutian Islands. It also provides a description of the general operating practices of these vessels, a description of fleet characteristics, and a summary of fleet operating costs.

3.1 Existing Marine Facilities

3.1.1 Akutan

There are two primary marine facilities in the Akutan city area, the city dock and the Trident Seafoods dock. Vessels also use moorage facilities in other ports in Alaska and the Pacific Northwest. FIGURE A2-13 is an aerial photo showing Akutan Bay, the city dock, the Trident Seafoods plant, and the layout of the town.



Source: City of Akutan and Trident Seafoods, 1989 photo.

FIGURE A2-13.—*Aerial photo of Akutan city area and adjacent Trident Seafoods plant*

City Dock. In 1989 the City of Akutan built a new dock at the location where a private processing plant once had a timber dock, which had been crushed by a barge. The new dock, the first city-owned dock in Akutan, is constructed of steel sheet-pile bulkhead, with part concrete-surfaced solid fill. Two breasting dolphins on the upper side in line with the face are connected by a 3-foot-wide, steel catwalk. The dock is fronted by a rubber-cushioned, timber-and-steel fender system. The unlighted dock is 100 feet by 100 feet, with a depth of -40 feet MLLW and a berthing space of 200 feet with the dolphins. The deck is 20 feet high at MLLW and has an open apron.

Because the design of the dock does not adequately account for the water depth, the dock will require continuous maintenance. In 1992 repairs were made to the dolphins, and a new fendering system was installed. Currently the dock is in good repair.

The city dock is operated by the city and Western Pioneer, Inc., a transportation company that operates coastal freighters. The dock is used to receive conventional general cargo and petroleum products and as a landing for the AMHS passenger and vehicle ferry. There are no mechanical handling facilities, railway connections, or highway connections at the dock. Electricity is not available. Water is supplied through a 2-inch line. Western Pioneer operates one 4-inch pipeline that extends from the wharf to 8 steel fuel-storage tanks at the rear of the dock. The tanks have a combined total capacity of 1,300 barrels.

Rafting and congestion do not appear to be issues. The dock is operated on a first-come, first-served basis, and there is no limit on the time a vessel can be there. Akutan residents' skiffs do not moor at the dock, but are pulled up onto the beach. The vessels that deliver to Trident may occasionally use the city dock for loading or offloading supplies. Freighters also deliver supplies for the community to the city dock.

Trident Seafoods Dock. The Trident Seafoods dock is used for receiving and shipping seafood, receiving and shipping containerized and conventional general cargo for the processor, receiving petroleum products, fueling vessels, and handling supplies for fishing vessels. One 8-inch fuel pipeline extends from the wharf to 5 steel storage tanks with a total capacity of 40,500 barrels. The seafood processing plant is at the rear of the dock. The dock is constructed of steel sheet-pile bulkhead with part concrete-surfaced solid fill and fronted by rubber tires and a timber fender system. The dock face is made up of 556-foot, 414-foot, 445-foot, and 185-foot sections, providing a total lighted berthing area of 1,600 linear feet. The depth at MLLW ranges between 15 and 30 feet.

Mechanical handling facilities at the dock include one 50-ton, diesel crawler crane with a 100-foot boom; one 17-ton, diesel mobile crane with a 75-foot boom; one 31-ton mobile, toplift truck; three 7-ton electric-hydraulic derricks with 50-foot booms; and fourteen 2- to 3-ton forklift trucks. There are no railway or highway connections to this dock. Water is provided to the vessels through a 2-inch line. Electricity is not available.

Vessels are not permitted to tie up for long periods or to raft at the dock because freighters and other vessels need regular access. The dock sustained approximately $500,000 in damage during a December 1997 storm because a vessel was tied to it. Trident officials have indicated that they would like to add 800 feet of dock space for offloading but have not made definite plans to do so.

There is a great deal of seasonal fluctuation in processing activities at the Trident processing plant. The fluctuations are a function of the fishing seasons (identified in Section 2, Marine Resource Assessment) imposed on all operators through the fishery management regimes.

3.1.2 Other Western Alaska Harbors

For many years, fishing vessels operating in the BSAI generally have crowded into the extremely limited moorage available in Dutch Harbor/Unalaska and traveled to other ports when moorage was not available. Over time, additional moorage for large vessels operating in the BSAI has been constructed at Kodiak, Sand Point, and King Cove. Additional public and private moorage facilities have also been constructed in Dutch Harbor/Unalaska.

Vessels unable to obtain moorage in Dutch Harbor/Unalaska, generally the preferred site for BSAI fishing vessels, try to obtain moorage in the next closest harbor. If a harbor were constructed at Akutan, vessels operating from Akutan or supported by the Trident plant probably would first seek moorage in Akutan. Because of Akutan's proximity to Dutch Harbor/Unalaska, other vessels that operate in the BSAI but do not deliver fish to Akutan would seek moorage at Akutan if space were not available in Dutch Harbor/Unalaska. Vessels unable to find moorage in Akutan would then travel to other ports seeking moorage. If space is not available in Dutch Harbor/Unalaska, King Cove, Sand Point, or Kodiak, vessels owned by residents of other states typically return to their homeports in the Pacific Northwest. Vessels owned by Alaska residents typically return to their homeports.

Table A2-4 presents an estimate of the number of long-term moorage spaces generally available in western Alaska to the large catcher vessels operating from Akutan and elsewhere in the BSAI fishing area. The table shows the total numbers of long-term moorage spaces available for large catcher boats by community, the numbers of moorage spaces where vessels have preferential or permanent berthing arrangements, the historical demand for moorage by other boats (not large catcher vessels) at facilities capable of accommodating large catcher vessels, and the resulting available moorage spaces. These estimates were obtained from interviews with port directors and harbormasters in these communities and from evaluation of moorage records. While there are a relatively high number of dock face temporary tie up spots in Unalaska/Dutch Harbor, most of these are for provision of services to fishing vessels and are not available for long or even short-term moorage. Moorage in other communities, such as Sand Point, King Cove and Kodiak tend to fill quickly during peak periods, making them unavailable to other Bering Sea vessels seeking moorage.

The Corps of Engineers is currently evaluating a proposed small boat harbor at Unalaska/Dutch Harbor that would provide moorage to fishing vessels operating in Bering Sea waters. As currently designed, the Unalaska/Dutch Harbor project would provide moorage for 75 vessels.

The proposed harbor in Unalaska/Dutch Harbor could provide secure moorage for up to 75 vessels. This project is in review, and whether or not the without-project condition will ultimately include a harbor in Unalaska/Dutch Harbor is uncertain. However, the study team believes that the moorage demand for the Akutan dock would be not be changed, whether or not the Unalaska/Dutch Harbor proposed harbor is eventually built.

The without-project condition in Akutan includes the following characteristics:

- Akutan supports one of the most valuable commercial fisheries in the U.S., with the largest and most modern fishing fleet in the world. The fishing conditions in the Bering Sea are some of the most difficult fishing conditions encountered by commercial fishers anywhere in the world.

- Trident Seafoods pioneered pollock processing in the region with construction of their Akutan plant in the 1980's. They are now one of the largest and most successful seafood companies in the world. Akutan is one of the largest commercial fishing ports in the U.S. based on value of product landed, processed and shipped to market. However, it has very little infrastructure. The fishing industry and the Aleutians East Bough have worked together for many years to provide some of the needed support infrastructure.

- The resource base the activities in the region are based upon conservatively managed fisheries, which should not be subject to boom and bust cycles that have occurred elsewhere in the nation. The North Pacific Fishery Management Council has managed the fishery resources in the region since 1977, and the fishery resources are maintaining very good abundance levels. Even with conservative management, however, there are still dynamic changes that occur. The American Fisheries Act fixed the total number of pollock fishing vessels, and individual quotas for the crab fishery may also affect the numbers of vessels in the near future.

- Even if radical changed come as a result of crab rationalization and the proposed port in Unalaska/Dutch Harbor is completed, the number of vessels seeking moorage will still exceed the available moorage in the region. In Unalaska/Dutch Harbor, there are docks, with dock frontage used for temporary moorage. The only real moorage is at the spit dock in Dutch Harbor. Capacity of the spit dock is approximately 20 vessels, assuming they raft three deep. If the Unalaska/Dutch Harbor is completed, the use of the spit dock will change, with a focus on large shipping vessels instead of mixed shipping and fishing vessels.

The demand for moorage in Akutan is based on the needs of the core fleet that is associated (i.e. makes deliveries to) the Trident Seafoods plant. Other vessels fishing the area, seeking secure moorage to wait out closed periods between fishing seasons will utilize any moorage space available in the harbor.

Pollock fishing in the Bering Sea is centered on the 100 fathom depth contour that extends northwest from Unimak Pass northwest past the Pribilof Islands. Akutan has a locational advantage of approximately three hours travel time to these grounds over Unalaska/Dutch Harbor. Akutan's existing infrastructure, the location of the fisheries resources harvested by the Bering Sea fleet and processed in Alutan will ensure future demand at the proposed harbor.

TABLE A2-4.—*Available long-term moorage in western Alaska for large catcher vessels*

	Moorage Spaces by Community				
Moorage Spaces	**Dutch Harbor/ Unalaska**	**King Cove**	**Sand Point**	**Kodiak**	**Total**
Total	[1]	**33**	**47**	**70**	**150**
Less:					
Permanent/preferential					
Moorage	[1]	5	4	60	69
Available moorage	[1]	**28**	**43**	**10**	**81**

Source: Estimate calculated from interviews with port directors and harbormasters and of moorage records. The figure for Sand Point includes improvements projected for 2005. The False Pass harbor may add up to 6 moorage slips for large vessels.

[1] There are 23 docks in Unalaska/Dutch Harbor that provide approximately 145 moorage tie-ups. However, with the exception of the Spit dock, which offers transient moorage, all the moorage slips in Dutch Harbor/Unalaska are dock frontage for fish processors or fisheries service businesses. The 145 slips in Dutch Harbor/Unalaska are not available long-term moorage by fishing vessels.

3.2 Fleet Operating Activities

Five major BSAI fisheries contribute to demand for a commercial fishing harbor at Akutan: pollock, Pacific cod, flatfish, king and tanner crab, and halibut. This subsection describes these fisheries in terms of gear types used to prosecute them. The information is presented as general background on fleet operating practices that affect moorage demand at Akutan.

Separate and identifiable fleets of vessels have developed around these fisheries. The pollock, Pacific cod and flatfish fisheries are primarily pursued by vessels operating trawl gear. Vessels using hook-and-line gear account for the halibut harvest, and a portion of the total harvest of Pacific cod. Most of the hook-and-line-caught Pacific cod is harvested by catcher processors. Vessels fishing pot gear pursue the crab fisheries, with some effort on Pacific cod and other species. Trawl and pot vessels are anticipated to account for the majority of moorage demand at the proposed Akutan harbor (See Section 3.4, Moorage Demand).

Subsections 3.2.1, 3.2.2, and 3.2.3 focus on the operating practices of catcher vessels that use trawl, hook-and-line, and pot gears. Catcher processors are not included because they are not anticipated to generate any significant demand for the proposed harbor at Akutan. This conclusion is based on the following factors developed from interviews with catcher processor owners and representatives of various associations:

- The catcher processors are generally larger than vessels that would likely be accommodated in a harbor at Akutan.
- Most of the pollock fillet and surimi catcher processors are also involved in the Pacific whiting fishery off the coasts of Washington and Oregon. This fishery takes place during late spring and summer.

- Catcher processors have large crews that are primarily from the Pacific Northwest. It is generally more cost-effective to transport the crews by vessel than to use air transportation to and from Dutch Harbor/Unalaska.
- Maintenance requirements are more intensive for catcher processors than for catcher vessels. Most of this maintenance is conducted during nonfishing periods and takes place in Seattle or Dutch Harbor/Unalaska, where technicians are available.
- Catcher processors produce finished product that is often shipped from Seattle to other ports. Transporting the product to Seattle on the catcher processor vessel rather than by other means results in savings on shipping costs.
- Smaller factory trawlers, one class of catcher processors, are seldom at moorage for extended periods, unlike trawl catcher vessels that are often left unattended in a safe moorage until the next fishing season opens.
- Offshore Systems Incorporated (OSI) in Dutch Harbor/Unalaska is dedicated to servicing the factory trawl fleet. The company can provide in-season moorage to a small number of vessels at one time, and other short-term moorage is available at public facilities in Dutch Harbor/Unalaska.

3.2.1 Trawl Vessels

The BSAI trawl catcher vessel fleet focuses its effort on pollock and Pacific cod. Pollock is the primary fishery for these vessels, with Pacific cod providing a supplementary fishery following the pollock seasons. Flatfish are generally pursued by smaller catcher processors using trawl gear.

In general, pollock trawl catcher vessels have exclusive and often long-term delivery arrangements with processors. In turn, processors guarantee that they will buy the vessels' pollock and often provide a market for Pacific cod as well. The number of large-scale processors of pollock that rely on deliveries from catcher vessels is limited. In addition to Trident in Akutan, there are three shore-based processors in Dutch Harbor/Unalaska: Unisea, Alyeska, and Westward. Two shore plants in the GOA also take deliveries of pollock harvested in the BSAI: Peter Pan in King Cove and Trident in Sand Point. There are also two floating processors usually operating in Beaver Inlet, south of Dutch Harbor/Unalaska Bay: the *Northern Victor* and the *Arctic Enterprise*. There are three motherships currently operating in the Bering Sea pollock fishery: the *Ocean Phoenix*, the *Excellence*, and the *Golden Alaska*.

Seasons. Trawlers make 2- to 3-day trips to the fishing grounds during the season, and—depending on catch rates—may spend 1 to 2 days tied to the processing plant or on anchor in Akutan Bay or near processing facilities around Dutch Harbor/Unalaska. Vessels spend more time in port when catch rates are high than when catch rates are low because of the longer time required to unload large catches and the shorter time required to harvest. Catch rates are normally higher during the winter months (January through March) when pollock are spawning, and lower in the fall months (August through November).

The majority of the shore-based pollock fishery occurs in the Bering Sea within about 80 miles of the Aleutian Islands and the Aleutian Peninsula, from Dutch Harbor/Unalaska Island east to Cold Bay and Izembek Lagoon. In some seasons, substantial harvest effort occurs 80 to 120 miles offshore, nearer to St. Paul and St. George Islands than to Dutch Harbor/Unalaska and Akutan. Shore-based processors require their vessels to deliver pollock within 12 to 18 hours of when it was first brought onboard, so there is a limit on how far the vessels can travel and still remain within this time.

Processors generally determine the number of vessels a given plant uses by assuming relatively low expected catch rates. A greater number of vessels will keep the plant operating at maximum capacity even when catch rates are low. If catch rates are high, then the number of vessels employed is greater than is optimally necessary, and vessels spend more idle time in port.

After the 1999 A1 pollock season, which ended on February 15, trawl catcher vessels typically tied up until the A2 season began on February 20. The time between seasons can be as short as 5 days, so crews seldom moor and fly home. Trawl catchers typically attempt to find moorage in Dutch Harbor/Unalaska or other nearby harbors and resupply the vessels, conduct minor repairs, and provide the crew with rest and relaxation. Following closure of the A2 pollock season (as late as April 15) some vessels tie up in Dutch Harbor/Unalaska or other nearby ports, while others switch to harvesting Pacific cod until that season ends, usually around the end of April.

Unless the trawl catcher vessels have moorage available at the Dutch Harbor/ Unalaska processing plant docks, most are unlikely to find moorage in Dutch Harbor/ Unalaska or other nearby ports—crab vessels would have taken most of the moorage spaces when the crab season ends, usually in March. Trawl catcher vessels have few options for alternative work during summer, so most seek moorage in King Cove, Sand Point, Kodiak, or Pacific Northwest ports if space is not available in Dutch Harbor/Unalaska. Some vessels may travel to shipyards elsewhere in Alaska or in the Pacific Northwest for haulout, inspection, and repairs during summer.

Recent management changes will result in the BSAI pollock trawl fishery reopening August 1. This B season could extend until September 15, but the quota will likely be reached before then. A new C season will open September 15 and could last until November 1. However, the C season quota probably will be attained before November 1. In-season operations for the fall pollock fishery are similar to those in the A1 and A2 seasons. However, it is more likely that pollock catch rates will be low in the fall season, because the pollock are not aggregating for spawning and are disbursed over a wide area. More vessels may be employed in the fall than in winter.

A typical trawl catcher vessel delivering to the Trident Akutan plant would leave its homeport in the Pacific Northwest in early January and travel to Akutan for the pollock season that opens in mid-January. The boat would deliver to the Trident plant at Akutan during the season. Following the end of the pollock season in March, the boat would switch to harvesting Pacific cod until that fishery closed in April. The vessel would then return to its homeport. In late July the vessel would return to Akutan for the pollock season that starts on August 1. After the B season closes, the vessel would moor in Dutch Harbor until the start of the C season on September 15. Following closure of the C season in October, the boat would return to its homeport and await the January pollock opening.

Moorage-related Issues. Trawl catcher vessels face limited moorage availability in March and October, because the winter and early fall crab seasons typically end before the fall pollock season. Crab vessels take most of the publicly available moorage, and the trawl vessels must travel to more distant ports to seek moorage.

Trawl catcher vessels are not permitted to moor for extended periods at the Trident dock or to moor during periods of inclement weather. During periods of inclement weather the vessels typically anchor in Akutan Bay, with all crewmembers onboard to maintain anchor watches. The boats keep their main engines running to prevent grounding in case the anchor drags, and wait for the weather to subside before returning to the dock.

When trawl vessels that deliver to Trident are seeking moorage they attempt to use public moorage or the dock that Trident leases in Dutch Harbor/Unalaska. (Trident leases a dock in Dutch Harbor/Unalaska for use by vessels delivering regularly to its plants. The dock can accommodate two vessels at the dock face and four additional vessels rafted out.)

Vessels using moorage in Dutch Harbor/Unalaska incur damages from rafting and additional costs due to congestion. For example, at the Unalaska Spit Dock vessels are rafted three deep during peak periods. A lengthy time is required to untie, move, and tie other vessels when moving a vessel away from an inside berth. This maneuvering may require up to a half-hour each time the vessel is moved, or longer if crews are not onboard to move the vessel under power and lines must be used.

In addition, frequent storms often result in substantial wave action at Dutch Harbor moorage facilities, with subsequent damage to vessel hulls and equipment. Other damages occur as vessels are positioning for moorage at the docks, and human error or equipment failure results in collisions at velocities sufficient to cause damage.

Interviews with vessel owners indicated that the annual damages per vessel incurred while mooring or at moorage range from $1,000 to nearly $10,000, depending on the size of the vessel and the weather. The most frequently cited amount was $2,000. Larger vessels fare better, incurring less damage. Damages typically include damaged rub rails, scratched and dented hulls, bent anchors, lost or deflated buoys used for cushioning between vessels, and snapped mooring lines. These damages are typically repaired when the vessel is dry-docked for inspections and other maintenance.

When vessels are moored for extended periods, vessel owners typically hire firms or individuals in Dutch Harbor/Unalaska to check on the vessels. This observation is particularly important when vessels are rafted or moved frequently and significant wind loads can strain or snap mooring lines. Some vessel owners retain a crewmember to live onboard during the nonfishing period to provide better monitoring.

3.2.2 Pot Vessels

The number of pot vessels participating in the BSAI crab fisheries varies from year to year, depending primarily on the guideline harvest levels (GHLs) set by fishery managers from ADF&G. In years with higher GHLs, more vessels participate. In recent years, GHLs for the

Bristol Bay red king crab fishery have been at historically low levels, and therefore relatively fewer vessels have been participating.

Most crab vessels delivering to Trident store their pots at the Trident pot storage facility across the bay during winter. In the weeks immediately before the fishing seasons open, crab vessels begin to arrive in Akutan. The vessels pick up their pots and make necessary repairs before the fishing season begins. Some repairs require work on land. Most of this work takes place on limited space on the Trident plant delivery docks. This space is available on a first-come, first-served basis before the season begins. During the season, space for repair at the delivery dock is very limited. The limited availability of space for gear repair results in vessels and crews arriving in Akutan earlier than would otherwise be necessary to ensure that they can complete the repairs before the season begins.

Seasons. Pot vessels begin harvesting opilio tanner crab on January 15, and the length of the season varies considerably with allowable harvests. For example, the fishing season was 33 days in 1995, 45 days in 1996, and 65 days in 1997. The opilio fishery occurs near the Pribilof Islands, with many vessels fishing near the edge of the seasonal ice pack as it moves south during late winter. In some years the ice pack moves south of the Pribilof Islands, and the small ports at St. Paul and St. George are closed. Crab catcher vessels and crab processing vessels operating near the Pribilof Islands are then forced to operate from the Aleutian Islands.

Following the opilio season, many crab vessels return to Akutan Bay to unload pots at the pot storage facility. Without a harbor at Akutan, many independently owned crab vessels make their last deliveries to a processor near other existing harbors, most likely Dutch Harbor/Unalaska, so that they can obtain moorage. This situation results in lost income to the Akutan plant, lost tax revenues to the community, and lost tax revenues to the AEB.

A few crab vessels continue operating in the Bering Sea following the opilio season, fishing for Pacific cod with pot gear. Two such vessels currently deliver Pacific cod to Trident at Akutan. Many crab vessels register to tender salmon. An Alaska Crab Coalition representative indicated that about 50 percent of the crab fleet operate as tender vessels in the salmon fisheries, and the remainder either undergo maintenance or tie up for the summer where space is available. Travel to ports in the Pacific Northwest may be required.

The St. Matthew and Pribilof Island king crab fisheries open September 15 near those islands. These fisheries are relatively short—usually 1 week—and vessels typically make only one landing during the season. Then they typically return to a port where moorage is available.

Most crab operators try to find a safe harbor in Alaska. Some go as far as Kodiak between the September and November crab fisheries, but few, if any, return to the Lower 48 between the two fisheries because the time between the two fisheries is so short.

On November 1, the Bristol Bay red king crab fishery opens. The opening for the Bering Sea bairdi tanner crab fishery typically occurs November 1, but the fishery was closed in 1998 because of low stocks. These two fisheries have been relatively short in recent years,[2] with

[2] The Bristol Bay red king crab fishery was closed in 1994 and 1995 and was reopened in 1996. In 1997 and 1998 the season lasted 4 days.

vessels making only one delivery during the season. The Bristol Bay red king crab fishery occurs in the outer waters of the bay. The bairdi tanner crab fishery generally occurs further west of the Bristol Bay fishery, with harvest areas ranging from about 20 to 100 miles north of the Aleutian Peninsula and Aleutian Islands.

A typical pot vessel delivering to Trident leaves its homeport in early January and travels to Akutan for the mid-January opening of the opilio fishery. After arriving in Akutan, the vessel loads pots onboard and makes preparations for the season. The vessel fishes until the season closes in March, delivering to the Trident plant in St. Paul, as well as the Trident plant in Akutan. The boat offloads its pots at Akutan, and moors in Dutch Harbor/Unalaska. The crew flies home. Three members of the crew return in mid-June and travel to Naknek to load equipment for a charter to operate as a salmon tender during the Bristol Bay salmon season. The boat offloads the tender equipment in mid-July and returns to Dutch Harbor/Unalaska for moorage. The crew flies home in late July. All crewmembers fly back to Dutch Harbor in early September to begin preparations for the St. Matthew and Pribilof Island king crab fisheries, which start on September 15. The vessel travels to Akutan to load its pots and then returns to Akutan at the end of the season to deliver the catch. Moorage space is available in Sand Point, so the pots are left on the boat. The vessel travels to Sand Point at the end of the season for moorage. Three crewmembers return home for the three to four weeks before the November 1 opening, while the remainder stay onboard and save money by avoiding the travel cost. At the end of October the crew returns to the vessel and prepares for the November 1 fisheries. At the end of the season the boat delivers its catch to Trident's Akutan plant and offloads its pots because moorage is unavailable. The vessels then travel to its homeport and remains there until early January, when it departs for Alaska again.

Moorage-related Issues. In the opilio fishery, vessels make 3- to 5-day trips. Sometimes vessels make longer trips, but the mortality rate for crab held in the hold increases over time. Increasing mortality constrains the ability to undertake longer trips. Occasionally, crab vessels stay in Akutan for a day or two to make repairs or obtain rest for crews. During these lay-ups, vessels are either tied to the delivery dock at the plant or anchored in the bay. The lack of a harbor requires some crewmembers to remain onboard or on-call to care for the vessel.

Following the November fisheries, crab vessels unload their pots and look for available harbors in Alaska or return to ports in Washington and Oregon.

Pot catcher crab vessels incur damages similar to those that trawl catcher vessels incur while moored at Dutch Harbor/Unalaska.

3.2.3 Hook-and-line Vessels

Hook-and-line catcher vessels as defined in this document include vessels operating longline gear, and vessels operating jig gear for groundfish. Hook-and-line catcher vessels target primarily halibut and blackcod, but also harvest Pacific cod. The fixed-gear and hook-and-line fisheries are relatively low-volume fisheries that require only a small portion of the available capacity at the processing facilities in Akutan and Dutch Harbor/Unalaska. The hook-and-line (longline and jig) vessels typically are much smaller than trawl and pot vessels.

Seasons. The halibut longline fishery and the blackcod fishery currently are managed under an Individual Fishing Quota (IFQ) management regime, which allows participants to catch a predetermined amount at any time during the open season from March 15 through November 15. This regime allows landings and other port calls to be spread over a long period. A total of 23 landings were made in Akutan in 1997, accounting for 64,130 pounds.

The fishing season for Pacific cod begins in January, but hook-and-line catcher vessels traditionally have started their seasons in more protected waters and moved north and west as the weather improves, arriving in the Bering Sea in May and June. The vessels generally return to more southerly waters in the fall.

A typical longline catcher vessel starts its year by traveling to Southeast Alaska just prior to March 15 and after that date harvesting the halibut and blackcod IFQs that the skipper and crew possess. The vessel then moves north to the central Gulf of Alaska, fishing from Seward or Homer during late March and early April. The crew supplements the halibut and blackcod IFQs with bycatch of Pacific cod. When the quota for this area is reached, the vessel moves west of Kodiak in early to mid-April and harvests the IFQs that the skipper and crew possess, delivering to Kodiak. By early May the vessel and crew travel to the Aleutian Islands to start harvesting their IFQs for this region. The vessel typically spends a week at sea, delivering to local processing plants throughout the Bering Sea, and then taking two to three days for rest and relaxation for the crew and maintaining the gear. In late May or early June the crew typically returns home for two to four weeks. The crew returns in late June, finishes harvesting any halibut and blackcod IFQs that remain, and then focuses on Pacific cod during the remainder of its time in the region. Sometime in August or early September the vessel departs for its homeport.

Moorage-related Issues. Because of their relatively small size, the hook-and-line vessels must have very protected waters for moorage and are limited by fuel and water capacity (among other items) in the amount of time that they can spend at sea. As a result, most of these vessels operate in the proximity of communities that can offer safe moorage, as well as fuel and supplies.

The hook-and-line vessels that operate in the vicinity of Akutan and Dutch Harbor typically use the small vessel harbor in Iliuliuk Harbor (Dutch Harbor/Unalaska) for long-term moorage and obtain shorter-term moorage at docks controlled by the shore plants in the community. At times, hook-and-line vessels moor at the Unalaska Spit Dock, generally on the shore side of the dock, where they do not have to raft with larger vessels. The CDQ groups have purchased a number of small hook-and-line vessels that are used by their members and are operated from Dutch Harbor/Unalaska, Atka, and Adak during periods of better weather. Vessels operating in the vicinity of Akutan generally travel to Dutch Harbor/Unalaska to seek moorage.

Hook-and-line vessels seeking moorage in Dutch Harbor/Unalaska incur less damage than the larger vessels because of the availability of slips at the small boat harbor and the more protected waters of Iliuliuk Harbor, where the Alyeska and Unisea docks are typically used for moorage after deliveries. Interviews with vessel owners indicate that annual damage values typically range from none to about $1,000, although several events resulted in damages of $3,000 to $5,000. The most frequently cited damage amount was $500.

Hook-and-line vessels unable to use the small boat harbor are allowed to tie up at the docks owned by processors. However, they are often asked to move away from the dock face when other vessels must deliver product or freighters call at the plant. Each of these hook-and-line vessels typically moves once or twice a day if other major fisheries are under way. During summer, hook-and-line vessels generally can use the docks with little need to move, because major fisheries are not being conducted.

3.3 Fleet Characteristics

Currently two distinct fleets of vessels use Akutan and Akutan Bay regularly: vessels owned by village residents (Akutan resident fleet) and vessels delivering to Trident (Akutan nonresident fleet). Other vessels that use the bay infrequently or deliver to Trident less than regularly are defined as the transient fleet. These fleet definitions are used to describe vessel groups that would have different use patterns for an Akutan harbor and to aid in estimating Akutan moorage demand. The following subsections describe selected characteristics of each fleet. Additional information on length overall (LOA) and beam and draft is presented in Section 3.4 (Moorage Demand).

3.3.1 Akutan Resident Fleet

In this analysis, the Akutan resident fleet is defined as vessels owned by residents of the Native village of Akutan. The Akutan resident fleet includes about 20 skiffs, one larger (36-foot) fishing vessel, and a landing craft owned by the City of Akutan.

The 36-foot fishing boat owned by an Akutan resident is used to fish salmon in Chignik and is kept there because moorage is not available in Akutan. Section 3.4.1 provides additional details pertaining to the Akutan resident fleet.

The city-owned landing craft is used to transport supplies and materials between Akutan and Dutch Harbor/Unalaska. Because moorage is not available in Akutan, the vessel is often moored in Dutch Harbor/Unalaska or anchored up at the end of Akutan Bay. When the landing craft is in Dutch Harbor/Unalaska, the skipper must fly between there and Akutan about once a month, at a roundtrip cost of $160. However, the city is trying to sell the landing craft.

Residents are unwilling to purchase larger vessels that could be used safely in open ocean because operating the vessel and caring for it adequately would require moving to a community with a harbor. Residents store their skiffs on the beach because no harbor is available. It is most likely that skiffs must be replaced once every four to five years because of the damage done by the dragging the skiffs up on the beach. An Akutan resident-fleet skiff typically is operated by a single skipper who resides in Akutan.

The skiffs are used primarily for subsistence activities, but also provide residents a limited ability to participate in selected commercial fisheries. Residents have expressed interest in increasing their participation in commercial fishing, and the CDQ program has provided a means to this end. The program is projected to be the primary factor that will affect this fleet in the future.

With CDQ program expansion, it is likely that more Akutan residents will wish to participate in the vessel-purchase program (or other similar programs) of the APICDA overall economic development plan. The cost of participation will probably include decisions to live for several months of each year in communities with harbors.

The CDQ program provides an opportunity for residents to become active commercial fishers. However, the lack of a local harbor may mean that the choice to do so leads to increased out-migration of younger residents, many of whom currently support elders and other family members through part-time employment and subsistence activities.

3.3.2 Akutan Nonresident Fleet

In this analysis, the Akutan nonresident fleet consists of vessels that regularly deliver crab or trawl-caught groundfish to the Trident plants at Akutan or St. Paul. Vessels delivering to St. Paul are included because Trident has indicated that these vessels are currently supported out of Akutan and will use the Akutan harbor, if and when it is built. Vessels that deliver groundfish, crab, or halibut less regularly to Trident are included in the transient fleet (Section 3.3.3).

The Akutan nonresident fleet contains about 86 vessels that regularly deliver to Trident plants. Of these vessels, 22 are owned by Alaska residents who prefer to use harbors in their hometown if space exists and if there is sufficient time for the vessels to travel to and from the homeport between fishing openings. There are 64 vessels in the nonresident fleet that would seek long-term moorage in Akutan. These vessels range from 91 feet to 166 feet in length, with an average LOA of about 111 feet. Of these 64 vessels, 11 owned wholly by Trident and 6 owned in part by Trident will use Akutan because of the company's commitment to making such a harbor feasible, and in order to reduce expenses. The 47 vessels owned by residents of Washington and Oregon would attempt to use an Akutan harbor to reduce expenses.

According to Trident, all of the vessels that the company owns, or in which it has an ownership interest, would regularly use a harbor in Akutan between fishing seasons. In addition, many, if not all, remaining members of the nonresident fleet would use Akutan for moorage during at least one off season within the fishing year.

The non-Alaskan vessels in the Akutan nonresident fleet are split about evenly between pot and trawl vessels, although a number of vessels have used both gear types. Section 3.4.2 provides additional detail on the Akutan nonresident fleet.

3.3.3 Transient Vessels

The vessels classified as transient in this document typically deliver to the Akutan Trident plant only on occasion, or during summer, when plant activity is low. Akutan Bay's location adjacent to some of the world's most productive fishing grounds suggests that a harbor would be used by vessels other than those delivering to Trident if existing area harbors cannot accommodate their need. Thus the demand for additional harbor space in Akutan depends not only on vessels that operate in the area, but also on existing harbors currently in use.

The transient fleet includes trawl and pot catcher vessels, with characteristics similar to those for these gear types in the Akutan nonresident fleet, and hook-and-line vessels. These vessels generally deliver to shore-based plants or floating processors operating elsewhere in the Bering Sea. The trawl and pot vessels would seek moorage in Akutan between major fishing seasons if moorage were not available in Dutch Harbor/Unalaska. A few hook-and-line vessels would use the harbor during their fishing seasons. No hook-and-line vessels (other than vessels owned by Akutan residents) are expected to seek long-term moorage in the harbor. The numbers and types of transient vessels using Akutan may fluctuate substantially because the availability of moorage in Dutch Harbor/Unalaska will determine the number of vessels seeking moorage in other ports, including Akutan. Section 3.4.3 provides additional information on the transient fleet.

3.4 Moorage Demand

This section describes the current demand for moorage in Akutan. Estimates of potential demand have been developed from existing conditions for the Akutan resident fleet, Akutan nonresident fleet, and transient vessels. There are ambiguities in the source data in terms of numbers and definitions, making it difficult to arrive at estimates. The numbers of vessels that create moorage demand as presented in this section are considered the most reliable estimates.

The demand estimate assumes that a harbor in Akutan would be equipped with minimal service levels, including access by road, electricity for moored vessels, boat watching and security services, and uplands sufficient to meet requirements for minor gear and vessel maintenance. The estimate also assumes that moorage rates are comparable with rates at Dutch Harbor facilities and that access is unconstrained by preferential use agreements.

The following discussion summarizes existing demand by vessels currently using Akutan Bay, including the Akutan resident fleet, the Akutan nonresident fleet delivering to Trident, and occasional users (transient fleet). The demand from these three sectors is combined in a summary section that provides an overall estimate of demand for moorage space in Akutan.

3.4.1 Akutan Resident Fleet

The Akutan resident fleet was defined in Section 3.3.1 as vessels owned by residents of Akutan. Table A2-52 is a summary of the Akutan resident fleet by vessel length, and Table A2-6 lists each vessel in the Akutan resident fleet.

TABLE A2-52.—*Demand for permanent moorage space by the Akutan resident fleet*

Vessel Length (Feet)	Number of Vessels
32 or less	20
33-60	1
61-125	1
Greater than 125	0
Total	**22**

All 20 of the vessels that are less than 32 feet LOA would be expected to use the Akutan Harbor on a permanent basis. The 36-foot vessel is used to fish for salmon and is homeported in Chignik. This vessel is not expected to homeport in Akutan because it targets salmon, not groundfish or crab. The 71-foot vessel is a landing craft that is owned by the City of Akutan moors at the end of Akutan Bay. The city is trying to sell the landing craft. Therefore, only the 20 vessels under 32 feet LOA are considered the Akutan resident fleet that creates moorage demand for an Akutan harbor.

TABLE A2-6.—*Akutan resident fleet*

Vessel Name	Vessel Length (feet)	Hull Type	Engine Type	Horsepower
	15	Wood	Gas	25
	16			
	16			
Island Girl	16	Wood	Gas	40
	16			
My Skiff	16	Aluminum	Gas	40
Lil Mutt	16			
Kas Kar	16			
	18			
	18			
Sea-Nile	18			
Mrs. T	18			
Miss Hali	18			
Kay-Kay	18	Aluminum	Gas	45
Annette K	18	Aluminum	Gas	40
Ms Agnes	19	Aluminum	Gas	115
Gambler	20	Aluminum	Gas	112
Bear	20	Aluminum	Gas	115
Ugamak	24			
Lady Di	28	Aluminum	Gas	260
Aleut Sister	36	Fiberglass	Diesel	250
Akutan Bay	71	Steel	Diesel	640

Sources: Alaska Commercial Fisheries Entry Commission 1997 Vessel Registration Files, and Akutan Fishermen's Association vessel list

3.4.2 Akutan Nonresident Fleet

The vessels in the nonresident fleet, vessels that regularly deliver to Trident in Akutan, are listed in Table A2-7. The LOA, beam, and draft for 64 of the 86 vessels in the Akutan nonresident fleet are included in the table.

TABLE A2-7.—*Akutan nonresident fleet vessels*

Akutan Harbor - Design Fleet Characteristics					
vessel name	**length**	**registered length**	**breadth**	**draft**	**homeport**
Lady Ann	106	93.4	27.2	9.6	Anchorage, AK
Lady Helen	90	43.2	n/a	9.3	Juneau, AK
Providence	70	57.9	22.1	6.8	Juneau, AK
Reliance	165	157.5	36.0	12.0	Juneau, AK
Alaska Spirit	98	81.6	24.0	11.7	Kodiak, AK
Lady Alaska	138	124.0	32.0	11.8	Kodiak, AK
Lady Kodiak	126	111.9	32.0	11.8	Kodiak, AK
Northwest Enterprise	162	143.7	38.0	16.0	Kodiak, AK
Northwestern	125	n/a	n/a	n/a	Kodiak, AK
Saga	107	94.3	30.0	11.1	Kodiak, AK
Cougar	96	79.9	24.2	11.3	Newport, OR
Pacific Ram	82	69.7	27.0	13.3	Newport, OR
Perseverance	87	n/a	n/a	n/a	Newport, OR
Predator	90	80.9	34.0	12.5	Newport, OR
Raven	92	84.7	33.0	10.8	Newport, OR
Seeker	98	87.1	26.0	13.0	Newport, OR
Trailblazer	134	n/a	n/a	n/a	Newport, OR
Theresa Marie	93	83.3	30.8	11.8	Petersburg, AK
Golden Pisces	90	81.6	24.0	11.7	Portland, OR
Pegasus	96	88.7	26.9	12.8	Portland, OR
Destination	99	98.6	32.2	13.0	Sand Point, AK
Silent Lady	150	139.2	36.1	14.4	Sand Point, AK
Alaskan Beauty	97	91.4	26.1	12.8	Seattle, WA
Aldebran	132	119.0	32.0	13.5	Seattle, WA
Aleutian Ballad	107	97.1	26.0	8.0	Seattle, WA
Aleutian Beauty	98	79.6	27.6	12.3	Seattle, WA
Aleutian Lady	165	154.7	38.1	11.5	Seattle, WA
Aleutian Rover	125	109.3	32.8	13.1	Seattle, WA
Arctic I	115	98.9	30.0	10.5	Seattle, WA
Arctic III	180	166.0	40.0	14.0	Seattle, WA
Arctic IV	155	139.7	36.0	n/a	Seattle, WA
Arctic VI	124	112.8	30.0	n/a	Seattle, WA
Arcturus	132	119.0	32.0	13.5	Seattle, WA
Autumn Dawn	128	106.0	30.1	12.1	Seattle, WA
Barbara J.	110	96.4	30.0	15.7	Seattle, WA
Billikin	132	116.2	31.1	11.2	Seattle, WA
Bountiful	165	n/a	n/a	n/a	Seattle, WA
Brittany	100	100.2	26.0	8.7	Seattle, WA

Columbia	123	106.9	30.2	13.7	Seattle, WA
Deborah D.	101	n/a	n/a	n/a	Seattle, WA
Dominator	124	111.7	41.9	13.6	Seattle, WA
Dona Lilliana	152	149.6	38.0	13.0	Seattle, WA
Dona Martita	152	149.6	38.0	13.0	Seattle, WA
Dona Paulita	152	149.6	38.0	13.0	Seattle, WA
Farwest Leader	110	100.6	26.0	8.8	Seattle, WA
Flying Cloud	124	111.7	42.0	13.6	Seattle, WA
Golden Dawn	149	132.6	30.9	14.3	Seattle, WA
Karin Lynn	127	113.8	29.5	12.7	Seattle, WA
Kodiak Queen	145	144.6	29.1	14.0	Seattle, WA
Majesty	106	90.7	30.0	14.2	Seattle, WA
Metrofania	95	n/a	n/a	n/a	Seattle, WA
Northwind	105	81.6	30.0	11.7	Seattle, WA
Notorios	119	119.6	32.0	12.2	Seattle, WA
Pacific Viking	130	112.4	28.2	13.0	Seattle, WA
Polar Lady	105	87.7	34.0	10.8	Seattle, WA
Royal Viking	108	91.9	27.3	9.3	Seattle, WA
Sea Rover	108	91.8	27.3	9.3	Seattle, WA
Sultan	111	113.3	30.0	11.5	Seattle, WA
Tanya Rose	90	71.6	23.0	12.1	Seattle, WA
Tempest	112	82.6	26.0	9.4	Seattle, WA
Valiant	111	104.7	26.0	10.1	Seattle, WA
Viking Explorer	125	111.5	32.0	10.7	Seattle, WA
Wizard	156	150.7	30.1	13.1	Seattle, WA
Last Frontier	88	88.7	26.0	8.0	Ugashik, AK
mean	*118.5*	*106.5*	*30.7*	*11.9*	
median	*111.5*	*102.6*	*30*	*12.1*	
range	*110*	*122.8*	*19.9*	*9.2*	
minimum	*70*	*43.2*	*22.1*	*6.8*	
maximum	*180*	*166*	*42*	*16.0*	

Source: ResourcEcon, February 2000. Data from Trident Seafoods, the U.S. Coast Guard and the Alaska Commercial Fisheries Entry Commission

note: n/a indicates that data were not available. The draft was also omitted For the Arctic VI and Arctic VI because the data appeared to be in error.

Residence and ownership are important determinants of demand for a harbor in Akutan. Vessels owned by Alaska residents are likely to use harbors in their hometowns if space exists. Eleven vessels owned wholly by Trident and six vessels owned in part by Trident will be very likely to use Akutan because of Trident's commitment to making such a harbor feasible. Vessels that are owned by residents of other states would attempt to use an Akutan harbor when practicable in order to reduce expenses. Interviews with vessel owners of the Akutan nonresident fleet did not identify any vessels with permanent moorage in other locations. Table A2-8 shows the Akutan nonresident fleet by the vessel owner's region of residence

TABLE A2-8.—*Summary of Akutan Design Fleet owner's area of residence*

Vessel Owner's Region or State of Residence	**No. of Vessels**	**percent**
Washington	41	64.1
Oregon	9	14.1
Kodiak	6	9.4
Sand Point	2	3.1
Southcentral/Southeast Alaska	5	7.8
Other	1	1.5
Grand Total	**64**	**100**

Sources: Trident Seafoods vessel list and 1999 Alaska Commercial Fisheries Entry Commission Vessel Registration Files

Akutan nonresident fleet moorage demand is expected to vary by season, with peaks expected to occur between November 15 and January 15 and between April 15 and August 15 (for both trawl and pot vessels), when pollock and crab seasons are closed.

According to Trident Seafoods representatives, all company-owned vessels (17) would regularly use a harbor in Akutan between fishing seasons. A conservative moorage demand estimate for the Akutan nonresident fleet is the demand created by the non-Alaskan-owned vessels (64) in the nonresident fleet. The 50 non-Alaskan vessels include the 17 Trident-owned vessels.

3.4.3 Transient Fleet

The transient fleet is defined as those vessels that participate in the BSAI fisheries but do not make regular deliveries to Trident. To determine the number of vessels in the transient fleet, the number of Akutan nonresident vessels (those making regular deliveries to Trident) was subtracted from the number of vessels that participate in the BSAI fisheries and do not have preferential moorage arrangements.[3] The resulting number (222) includes trawl, pot, and other vessels.

There are 42 trawl vessels, without permanent moorage, that deliver to offshore processors, floating processors, and motherships. These 42 vessels are part of public demand for moorage space. Another 29 trawl vessels deliver pollock to Trident's Akutan plant, and

[3] Twenty-eight trawl vessels are able to moor at the processing plants where they make deliveries.

20 vessels fish for pollock out of King Cove, Sand Point, and Kodiak. The BSAI pollock fishery involves a total of 91 trawl vessels (42 + 29 + 20) that seek public moorage in western Alaska ports.

There are several other vessel types that participate in the BSAI fisheries on occasion and add to the public moorage demand. However, these vessels, such as hook-and-line vessels, do not contribute consistently to moorage demand because they generally return to their homeport at the end of the season and are difficult to quantify. The analysis of the transient fleet quantifies only the trawl and pot catcher vessels participating in the BSAI fisheries.

Table A2-9 summarizes the overall moorage demand by the trawl and pot vessels that participate in the BSAI fisheries. The table delineates the approximate split between Alaskan- and non-Alaskan-owned vessels.

TABLE A2-9.—*Bering Sea and Aleutian Islands fleets*

3.4.3.1

	Catcher Vessel Type	Typical Length Overall (Feet)	Vessel Owner Residence	Number of Vessels
Pollock	Trawl	90-150		**91**
			Alaska	14
			Not Alaska	77
Crab	Pot	90-155		**250**
			Alaska	105
			Not Alaska	145
Total				**341**
			Alaska	119
			Not Alaska	222

Source: Commercial Fisheries Entry Commission vessel registration files.

The 341 pot and trawl vessels identified above as the total BSAI fleet include the Akutan design fleet nonresident fleet. Table A2-10 shows the Akutan nonresident and transient fleet components for the BSAI fisheries.

TABLE A2-10.—*Akutan nonresident and transient fleet components for BSAI fisheries*

Fleet	Trawl	Pot	Total
Akutan nonresident fleet	**37**	**49**	**86**
Alaskan-owned	6	16	**22**
Non-Alaskan-owned	31	33	**64**
Transient fleet	**54**	**201**	**255**
Alaskan-owned	8	89	**97**
Non-Alaskan-owned	46	112	**158**
BSAI participants	**91**	**250**	**341**
Alaskan-owned	14	105	**119**
Non-Alaskan-owned	77	145	**222**

Source: Commercial Fisheries Entry Commission vessel registration files.

The 97 Alaskan-owned vessels in the transient fleet have preferential moorage in Alaska or at least a preference for moorage in proximity to the owner's residence. Therefore, only the non-Alaskan-owned vessels in the transient fleet are expected to create demand for public moorage at Akutan. Table A2-11 summarizes the non-Alaskan-owned vessels that contribute to the demand for public moorage.

TABLE A2-11— *Moorage demand by transient fleet*

Vessel Type	Number of Vessels
Trawl	46
Pot	112
Total	**158**

3.4.4 Summary of Moorage Demand

Combining the components of demand for moorage results in a peak estimate of 242 vessels. This number includes 20 Akutan resident vessels, 64 non-Alaskan vessels in the Akutan nonresident fleet, and 158 trawl and pot vessels in the transient fleet. The Akutan resident fleet and the non-Alaskan boats in the Akutan nonresident fleet would prefer some type of preferential moorage arrangement, although the cost of such moorage will be a factor in the decision to select permanent or preferential moorage as opposed to transient moorage. Peak demand occurs during off-season period between November 15 and January 15. The type of moorage during the off-season is long-term, with vessels moored on a continual basis. Table A2-12 shows the total peak season demand.

TABLE A2-12.—*Peak moorage demand summary by fleet*

Fleet	Number of Vessels
Akutan resident	20
Akutan nonresident, non-Alaskan-owned vessels	64
Transient	158
Total Peak Demand	**242**

Note: Peak demand occurs between November 15 and January 15.

Vessels seeking moorage during the fishing season are tied to the dock for short periods for minor repairs and for restocking supplies. The entire Akutan resident fleet and portions of the Akutan nonresident and transient fleets create demand for short-term moorage during the fishing seasons.

3.4.5 Vessel Response to Available Moorage Space

There are 222 non-Alaskan-owned vessels in the BSAI fishing fleet that seek public moorage in Alaska. Their general preference is for moorage in Dutch Harbor/Unalaska. If Dutch Harbor/Unalaska is filled, the next-closest alternative for Bering Sea vessels is King Cove, followed by Sand Point and Kodiak respectively. If all moorage spaces are filled in these four harbors, the vessels generally travel south to Seattle or other Pacific Northwest ports for moorage.

The number of vessels seeking moorage must be adjusted to account for trips made to other ports for inspection and maintenance. Currently, trawl vessels unable to find moorage in Dutch Harbor/Unalaska must make two trips to other ports: in March or April at the end of the winter fisheries, and again at the end of the fall fisheries in October. In addition to long-term moorage needs at about these same times, crab vessels need shorter-term moorage between the September and October crab openings. Crab vessels unable to find moorage in western Alaska ports during this short period seldom travel to Pacific Northwest ports because of the time and expense required to travel these distances. The vessels will anchor in different bays, and crewmembers will remain on board to monitor the boat and perform routine maintenance.

4 DESCRIPTION OF ALTERNATIVE PLANS

4.1 Non-Structural Alternatives

Under without project conditions in Akutan, the fishing industry will continue to operate without adequate moorage. The results of this will include:

- Damage to vessels and docking facilities from overcrowded conditions
- Vessels will be constrained in achieving full fishing effort as they compete for limited mooring space
- The local small boat fleet will not have access to secure moorage. This will result in reduced subsistence production and will constrain opportunities for development of small vessel groundfish operations
- Economic benefits to the fleet of commercial vessels fishing within the region will continue to incur substantial annual expenses associated with travel to alternate ports.

4.2 Structural Alternatives

There is a detailed description of the alternatives considered in Appendix A, section 6.0 (Alternatives Considered). In addition to the no-action alternative, several alternative sites were considered for the proposed project. The sites included: Akutan Point, North Shore Area 1, North Shore Area 2, Salthouse Cove, North Creek, Head of the Bay,Whaling Station, South Shore Area 1, South Shore Area 2 and South Shore Area 3. Table 6-1 in Appendix A details the respective advantages and disadvantages for each of the site considered.

4.3 Summary of Alternatives

A preliminary site assessment for the project recommended the North Creek site as the most likely site for consideration in the feasibility study. Subsequent studies revealed that the North Creek site was unsuitable because of the steeply sloping terrain. Development on the site was limited to a long narrow harbor of approximately nine acres, which was not likely to be an economically viable harbor.

The focus of the project shifted to the head of the bay, and several types of alternative harbor designs were considered: an offshore harbor, an onshore/offshore harbor and a dredged inland harbor. The basin sizes evaluated were 12 acres, 15 acres and 20 acres. Detail on the specific design considerations and constraints are presented in Appendix A, Section 6. Due to engineering design, cost, and environmental considerations, the inland harbor was selected as the best choice for the harbor design. The proposed harbor will provide protected moorage for 38, 48 or 60 Bering Sea fishing vessels (12 Acre Basin, 15 Acre Basin and 20 Acre Basin, respectively) as well as the 20 skiffs owned by Akutan residents. Moorage inside the harbor will be at parallel slips, allowing vessels quick arrivals and departures and preventing rafting and other wave-induced vessel damage.

5 WITHOUT-PROJECT CONDITIONS

The absence of moorage in Akutan causes large vessels to move to other harbors in an effort to secure protected moorage, and causes local residents to haul their small vessels from the water to be stored onshore. These actions cause increased maintenance and repair requirements for vessels and facilities, require vessels to be moved about the congested mooring areas in other ports, and require operators to take special precautions during storms. These activities consume time and labor and raise operating costs, causing operators to incur additional expenses, thereby reducing net income.

Vessels that operate primarily from Akutan, or are supported by the local processing plant, incur significant damage from rafting at ports that are more distant. When one vessel needs to move, vessels to the outside have to be untied and then the raft must be reassembled. This process requires the time and effort of several people and can be lengthy if these large vessels must be moved by physical labor, which is difficult to accomplish in windy conditions. All of these problems cause increased operating costs and loss of time for the vessels' crew.

Most vessels in the Bering Sea fleet, including vessels delivering to Akutan or supported by the local plant, will continue to seek moorage western Alaska that is available on a first-come, first-served basis. As a result, some vessels will travel to Seattle or other Pacific Northwest ports for moorage because they will be unable to find moorage in western Alaska.

The proposed harbor would be designed to accommodate smaller boats owned by local residents as well as larger vessels delivering to the local processing plant. The presence of a harbor would reduce out-migration from the community by enabling local residents to obtain vessels larger than their current skiffs and participate in local fisheries. A harbor would also reduce the potential for damage to local docks and vessels during storm conditions.

The number of commercial vessels seeking moorage in Akutan harbor is projected to remain at the levels presented in this document over the 50-year period of the analysis. The number of vessels is based on information from documents supporting the most recent management changes. Although there will be minor increases and decreases as marginal operators move in and out of the industry, and as additional management changes occur, the overall trend is for no significant increase or decrease.

5.1 Vessel Operating Costs

The cost of operating a vessel is an important factor considered by a vessel owner when evaluating options at the end of a fishing season. Many vessels might not travel to Pacific Northwest ports during the off season if harbor space were available in Akutan. The reduced operating costs and the time available to the crewmembers for other activities are benefits that may result from a harbor in Akutan. The *Fleet Survey Project* report prepared by Northern Economics and ResourcEcon in 1997 provides vessel operating costs and the opportunity cost of time for crewmembers based on trawl or pot vessel type and length overall Information from that study is presented here for trawl and pot vessels.

The trend is toward fewer trawl fishing days per year, reflecting the movement to shorter seasons that has occurred over the past decade. Recent regulatory changes are expected to decrease the number of vessels participating, but increase the length of the fishing season.

The vessel operating costs presented in the 1997 *Fleet Survey Project* are characterized by vessel type in Tables A2-13 and A2-14.

TABLE A2-13.—*Trawl vessel cost profile*

	Cost for Line Items by Vessel Group ($)			
Item	**100 feet or less**	**101 feet to 130 feet**	**131 feet to 160 feet**	**Greater than 160 feet**
Fuel, lube and hydraulic oil	115,452	213,540	338,512	$462,031
Vessel and machinery maintenance	69,021	217,413	406,475	593,339
Fishing gear maintenance and repair	28,316	28,316	28,316	28,316
Bait	5,887	5,887	5,887	5,887
Food	12,778	12,778	12,778	12,778
Other stores and supplies	5,434	21,686	84,357	245,201
Licenses	3,509	9,435	16,985	24,448
Freight cost	1,042	1,713	2,791	4,096
Hull and machinery insurance	51,101	79,354	115,350	150,928
Moorage or storage	6,449	10,392	15,415	20,380
Business expenses[1]	386,382	507,142	661,000	813,068
Crew costs:				
Crew share	45,811	54,326	65,175	75,897
Crew salary and benefits	29,695	40,282	53,770	67,101
P&I[2] insurance and other	16,648	29,704	46,339	62,780
Total[3]	**$702,019**	**$1,137,361**	**$1,734,206**	**$2,423,252**

Source: Northern Economics and ResourcEcon, *Fleet Survey Project,* 1997.
Notes:
[1] Business expenses include observer fees and assessments/fish taxes
[2] P&I = Liability protection and indemnity
[3] Total operating costs do not include crew salary and benefits or P&I insurance and other.

TABLE A2-14.—*Pot vessel cost profile*

	Cost for Line Items by Vessel Group ($)			
Item	**100 feet or less**	**101 feet to 130 feet**	**131 feet to 160 feet**	**Greater than 160 feet**
Fuel, lube and hydraulic oil	34,716	57,217	87,854	107,442
Vessel and machinery maintenance	66,203	113,623	204,029	278,890
Fishing gear maintenance and repair	32,336	36,309	41,718	45,176
Bait	15,722	23,627	34,390	41,272
Food	11,273	14,117	17,989	20,465
Other stores and supplies	3,486	11,737	61,305	176,400
Licenses	1,963	2,403	3,002	3,385
Freight cost	1,086	1,642	2,569	3,263
Hull and machinery insurance	54,627	70,105	91,181	104,655
Moorage or storage	6,741	10,012	14,466	17,314
Business expenses[1]	58,924	59,340	59,907	60,270
Crew costs:				
Crew share	261,138	410,571	670,435	871,102
Crew salary and benefits	46,442	53,506	63,125	69,275
P&I[2] insurance and other	27,375	36,028	47,809	55,341
Total[3]	**$548,216**	**$810,703**	**$1,288,845**	**$1,729,632**

Source: Northern Economics and ResourcEcon, *Fleet Survey Project,* 1997.
Notes:
[1] Business expenses include observer fees and assessments/fish taxes
[2] P&I = Liability protection and indemnity
[3] Total operating costs do not include crew salary and benefits or P&I insurance and other.

Pot and trawl vessels that are unable to find moorage in Akutan or Dutch Harbor must travel to more distant ports when major fishing seasons are closed and they have no other activities in which to engage.

Most hook-and-line vessels operating in the BSAI management areas return to their homeports or go to other fishing areas during winter to undertake repairs and maintenance or pursue other fisheries. Because most of the hook-and-line vessels are not traveling to other ports to seek moorage in the off season, they do not substantially contribute to moorage benefits. The vessels will make a minimal contribution to moorage demand while they are operating near Akutan during the fishing season, but their demand is not readily quantifiable.

There are other factors that may affect harbor demand. Insurance underwriters require that large catcher vessels be inspected twice during a 5-year period. The vessel must be dry-docked for the inspections, and vessels generally have a 2-year period and a 3-year period between inspections. Vessels smaller than about 95 feet in length can be hauled at the Walashek Shipyard in Dutch Harbor/Unalaska, but larger boats must travel to Seward or Ketchikan in Alaska, or to shipyards in the Puget Sound and Portland areas. Over a 5-year period, vessels will use 2 of the 10 semiannual (summer or late fall) fishing closures to travel to a shipyard for inspections.

5.1.1 Vessel Travel Costs

The trawl and pot vessels that must travel to other harbors in Alaska and the Pacific Northwest to find moorage incur travel costs for the vessel and crew. The majority of expense incurred by the vessel during travel between harbors is for fuel and oil. For this analysis, fuel costs were estimated at $1.31 per gallon (an average of the 2001 fuel costs in Akutan and the Pacific Northwest) and oil costs were estimated at 7 percent of total fuel costs. The 1997 *Fleet Survey Project* data indicate that there are relatively small differences in fuel consumption and speed between the average trawl and pot vessels. Therefore, travel costs for these vessel types have been averaged for this analysis. The fuel consumption per hour was calculated by the estimated regression line for pot and trawl vessels matching the Akutan harbor design fleet (Average length 118 feet) from the 1997 Fleet Survey. The estimated fuel use for these calculations is an average of 42 gallons per hour. Table A2-15 summarizes the roundtrip travel costs.

TABLE A2-15.—*Estimated roundtrip travel costs from Akutan to other harbors for trawl and pot vessels*

	Harbor				
Travel Cost Item	**Dutch Harbor**	**King Cove**	**Sand Point**	**Kodiak**	**Juneau**
Distance (nautical miles)	58	268	394	1002	2,158
Average speed (knots)	9.5	9.5	9.5	9.5	9.5
Time (hours)	6.1	28.2	41.5	105.5	227.2
Fuel consumption (gallons)	256	1,185	1,742	4,430	9,541.0
Fuel/oil costs[a]	$359	$1,661	$2,442	$6,209	$13,372

Source: *Fleet Survey Project,* 1997.
Notes:
[a] Based on estimated fuel cost of $1.31 per gallon
[b] Estimated at 7 percent of total fuel costs

TABLE A2-15 (con't).—*Estimated roundtrip travel costs from Akutan to other harbors for trawl and pot vessels*

	Harbor		
Travel Cost Item	**Petersburg**	**Seattle**	**Portland**
Distance (nautical miles)	2,250	3,336	3,408
Average speed (knots)	9.5	9.5	9.5
Time (hours)	236.8	351.2	358.7
Fuel consumption (gallons)	9,947	14,749	15,067
Fuel/oil costs[a]	$13,943	$20,673	$21,119

Source: *Fleet Survey Project,* 1997.
[a] Based on estimated fuel cost of $1.31 per gallon and oil use estimated at 7 percent of total fuel costs

5.2 Opportunity Cost of Time

Travel results in additional costs for vessels and crew. If fishers are traveling between ports, they are not receiving crew share because they are not pursing harvesting activities and are not able to pursue other work or leisure activities. The opportunity cost of time is the value of other work or leisure activities foregone during the time the vessel is traveling between ports or experiencing work interruptions (for example, when congestion delays vessel movement). The more time the crew would spend traveling from Akutan to another harbor, the greater the benefit from establishing a harbor in Akutan.

In calculating the opportunity cost of time, the value of the next-best alternative use of the worker's time is employed. For this report, the value of leisure time is considered the most appropriate measure. According to Engineering Regulation (ER) 1105-2-100, in lieu of a project-specific estimate of the opportunity cost of leisure, a value equal to one-third the wage rate is used.

Based on the 1997 fleet survey by Northern Economics and ResourcEcon, one-third the hourly wage rate for Alaska commercial fishers working in the BSAI fisheries is $14.67, or approximately $15.00.

The estimated opportunity costs for crews traveling between Akutan and other harbors are presented in Table A2-16 for the reduced number of crew typically used for vessel travel.

TABLE A2-16.—*Estimated crew opportunity costs per vessel for roundtrips from Akutan to other harbors*

	Harbor		
Vessel Operating Cost Item	**Seattle**	**Portland**	**Average**
Number of crewmembers	3	3	
Distance (nautical miles)	3,336	3,408	
Average speed (knots)	9.5	9.5	
Time (hours)	351.2	358.7	
Opportunity cost of crewmembers' time[a]	$ 15,802	$16,143	$15,973

Source: Estimated from data presented in *Fleet Survey Project,* 1997.
Note: [a] Opportunity cost of crewmembers' time computed at $15 per hour

5.3 Expenses Under Existing Conditions

5.3.1 Expenses Related to Rafting and Congestion

Rafting causes damages to vessels through minor collisions from other vessels and bumping against the dock cause scratches and dents, and damages to rails, guards, hardwood, and vessel fixtures. Annual damages vary depending on the size and type of vessel. In interviews, owners of large catcher vessels cited annual damages averaging $5,000.

5.4 Subsistence Activities

Under the without project conditions, local residents have limited access to secure, year-round moorage for their skiffs. As discussed in Section 8 of this report, residents' harvests of subsistence foods are constrained by lack of moorage, particularly during the winter months. As a result, residents are forced to use import substitution for culturally preferred subsistence foods. The alternative is to purchase meats, predominantly at the local Akutan Store.

6 WITH-PROJECT CONDITIONS

6.1 NED Benefits for the Proposed Project

The proposed Akutan harbor National Economic Development (NED) benefits for each of the basin sizes. The with-project benefits are described in the sections below. The with-project conditions reflect changes that will result to Bering Sea commercial fishing businesses and residents of Akutan as a result of the project. The constraints project will help to address the constraints identified in the without-project conditions. However, there will still be unmet demand for moorage in the region, even with completion of this project.

6.2 Benefits from Dredged Materials

The productive use of dredged material from the harbor site will result in a greater economic benefit than at-sea disposal. The three harbor alternatives will result in substantial quantities of dredged materials that are valuable for uses in other projects in the region. Sand for building and construction projects is a scarce commodity in Akutan, Unalaska/Dutch Harbor and other communities in the region. The proposed project will produce a relatively scarce material: coarse to fine grained sand. Once drained, this material will be suitable for use in construction projects.

In a recent contract with South Coast Construction in Unalaska/Dutch Harbor (South Coast construction, personal communication, December 2001), it was revealed that old concrete was being collected and broken up to obtain the necessary fines for new concrete. In another instance, sand was barged in to Unalaska/Dutch Harbor from Nelson Lagoon. The contractor estimated the value of sand on-site in Unalaska Dutch Harbor to be $20 per ton.

The alternatives will produce the following volumes of dredged sand:

12 Acre Basin	850,000 cubic yards
15 Acre Basin	990,000 cubic yards
20 Acre Basin	1,175,000 cubic yards
Reconfigured 12 Acre Basin	843,000 cubic yards

Using a factor of 1.62 tons of sand per cubic yard, and assuming that 425,000 cubic yards (72,000 cubic yards for the reconfigures 12 acre basin) will be needed for the Akutan project to develop uplands, the alternatives will have surplus amounts for each alternative shown in Table A2-17.

A spreadsheet model was developed to calculate the value of the dredged sand, net of transportation costs from Akutan to Unalaska. The dredged materials were assumed to be sold in four equal increments over time, at the end of five years, ten years, fifteen years and twenty years. The present value of the sand at the end of each of those periods was calculated, using the current Corps of Engineers discount rate of 5.625 percent. The present value for the sand was calculated, and then the annual benefits were calculated over the 50 year life of the project to arrive at a benefit from use of the dredged materials.

Table A2-17: Value of Dredged Sand for Akutan Project Alternatives

harbor size/alternative	12 acre inland	15 acre inland	20 acre inland	reconfigured 12 acre
total dredged cubic yards	850,000	990,000	1,175,000	843,000
amount needed on site	425,000	425,000	425,000	72,000
available sand	425,000	565,000	750,000	771,000
convert yards to tons	688,500	915,300	1,215,000	1,249,020
value of sand @$20/ton	$13,770,000	$18,306,000	$24,300,000	$24,980,400
cost of transportation (2.13/ton)	$1,466,505	$1,949,589	$2,587,950	$2,660,413
gross value of dredged sand	$12,303,495	$16,356,411	$21,712,050	$22,319,987
present value of dredged material sales over 20 years	$6,502,125	$8,644,001	$11,474,338	$11,795,620
annual benefit over 50 years	$391,092	$519,922	$690,163	$709,487

6.3 Damage to Vessels

Vessels mooring in the Akutan harbor will not incur rafting damage and the resulting annual cost associated with that damage. In designing the inner-harbor configuration for the Akutan dock, a parallel moorage configuration was selected to take best advantage of the available space in the basin while still providing secure moorage for harbor users. The parallel moorage within a wave-protected harbor should prevent any vessel damage while moored within the Akutan Harbor. However, these vessels will spend at least part of the year operating in other areas, and may continue to incur mooring damage in those other locations. An average annual rafting damage of $5,000 was reduced by one-quarter of that annual damage amount ($1,250 per vessel) to account for the measure of protection afforded while utilizing the Akutan Harbor.

In the with-project condition, the prevention of damage to vessels will provide $1,250 x 38 vessels, or a total annual benefit of $47,500 (Alternative 1). For Alternative 2 the annual benefit is $1,250 x 48 vessels ($60,000) and for Alternative 3, the annual benefit is $1,250 x 60 vessels ($75,000).

6.4 Vessel in-Season Mooring Costs

Two or three times every fishing season, vessels fishing in the Bering Sea come to the end of a fishery opening and have to find short-term moorage until the next fishery opens. The proposed project will allow between 38 (12 Acre Basin) and 60 (20 Acre Basin) vessels to obtain secure moorage in Akutan.

The benefits associated with this moorage were calculated based upon two trips to obtain moorage every season. It is assumed that the fleet, in the absence of the project, would be forced to seek moorage in other ports, from preference to the closer port of Unalaska, to King Cove, Sand Point, Kodiak, ports in Southeast Alaska and finally in the Pacific Northwest (Seattle areas and Portland/Astoria).

Since each end of the season is an independent event, we can't know with certainty which of the harbors the vessels projected to utilize the Akutan harbor would have found. It was assumed that the capacity of the harbor (38, 48 and 60 vessels) would have obtained seasonal moorage 25 percent in the closest ports (Dutch Harbor, King Cove and Sand Point). The second 25 percent would find moorage in Kodiak. The third 25 percent would find moorage in Southwest Alaska (Juneau and Petersburg) while the remaining 25 percent would be forced to travel to the Pacific Northwest. Table A2-15 estimated the travel costs to these alternate port. The total benefit from elimination of this cost for the different alternatives is as follows. The estimated costs for reduced costs associated with in-season moorage include only vessel operating costs and do not include opportunity costs for the crew members.

The travel costs are averaged round trips to/from the ports of 1) Dutch Harbor-King Cove-Sand Point, 2) Juneau & Petersburg, 3) Seattle and Portland. The port of Kodiak is a discrete travel distance/cost in itself. The travel costs used for this calculation are shown in Table A2-15 as follows: Dutch Harbor – King Cove – Sand Point average cost of $1,487/trip; Kodiak $6,209/trip; Juneau-Petersburg average cost of $13,658/trip; and Seattle-Portland average cost of $20,896/trip.

12 Acre Basin

38 vessels times the travel cost per trip (as shown in Table A2-15) times two trips per year results in an annual cost of $761,436. The calculation is as follows: (2 trips per year x 10 vessels x $1,487/trip) plus (2 trips per year x 10 vessels x $6,209/trip) plus (2 trips per year x 10 vessels x $13,658/trip) plus (2 trips per year x 8 vessels x $20,896/trip).

15 Acre Basin

48 vessels times the travel cost per trip (as shown in Table A2-15) times two trips per year results in an annual cost of $1,014,025. The calculation was made in the same manner as

shown above for the 12 acre basin, with the vessel distribution of 12 vessels for each of the alternate port destinations.

20 Acre Basin

60 vessels times the travel cost per trip (as shown in Table A2-15) times two trips per year results in an annual cost of $1,267,532. The calculation was made in the same manner as shown above for the 12 acre basin, with the vessel distribution of 15 vessels for each of the alternate port destinations.

6.5 Pacific Northwest Annual Travel Cost

As discussed earlier in the report, in the absence of secure moorage in Akutan, fishing vessels travel back to their home ports in the Pacific Northwest at the end of the fishing season. Moorage in Akutan will save these vessels the travel costs associated with the trip once every other year (0.5 times per year). Every other year, vessels will still travel to the Pacific Northwest to take care of regular maintenance, haul out and insurance inspections. The project benefit will come from the elimination of one end-of-season trip to the Pacific Northwest each year. This trip will still be necessary every two to three years for vessel and gear maintenance, overhaul, insurance inspections, drydock maintenance and other needed repairs and refitting.

The benefits estimated result from the reduction of one trip every other year to the Pacific Northwest. This is and end-of-season return to the vessel's homeport and not in-season moorage. The calculation is based on the savings of one trip every other year. Since the without-project condition is to return to the Pacific Northwest every year, we believe it is appropriate to include the opportunity cost of time based on the survey data from the 1997 Fleet Survey Project for Seattle and Portland.

The benefits associated with elimination of this cost are as follows:

Alternative 1

Taking the average travel cost to the Pacific Northwest from Table A2-15 ($20,896) x 0.5 times per year plus the average Pacific Northwest opportunity cost from Table 2A-16 ($15,973 for 3 crew members) x 38 vessels equals times 0.5 times per year equals $700,508.

Alternative 2

Taking the average travel cost to the Pacific Northwest from Table A2-15 ($20,896) x 0.5 times per year plus the average Pacific Northwest opportunity cost from Table 2A-16 ($15,973 for 3 crew members) x 48 vessels x 0.5 times per year equals $884,853.

Alternative 3

Taking the average travel cost to the Pacific Northwest from Table A2-15 ($20,896) x 0.5 times per year plus the average Pacific Northwest opportunity cost from Table 2A-16 ($15,973 for 3 crew members) x 60 vessels equals $1,106,066.

Future benefits from this category will be dependent upon vessels being able to obtain seasonal moorage in the Pacific Northwest every other year. The current policy regarding priority moorage in the Fishermen's Terminal in Seattle is provided by the following information:

> *"In January 2002, the Port of Seattle Commission adopted Resolution No. 3480, as amended, which allows non-commercial vessels to moor in slips not needed by the fishing and commercial workboat industries. On May 14, 2002, the Commission reviewed the Introduction Plan that reaffirms that the Terminal is a facility primarily for the fishing industry, meets the requirements of Resolution No. 3480, as amended, and has been reviewed and approved by the Fishermen's Terminal Advisory Committee (FTAC) and other interested users of the Terminal."*
>
> *Source: letter from Kenneth R. Lyles, General Manager, Fishermen's Terminal, May 29, 2002.*

In addition to the above, the letter stipulates that:

- *"Priority for vessel moorage will be given to those vessels actively engaged in bona fide commercial fishing operations and to those vessels otherwise qualifying but inactive due to govern mandated closure of their fisher(ies). Second priority will be given to shoes vessels actively engaged in commercial marine operations and those that become inactive while moored while at the Terminal. Third priority will be given to vessels not actively engaged in commercial fishing or marine operations, including recreational vessels."*

- *Vessels not engaged in commercial operations will be permitted only if they do not displace commercial fishing, commercial marine operations or impede fishing or industrial operations*. (emphasis added)

Another letter from Charlie Sheldon, managing director of the Seaport at the Port of Seattle was published in the Seattle Post-Intelligencer on May 14, 2002. This letter provides the following comments:

- *"Fishermen's Terminal is without question the best facility for fishermen on the West Coast, with a special combination of businesses, moorage and facilities to help support and maintain their industry."*

- *"Fishermen's Terminal is not in decline. It has been renovated a number of times. It went through a $13 million expansion in 1988 and is currently undergoing a $35 million, three-year improvement project."*
- *"Throughout its history, fishermen and the port have insisted that the Fishermen's Terminal be maintained as an industrial facility for working boats. Over the years, we have added tenants on the uplands to improve the business climate, such as restaurants and the Wild Salmon fish market, but we have been able to maintain the working character of the area."*

It is clear from these policy documents that while it is true that the Port of Seattle passed a resolution allowing recreational use for unused moorage in Fishermen's Terminal, commercial fishing vessels clearly have the priority use of the facility. There should be no diminished availability for moorage of vessels fishing in the Bering Sea and traveling to the Pacific Northwest for moorage, vessel and gear maintenance and overhaul, insurance inspections and other needed services and drydock maintenance and repairs and refitting.

6.6 Subsistence Benefits

The Akutan project will provide moorage space for 20 locally-owned skiffs that are utilized by residents to produce subsistence foods for their family's consumption. The ability of these residents to keep their skiffs in the water and ready for use will increase their subsistence activities and harvests. The local residents will therefore benefit from increased subsistence production as a direct consequence of the project.

Subsistence is a household production in Akutan, similar to many remote communities in Alaska. The term includes traditional food gathering activities practiced by the Aleut residents living in the village of Akutan. There is no market value associated with subsistence production because it is a non-market commodity. Placing a value on increased subsistence production requires the use one of several methods to determine a value for non-market goods.

The study team favors a methodology to determine the value of increased subsistence value by its substitution value. That is, what is the value (local cost) of the food that will be replaced by subsistence production. This substitution methodology acknowledges that it overlooks the cultural values inherent in production and consumption of subsistence foods (Peterson et al., 1992).

Table A2-18 shows the current (January 2002) cost for meats in Akutan. This table is based on interviews with the Akutan Store, the only store in the community. The average price per pound for all meat products is $6.15 per pound. This represents the cost for residents for meats they have to purchase, if their subsistence harvests are insufficient to meet their needs. This average cost is similar, although slightly lower, than the average cost per pound of $6.74 recently reported in the Corps of Engineers feasibility report for the False Pass, Alaska Navigation Improvements study (Corps of Engineers, 2000). The shadow price for subsistence production is based upon the per pound value of all substitute foods purchased by Akutan residents.

The calculation of the value of increased subsistence production by Akutan residents is made by multiplying 466 pounds per capita (annual consumption) by 15 percent (the estimated increase in production resulting from project completion). This result in multiplied by 112, the number of residents in Akutan and then multiplied by $6.15 per pound, the weighted average of all substitute food products in the Akutan store. Subsistence benefits only account for two and one-half percent of the total project benefits. However, to the Aleut residents of the village of Akutan, these are perhaps the most important benefits of the project.

Table A2-18: Cost for Food Items at Akutan Store

food item	price per pound	food item	price per pound
ground beef	$2.45	Bacon	$4.18
cube steak	$5.82	beef sausage	$6.65
rib steak	$11.29	ham	$3.95
T-bone steak	$11.28	hot dogs	$4.88
Sirloin roast	$4.32	Bologna	$1.61
Beef ribs	$5.35	Pepperoni	$10.70
beef spare ribs	$3.81	Salami	$9.42
stew beef	$4.51	sliced ham	$6.14
pork spareribs	$4.21	canned clams	$8.62
pork chops	$6.04	Oysters	$10.79
pork loin	$6.04	Vienna sausages	$3.16
ham hocks	$4.71	Herring	$4.04
Polish sausage	$4.22	micro clams	$11.91
game hens	$4.27	beef jerky	$12.96
Chicken breast	$5.54	breaded cod fillets	$7.21
Chicken fryer	$2.09	breaded prawns	$6.29
Turkey	$1.92	salt pork	$3.89
canned shrimp	$11.75	fish sticks	$5.36
Average price per pound – all items			**$6.15**

Source: Akutan Store, January 2002.

6.7 Summary of Benefits

A summary of project benefits is shown in Table A2-19 for the benefit categories discussed above.

Table A2-19

Summary Sheet for Akutan Small Boat Harbor Benefits: Annual Benefits

Benefit Category	12 Acre Basin	15 Acre Basin	20 Acre Basin	reconfigured 12 acre basin
1) use of dredged materials	$391,000	$520,000	$690,000	$709,000
2) operating cost reductions				
2(a) reduced travel to Pac NW	$701,000	$885,000	$1,106,000	$701,000
2(b) In-season moorage travel costs	$761,000	$1,014,000	$1,268,000	$761,000
3) prevention of rafting damage	$48,000	$60,000	$75,000	$48,000
4) increase to subsistence production	$48,000	$48,000	$48,000	$48,000
Total Annual Benefits	**$1,949,000**	**$2,527,000**	**$3,187,000**	**$2,267,000**

7 REGIONAL BENEFITS

The evaluation of regional benefits provides information for the residents of the Akutan, as well as the Aleutians East Borough on some of the impacts of the proposed project. The Corps of Engineers project evaluation methodology provides a structures analysis of the benefits to the nation resulting from the project. The Corps federal interest is based on costs and benefits evaluated under the national economic development (NED) guidelines.

While the national accounting stance is appropriate for the Corps of Engineers project evaluation, the local sponsor has a more focused concern. The project sponsor, the Aleutians East Borough and the City of Akutan, need to know that the facility will be a financial asset to their community. The important questions for these local government entities are, will the project add diversification and stability to employment in the region? Will it serve the moorage needs of the residents?

Although meeting the moorage needs of the community takes a relatively small portion of the moorage basin, it is an important aspect of providing benefits to Akutan residents. As discussed in the benefits section, local residents will gain the benefit of increased subsistence production as a result of the project. Moorage in the community will also allow several local residents to enter commercial fishing activities. The participation of the community in the Aleutian Islands/Pribilof Community Development Quota group provides them with access to fisheries resources that they may be able to pursue, with the advantage of moorage in the community. Under the without-project condition, residents interested in commercial fishing are forced to leave the community to operate.

There is an inshore waters State waters fishery for Pacific cod that is only open to small boats, such as those owned by the residents of Akutan. Again, having moorage available during the Pacific cod season will allow several local residents to pursue that fishery.

It is anticipated that moorage revenues from the project will be sufficient to fund annual operations and maintenance and also cover long-term maintenance to ensure that the harbor is preserved for continued future operation. There are at least two direct local jobs that will come out of operation of the facility. A harbormaster will be needed to operate the facility, with annual salary benefits in the $30,000 to $40,000 range. In addition, there will probably be the opportunity, and need, for a boat sitting service. This business will monitor vessels moored in the harbor for owners during long-term moored periods. This operation is similar to Mac Enterprises in Unalaska/Dutch Harbor, and provides full time employment for at least one person.

There are limited opportunities for employment in Akutan, especially outside of fish processing. The proposed project will create a number of jobs during the construction phase that are likely to be filled by Akutan residents. These relatively high paying jobs will have a large beneficial impact on workers and families in Akutan.

Other vessel services may be developed adjacent to the harbor that will provide local business opportunities for Akutan residents, such as gear or crab pot storage.

There is a general trend for remote tourism development in the Aleutians by ecotourism groups, birders, ocean kayakers and sport fishermen. A substantial sport fishery has developed in Unalaska, following recognition of a world record halibut caught nearby. The completion of the proposed project may act as a catalyst to help develop some of these options.

8 SUBSISTENCE

The purpose of this section is to briefly describe the subsistence harvests and activities in Akutan, Alaska and address some potential effects a proposed harbor would have on subsistence harvests.

8.1 METHOD

For the summary of subsistence harvests in Akutan, SRB&A primarily relied on the Alaska Department of Fish and Game (ADF&G) Community Profile Data Base (CPDB) (ADF&G 2001) and secondarily on an unpublished subsistence report on Akutan (ADF&G 1993). Braund, Moorehead, Burnham, Hagenstein, and Holmes (1986b) provided some general subsistence information for the community. In January 2002, SRB&A made several phone calls to Akutan and conducted short interviews related to current subsistence activities and potential influences to subsistence with increased access to salt water associated with a port in Akutan. The interviewees had lived in Akutan between 36 and 49 years.

8.2 SUBSISTENCE IN AKUTAN, ALASKA

Subsistence is the non-commercial, traditional and customary harvest of renewable resources for food, clothing, fuel, transportation, construction, arts, crafts, sharing, and customary trade. These uses of wild resources are of important cultural and economic value in rural Alaska. Akutan is a typical rural community in the sense that subsistence activities are prevalent and significant.

ADF&G gathered subsistence activity data in Akutan in 1991 for a one year period from October 1990 through September 1991. The resulting data were published in the Community Profile Database (ADF&G 2001). These data are the basis for most of the following description of Akutan subsistence. Table A2-20 summarizes subsistence harvests by major resource category for the 1990-1991 study year, and Table A2-21 displays the species harvested in order of their contribution to the total community subsistence harvest. The top nine species were: halibut (18 percent), sockeye salmon (16 percent), Steller sea lion (16 percent), Pacific cod (six percent), feral cattle (six percent), coho salmon (five percent), pink salmon (four percent), harbor seal (four percent), and ducks (three percent). Thus, the vast majority of Akutan subsistence harvests by weight are marine resources.

In 1990-1991, the community Akutan harvested 69 different subsistence resources (ADF&G 1993). The community harvested a total of 47,397 pounds of wild resources during the study year. Residents harvested an average of 1,529 pounds per household of usable weight in subsistence products, or 466 pounds per person. This is over twice the 222 pounds per person of meat, fish, and poultry that the average western United State household purchased in the 1970s (US Department of Agriculture 1983 as cited in Fall et al. 1996:32). Ninety-six percent of Akutan households attempted to harvest subsistence resources and, due to sharing, 100 percent used wild resources (ADF&G 2001).

Table A2-20: Subsistence Harvests & Subsistence Activities for Akutan, Alaska, 1990-1991

Resource	Percentage of Households: Using	Trying to Harvest	Harvesting	Receiving	Giving	Estimated Harvest: Est. Number	Total Pounds	Mean HH Pounds	Per Capita Lbs	% Total Harvest
All Resources	100	96	96	100	92		47,397	1,529	466	100%
Fish	100	92	92	96	88		26,921	868	265	57%
Salmon	96	76	76	84	64	3,269	12,339	398	121	26%
Non-Salmon Fish	100	92	92	92	76		14,581	470	143	31%
Land Mammals	72	28	20	64	24	19	2,822	91	28	6%
Large Land Mammals	36	0	0	36	0		0	0	0	0%
Small Land Mammals	12	12	8	4	4	11	22	1	0	0%
Feral Animals	64	24	20	56	24	8	2,800	90	28	6%
Marine Mammals	92	48	44	84	40	142	10,767	347	106	23%
Birds and Eggs	92	72	68	84	52	4,840	2,882	93	28	6%
Marine Invertebrates	88	68	64	72	56		2,866	92	28	6%
Vegetation	100	96	96	64	52		1,140	37	11	2%

Source: ADF&G, Division of Subsistence CPDB, Version 3.10, January 2001.

Stephen R. Braund & Associates, 2002.

Table A2-21: Subsistence Species Used by Akutan Residents, 1990-1991

Resource	Percentage of Households: Using	Trying to Harvest	Harvesting	Receiving	Giving	Estimated Harvest: Est. # of Units Harv by Comm.	Est. Total Lbs Hrv by Community	Mean HH Pounds Harvested	Per Capita Lbs	% Total Harvest
All Resources	100	96	96	100	92	47,397	47,397	1,529	466	100%
Halibut	100	80	80	76	64	271	8,689	280	85	18%
Sockeye Salmon	92	72	68	72	44	1,872	7,752	250	76	16%
Steller Sea Lion	88	32	32	80	32	38	7,688	248	76	16%
Cod					48	930	2,975	96	29	6%
Cattle – Feral	60	24	20	52	24	8	2,800	90	28	6%
Coho Salmon	92	64	64	80	48	429	2,222	72	22	5%
Pink Salmon	76	56	56	60	36	915	2,068	67	20	4%
Harbor Seal	80	32	32	72	32	36	1,875	60	18	4%
Ducks	84	52	52	56	48	1,827	1,374	44	14	3%
Vegetation	100	96	96	64	52	1,140	1,140	37	11	2%
Rockfish	76	60	56	40	44	717	1,076	35	11	2%
Char	88	76	76	56	52	737	1,032	33	10	2%
Fur Seal	68	36	28	52	20	67	1,004	32	10	2%
Tanner Crab	68	24	24	48	24	1,004	1,004	32	10	2%
Octopus	84	48	48	52	36	195	781	25	8	2%
Bird Eggs	88	60	56	76	40	2,217	646	21	6	1%
King Crab	68	28	28	48	28	250	576	19	6	1%
Geese	72	40	40	52	32	221	511	16	5	1%

Emperor Geese	64	32	32	44	28	160	400	13	4	1%
Eider	68	40	40	40	36	236	307	10	3	1%
Chitons (bidarkis, gumboots)	56	48	48	32	36	61	244	8	2	1%

Source: ADF&G, Division of Subsistence CPDB, Version 3.10 January 2001.

Stephen R. Braund & Associates, 2002.

Fish accounted for over half (57 percent) of the subsistence take in Akutan. Residents harvested an average of 868 usable pounds of fish or 265 pounds per person. The top two individual subsistence species were in this category: halibut at 280 pounds per household and sockeye salmon at 250 pounds per household. Halibut harvests can occur throughout the year but sockeye salmon harvests are restricted to the summer months. Other fish species harvested include coho and pink salmon (plus a small number of chinook and chum salmon), Pacific cod, greenling, flounder, sole, herring black rockfish, sculpin, Dolly Varden and trout (ADF&G 2001).

Twenty-three percent of the 1990-1991 Akutan subsistence harvest consisted of marine mammals, specifically Steller sea lion and harbor seals. Steller sea lions were the third largest harvest of a single species. Households harvested an average of 248 pounds, which equated to 76 pounds per capita. Harbor seal harvests constituted four percent of the total community harvest (ADF&G 2001). A statewide study of harbor seal and Steller sea lion harvests (Wolfe & Mishler 1996) added data for 1992 through 1995 for Akutan, shown in Table A2-22 Harvests of both species declined during the study period.

Table A2-22 Akutan Harbor Seal and Sea Lion Harvests, 1992-1995

Harbor Seal Harvest

Year	**1992**	**1993**	**1994**	**1995**	**Primary Harvest Months**
Number	13	16	14	7	May, Aug thru Nov, Jan & Feb Aleutian Islands harbor seal harvest season is primarily Sept. thru Dec. (Wolfe & Mishler, 1996:B-12).

Sea Lion Harvest

Year	**1992**	**1993**	**1994**	**1995**	**Primary Harvest Months**
Number	26	15	13	6	March, April, June Aleutian Islands sea lion harvest season is primarily Oct thru Dec. (Wolfe & Mishler, 1996:B-12).

Source: Wolfe, R. and C. Mishler, 1996 (Tables 6, 10, 16 & 17 & Pages B-12, C-84)

Stephen R. Braund & Associates, 2002.

Harvests of land mammals, birds and eggs, and marine invertebrates each were six percent of the total community subsistence harvest. Land mammals consisted only of one species, feral cattle. Birds harvested were not specified but were classified as ducks (including eiders) and geese (including emperor geese). Ducks constituted most of the bird harvest (65 percent). Bird eggs collected from seabirds, loons and gulls contributed one percent of the total community harvest (646 pounds) and averaged 21 pounds per household. Marine invertebrates harvested by Akutan households included chitons, king and tanner crab, and octopus. Residents harvested an average of 92 pounds of marine invertebrates per household, or 28 pounds per person (ADF&G 2001).

8.3 EFFECTS OF PROPOSED HARBOR ON AKUTAN SUBSISTENCE

8.3.1 Boat Season and Use

Akutan is generally ice-free 12 months a year. In 1985, Akutan residents reported that the ice-free marine environment offered them boat access year-round to different areas for harvesting subsistence resources (Braund et al. 1986). However, several factors limit subsistence harvesters from having continuous access to the marine environment, including 1) inclement weather, 2) small boat size, and 3) the difficulty of continually having to launch and beach skiffs to protect them from bad weather.

According to the 2002 interviews, Akutan residents generally use smaller skiffs (e.g., 18 foot aluminum watercraft) for marine subsistence activities. With no protection for these watercraft in the water, boaters typically have to put them in and out of the water after each use. This is an arduous task and pulling the skiffs up and down the beach is wearing on the watercraft. Furthermore, it often requires a cooperative labor effort.

To accomplish this constant beaching of their boats, Akutan residents who use skiffs for subsistence harvesting build a wooden "skid" on the beach out of lumber. They use this to pull their skiffs up and down the beach. Often these skids or launches are gone after the winter storms. Akutan boaters continuously have to dig them out and repair them for use during the summer. One interviewee said, "That is a real headache. Changing weather patterns continually ruins the wooden landings that we have. A boat harbor would help in more ways than one."

When asked the boat season, one interviewee responded that the halibut season is open in their area from March/April to November. He indicated that he has his boat "in the water" for approximately three months focusing in the summer when the weather is nice and he is able to fish. He said he stores his boat out of the water in early September for the winter.

Another boater also indicated he has to take his boat out of the water each time he went out. He said it depends on the weather and "it is a lot of work to do that. We can go out 12 months a year depending on the weather, but moving the boats is a lot of work." Whenever he has time and the weather is suitable, he goes trolling and duck hunting. He watches the weather predictions and takes his boat in and out of water depending on the forecast and his observations.

One interviewee said,

> "This is the first year with a marina; the Borough just put it in and people are just starting to use it. My brother's 24 footer allows him to get out further. People are just getting used to having it there. We use boats for subsistence, but we have to pull them out. We build "skids" that are about 60 feet long using 4 x 4s with winch at the top. I pull up my boat and lash it down. Sometimes the swell is bad and we cannot get off the skid. If something hangs up or a wave hits, it could swamp the boat."

8.3.2 Months Cannot Currently Use Boat

According to the interviews, during the fall/winter from approximately early September through April the weather is generally poor and small boat activity is limited. There can also be periods during the summer when it is blowing so hard people pull their skiff out of water and put them on the beach. However, in the summer, people often take their "chances with calm weather and leave the boat in the water for longer periods," but at sign of bad weather, they have to pull their boats out of the water.

One interviewee said, "The weather is worst from January to March; it can be really bad. It is not so bad in the fall, October and November."

Describing the seasonality and opportunistic nature of subsistence, one hunter said, "Subsistence is all year round. Summer is for fish, fall is for ducks and seals if they are around. We work with the seasons and what is out there."

Another hunter said, "There are months we cannot get out: January and February are bad months, but it all depends on what kind of fall year we had. It does freeze over here; it is always open. But the idea of hauling boats up and down the beach and wear and tear on the skiffs is hard."

One subsistence boater said they were limited from going out in boats "this time of the year" (January). He said that during the winter, they cannot get out 60-70 percent of the time.

Another hunter indicated that "December (this year), January, February, and March are the months with limited access due to weather." He said that he could only get out 10 percent of the time for several months. In November, he could get out 20 percent of the time and then it dropped to 10 percent in December.

8.3.3 Harbor's Influence on Subsistence Activities: – easier access; safer launching; additional trips; bigger boats; hunt other areas further away; increased harvests

One interviewee said, "If we had a boat harbor, people would get bigger boats and be out more and get more subsistence foods. They would be out a longer time also. Furthermore, there are other places around the island that residents could travel to with access to larger boats in the fall that are good for subsistence."

During periods when the surf is high due to an ocean swell, the water is acceptable for boating, but it is difficult for Akutan harvesters to launch their boats off of the "skids." The surf at the beach edge can be a dangerous transition zone where boats can swamp causing accidents. A harbor would eliminate the necessity of continually launching skiffs every time a subsistence harvester went out into salt water.

One interviewee indicated that there were cattle on "next island up from Akutan." He said the Native corporation owns them and "a good time to hunt them is in September and October before the grass dries." Currently, this is at the margin of the annual weather window for safe boat travel, especially in small skiffs that are used for subsistence (because there is no place to harbor a larger watercraft and the skiffs are generally removed from the water at the end of each trip).

Another subsistence harvester said,

> *We do commercial fish here also. However, we are limited to a skiff fishery due to no boat harbor. If we had a boat harbor, we could get into 32 foot class boats and be able to fish other species than halibut. We got added to the caribou hunt in Unimak Island (False Pass), but we cannot do that due to our skiff being too small to travel there. If we had a harbor and bigger boats, we could take advantage of that. My relatives are originally from the Chignik Lake area. I used to hunt caribou there. Some people locally would attempt to go to the next island up and hunt caribou if they had a bigger boat. The ability to get bigger boat and tow a skiff would give us the ability to go other places. For a bigger boat, we need a harbor.*

Interviewees indicated that if they had the ability to keep their boat in the water, they could go out more and rely on subsistence more. One hunter said,

> *We have to put the boats in and out of the water each time we use them. If we had a boat harbor to put our skiffs in, that would be one less worry. Basically, our subsistence lifestyle is done on nice days. It is a problem for us to pull our skiffs in and out of water. It stops you doing subsistence; it is a pain to keep doing that. In the winter we get weird storms that change the beach and waterfront. Most skiffs are aluminum and if do that [up and down the beach] too many times, it ruins them. Lunds have rivets in them. I cannot keep one in the water anymore due to*

running it up and down the beach. Having the ability to keep boats in the water would save our skiffs and you would see greater attempts to go out and get subsistence foods.

Additional comments included:

You need a bigger boat in order to get out and pull pots and stuff. A lot of guys have plans for bigger boats. The Marina will not hold all of the boats in a few years. We are hardly involved in commercial fisheries around here except for the Trident boats due to lack of a facility for commercial vessels without having it in Dutch where there is no space left. It is hard to work away from home. A harbor will change Akutan. It will allow people to get involved locally.

A boat harbor means we could have bigger boats and then travel further. My brother has plans for a bigger boat. For subsistence we sometimes use commercial craft out of season to hunt like at Unimak Island. We used to do that in the past when my uncle and grandfather had boats moored in the bay. We used to go to Unimak near False Pass to hunt caribou and reindeer.

With easier access to my boat [i.e., with a boat harbor], I would not have it on the beach. I would have it out or if we had a harbor I would have it in there. Therefore, I would not have any worry and hope that I can get it up the beach tonight. It would save a lot of headaches.

Oh yeah, I would use it more than now for sure. That way it [his boat] is always out and I do not have to find people to help me haul it in and out of the water. If a harbor was there, I would not need anybody.

In 2001, the Aleutians East Borough a built small skiff moorage next to the Akutan large ship dock. This facility provides some protected moorage for six to eight skiffs next to the dock. However, when the wind blows, these boats have to be taken out of the water and put on land. This is a difficult task. There is no hoist or crane to facilitate this maneuver. The small skiffs are moved up and down the beach. The bigger boats are even harder to move in and out of the water. Generally larger boats leave Akutan and look for winter moorage in comminutes with harbors (e.g., Sand Point, Dutch Harbor, King Cove or further south).

Substantial subsistence hunting and fishing is not in the bay, but is outside of the bay. With a little skiff, subsistence harvesters have to wait for good weather. Harvesters go to the next island over (Akun Island) or to the back of Akutan Island (go around on Bering Sea side), or to a couple of smaller, nearby islands (e.g., *Rootok Island). This travel would be facilitated by larger craft that could be stored in a harbor.*

8.4 Percent Increase in Subsistence Harvests with a Harbor

One person estimated that approximately 40 percent of his household's food currently comes from subsistence. He thought a harbor would increase that by 10 to 15 percent. Other comments included:

> *With boat harbor we would have more access to the water. People would get out more; the ones that hunt and have time. If we had a larger boat to get out to the bay and get cod or get out to where the fish are...currently subsistence is close.*
>
> *With a harbor, I would use my boat all year round if weather was good. I would use it 50 percent more if had access to the water all of the time. My subsistence harvests would increase throughout the year. It would increase 10% or more.*
>
> *With harbor, increase, right away, mainly because of the road, I would say maybe five or 10 or 15 percent increase.*

9 SENSITITIVITY ANALYSIS

Future use of the proposed harbor will be contingent upon continued demand for secure moorage by vessels operating in Bering Sea waters adjacent to Akutan. The primary fisheries for these vessels are pollock, king crab, tanner crab, Pacific cod, sablefish, and a number of species of rockfish. Since 1977, the North Pacific Fishery Management Council (NPFMC) has managed these fisheries. While resource fluctuation is always going to occur, the management regulations provided by the NPFMC has been conservative, and has not resulted in depleted stocks of fishery resources in the Bering Sea.

It is well recognized that farmed salmon have had a very disruptive effect on the Alaska salmon industry. However, salmon are not an important species to the operation of fisheries activities at Akutan. In 2002 for instance, there were zero landings of salmon in Akutan for the entire year. Trident Seafoods, the owner and operator of the shore plant in Akutan does process salmon, but the main focus of the company is on Bering Sea groundfish and crab. Therefore, changes to market conditions for salmon are unlikely to have any effect for the Akutan harbor project.

The benefits from the proposed project result from cost savings calculated as the difference between the without-project conditions and the with-project conditions. Under the with-project conditions, the benefits will accrue to several different groups.

Components of the fishing fleets fishing in the Bering Sea, and to a lesser extent the Gulf of Alaska, will realize lower variable operating costs as a result of this project. The moorage benefits represent the largest components of overall benefits (89 percent). The benefits calculations are based on several assumptions, calculation and interview data and are representative of current conditions facing the fishing fleet. Several of the key assumptions, such as the number of in-season lay-ups were specifically chosen to be conservative. Interviews from fishermen indicated that on average, three in-season lay-ups were necessary during a typical year. To account for any seasonal variation and to be conservative, only two in-season lay-up periods were utilized in benefit calculation.

Moorage demand is always subject to change, however, the proposed project will only provide moorage for a portion of the vessels seeking in-season and seasonal moorage in Akutan. Any reductions in numbers of vessels through regulatory change are unlikely to affect operation of the Akutan harbor. Trident Seafoods reports over 200 vessels operating in the region make occasional deliveries to their plant. The design fleet was based on 64 vessels that make up the vessels that constantly operate in the area and deliver fish to the Trident Seafoods Akutan plant. None of the alternatives would provide moorage to even this entire group.

The benefit cost ratio is relatively sensitive to changes in the calculation of benefits to fishing vessels. If, for example, the vessel benefits were reduced by 50 percent, the benefit cost ratio would be reduced, however, even with a change of this magnitude each of the alternatives still represents an economically viable project.

Moorage benefits to vessels are largely comprised of fuel cost savings. For purposes of calculation, the monthly fuel cost in the Seattle area was averaged with the monthly fuel cost in Akutan (which is the same price as Unalaska-Dutch Harbor) over the most recent full year (2001). If fuel costs were to vary from this annual average composite price for the Pacific northwest and Akutan, the benefits calculation would be directly affected. The long-term trend for fuel prices has been to increase over time. Therefore, it is most likely that future price changes would tend to increase the benefits to the fishing fleet rather than decrease them.

The benefit cost ratio is influenced to a lesser extent by the other benefit categories, that include: prevention of rafting damage (2.12 to 2.46 percent) of total benefits; use of dredged materials accounts for 20.06 to 31.27 percent of total benefits, depending on the specific alternative, and increased subsistence production accounts for 1.51 percent to 2.46 percent of total benefits, depending on the specific alternative.

10 SUMMARY

Table A2-23 provides a summary of the Akutan Harbor benefits and costs. Each of the alternatives show a benefit cost ration greater than unity. The highest benefit cost ratio is for the 20 Acre Basin and this is the NED alternative. Although this alternative may show the highest economic return for the Akutan harbor, there are environmental and physical space factors that favor the selection of the Reconfigured 12 Acre Basin as the preferred alternative.

TABLE A2-23 - Akutan Harbor Project Benefit and Cost Summary

	12 Acre Basin	15 Acre Basin	20 Acre Basin	Reconfigured 12 Acre Basin
Total NED construction costs	\$18,960,000	\$20,828,000	\$23,445,000	\$19,013,000
NED interest during construction	\$800,000	\$879,000	\$989,000	\$802,000
Total NED investment cost	\$19,760,000	\$21,707,000	\$24,434,000	\$19,815,000
Annual NED Cost - (50 years at 5-5/8%)	\$1,189,000	\$1,306,000	\$1,470,000	\$1,192,000
Annual Operations & Maintenance	\$50,000	\$60,000	\$75,000	\$50,000
Total Annual NED Costs	\$1,239,000	\$1,366,000	\$1,545,000	\$1,242,000
Annual Project benefits	\$1,949,000	\$2,527,000	\$3,187,000	\$2,267,000
Benefit/cost ratio	1.57	1.85	2.07	1.83
net annual benefits	\$710,000	\$1,161,000	\$1,642,000	\$1,025,000

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APPENDIX C
GEOTECHNICAL ANALYSIS
NAVIGATION IMPROVEMENTS
AKUTAN, ALASKA

Geotechnical Report
Akutan Small Boat Harbor
Akutan, Alaska

April 2002

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TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 SITE AND PROJECT DESCRIPTION 2
  2.1 North Creek 2
  2.2 Head of Akutan Bay 3
3.0 FIELD EXPLORATIONS 4
  3.1 1998 Explorations 4
    3.1.1 Geophysics 5
  3.2 2001 Explorations 5
4.0 LABORATORY TESTING 6
5.0 Regional Geology 7
6.0 Subsurface Conditions 9
  6.1 1998 Explorations 9
    6.1.1 North Creek Site Subsurface Conditions 9
    6.1.2 Head of Akutan Bay Subsurface Conditions 10
  6.2 2001 Explorations 11
7.0 RECOMMENDATIONS 12
  7.1 Seismic Considerations 12
  7.2 Breakwater Foundation 13
  7.3 Breakwater Settlements 14
  7.4 Dredge Slopes 15
  7.5 Dredge Slope Protection 15
  7.6 Liquefaction Considerations 16
  7.7 Dredging 17
  7.8 Staging Area 17
  7.9 Site Drainage 18
8.0 LIMITATIONS 18

LIST OF FIGURES

Figure 1 Vicinity Map
Figure 2 Site Plan
Figure 3 Grain Size Classification
Figure 4 Penetrations Resistance vs. Depth.
Figure 5 Grain Sizes Susceptible to Liquefaction
Figure 6 Breakwater Geometry

LIST OF APPENDICES

Appendix A 1989 Exploratory Data
Appendix B 2001 Exploratory Data
Appendix C Stability Analysis Results
Appendix D Important Information About Your Geotechnical/Environmental Report

GEOTECHNICAL REPORT
AKUTAN SMALL BOAT HARBOR
AKUTAN BAY, ALASKA

1.0 INTRODUCTION

This report presents the results of literature review, field explorations, laboratory testing and geotechnical engineering studies conducted for a proposed small boat harbor to be located in Akutan Bay on Akutan Island, Alaska. In June 1998, Shannon & Wilson, Inc. was contracted to review existing geotechnical information that had been compiled from studies around Akutan Bay. As part of this work, five locations were selected as possible harbor locations. Literature was gathered from the United Stated Geological Society (USGS), the State of Alaska Division of Geological and Geophysical Surveys (DGGS), the Corps of Engineers (COE), Tryck Nyman Hayes (TNH), and our own library. In this first effort, we found very little published geological information about Akutan Island.

In this 1998 study, five sites, listed below, were being considered for the new harbor facility:

- Site 1 North Creek
- Site 2 Akutan Point (at east end of Akutan Bay)
- Site 3 Akutan Village (Salthouse Cove)
- Site 4 Head of Akutan Bay (at west end of Akutan Bay), and
- Site 5 Old Whaling Station.

Based on the results of this initial literature search, two of the sites were selected for further study. These were the North Creek and the Head of Akutan Bay (HAB) sites.

In October 1998, Shannon & Wilson, Inc. contracted with Tryck Nyman Hayes to conduct offshore geotechnical explorations at the two sites in Akutan Bay. As part of this effort, Arctic Geosciences, Inc. was subcontracted to perform a geophysical investigation at each proposed harbor site. This work provided subbottom profile data to show relative soil layering and bedrock contact depths across each site to complement the geotechnical explorations. Appendix A contains project specific site plans and boring logs for this project phase.

Ten borings were drilled for this study, eight in the North Creek site, and two in the HAB site. Select samples from the borings were transported to a chemical analysis laboratory for environmental testing. Geotechnical studies based on these explorations indicated that pile supported structures would be feasible due to very dense soil conditions relatively close to the mudline in the North Creek site. Initial efforts toward designing the appropriate harbor structures for the North Creek site were thwarted because the bottom topography sloped steeply so near shore that sufficient harbor area could not be provided to accommodate the expected boat volume.

The last exploratory effort was conducted onshore at the HAB site at the west end of Akutan Bay. Ten borings for geotechnical information and 31 test pits for environmental information were advanced across the proposed harbor site. The geotechnical and environmental exploratory work was performed simultaneously from March 21 to March 27, 2001. The purpose of this exploration program was to determine the onshore surface and subsurface soil conditions, develop preliminary design recommendations for the proposed small boat harbor development, and give guidance concerning environmental conditions at the site. The environmental concerns were addressed in a separate report. For the geotechnical report, engineering recommendations were given concerning earthquake risks and liquefaction potential, foundation requirements for rubble mound jetties, pile capacities to support docking floats, viable slopes for the onshore dredged harbor, and construction of upland facilities and an access road. Appendix B contains boring logs from this 2001 effort.

2.0 SITE AND PROJECT DESCRIPTION

As stated previously, two of the five sites were considered for potential harbor sites. Initially, both sited were considered in terms of offshore harbor facilities. After the 1998 studies, the project was further refined to consider a dredged harbor facility in the inland area of the HAB site. Following are descriptions of the sites that were considered.

2.1 North Creek

The North Creek Site is located on the north shore of Akutan Bay at the base of a steep hillside that extends to the water line. Water depths at this site increase rapidly toward the bay. The proposed harbor was planned approximately 1,000 feet west of the Trident facility. The harbor plan consisted of a 2.3-acre constructed upland area to make up the eastern portion of the harbor facility with approximate 8.76-acres of mooring basin enclosed by a pile supported 1,200-foot long wave barrier and dock structure some 320 feet from shore.

Two creeks fall out of the mountains on either side of the harbor. Approximately 1,300 feet to the east of the proposed site a creek drains a mountain valley. This creek supplies the Trident facilities with fresh water via four underwater HDPE pipes that are situated along this site. The creek to the west was included in the planned development area. Sediment from this creek has created an alluvial fan that was to support the planned upland construction. The upland area fill was to be enclosed on the seaward side by a sheet pile bulkhead.

2.2 Head of Akutan Bay

The HAB site is located at the western terminus of Akutan Bay and consists of a gently sloping beach that is adjacent to low-lying wetlands from which two primary streams enter the bay. One of the streams is directly north of the project area and the other is south of the project area. The water depths in this portion of the bay are shallower due to sediment deposition. Limited offshore explorations at this site encountered loose sand soils that extended to depths that indicated that an offshore facility should be ruled out in this location.

The proposed onshore harbor location is in the currently undeveloped onshore area at the head of the Bay. The site specific topography consists of a gently sloping beach and a narrow, sharply elevated beach berm, with slightly sloping headlands reaching back to mountain slopes approximately 1,300 feet behind the beach berm. This berm and the gradual rise in elevation are reflected in the contours in the site plan of Fig. 2. The ground surface across the site is covered with tidal grasses. At the north end of the beach, a narrow valley extends in a northwesterly direction to Akutan Mountain. The larger of two significant streams that enter the bay from the upland area drains this narrow valley along the toe of the mountains and dumps into the bay at the north end of the beach. The smaller of these two streams carries melt and runoff water out of the mountains at the south end of the beach and directly west of the beach. During times when snow melt and heavy rains cause seasonal high water, several minor surface rivulets traverse the beach uplands from out of the mountain to the west.

The vegetative cover of the island is sparse of trees. Land cover consists of several varieties of short shrubs, brush and grasses. Grasses, sedges and mosses grow thick on the hillsides within Akutan Bay. The relatively flat lying ground at the head of the bay is covered with a thick matte of grasses and interspersed brush.

The offshore water depths in this western portion of the bay are shallower than the north and south portions due to sediment deposition of streams and wave action. The current harbor plan consists of a dredged harbor area located behind the beach in the upland area, level storage/parking areas, and a road to the City of Akutan. These proposed features are shown in yellow on Fig. 2. The storage areas and road will be built up using dredged material from the basin as fill. The mooring basin will be an estimated 12 acres. The marine (offshore) entrance to the harbor will be a channel constructed across the beach and enclosed by the rubble mound breakwaters shown in Fig. 2. At the time that our crew arrived at the site, the snow had melted and caused the near surface soils to be saturated. The rivulets mentioned earlier were running full. Within two days, the temperature dropped below freezing, a light snow covered the ground, and the level of the water in the rivulets had diminished considerably.

3.0 FIELD EXPLORATIONS

Exploratory trips were made to Akutan Bay in 1998 and 2001 to determine subsurface soil conditions and to provide information for design of the proposed harbor. During both trips our explorations included drilling work. For the 2001 work test pits were dug throughout the proposed dredge site for environmental purposes. The soil data from the test pits was included in our studies for geotechnical considerations. Sampling from the borings was typically conducted using Modified Penetration Test procedures. In the Modified Penetration Test, samples are recovered by driving a 3-inch outside diameter (O.D.) split spoon sampler into the bottom of the advancing hole with blows of a 340-lb hammer free-falling 30 inches onto the drill rod. The number of blows required to advance the sampler the final 12 inches of a total 18-inch penetration in the test is termed the Modified Penetration Resistance, which was recorded for each sample. These values are shown graphically on the boring logs adjacent to the sample depth. The values give a measure of the relative density (compactness) or consistency (stiffness) of cohesionless or cohesive soils, respectively.

3.1 1998 Explorations

A total of 10 off-shore borings, designated BH-A, BH-1 through BH-7, BH-10 and BH-11, were advanced at two sites within Akutan Bay between October 14 and October 24, 1998. Borings BH-A and BH-1 through BH-7 were advanced at the North Creek Site. Borings BH-10 and BH-11 were located at the HAB site. Borings were drilled to variable depths, depending on conditions encountered in the borings. The exact depths reached in each boring are recorded on the 1998 boring logs in Appendix A. Boring locations are shown on the site plans presented as Figures 2 and 3 of that Appendix.

Drilling services were provided by Tester Drilling Services of Anchorage, Alaska. The drill rig was a Nodwell-mounted Mobile B-61 drill rig parked with the drill apparatus over water on a barge operated by Fairweather Marine. A temporary deck was attached behind the barge in such a way that the driller, helper, and engineer could work behind the rig, over the water. The borings were advanced using 8-inch outside diameter, 3-1/4 inch inside diameter, continuous flight, hollow-stem auger.

The barge was stabilized by a four point anchor system and was guided to each drilling location by a tug boat which remained tied to the barge while drilling was accomplished, standing by as emergency transport. An experienced engineer from our firm was present continuously during drilling to locate the borings, observe drill action, collect samples and log subsurface conditions.

Borings ranged in depths of between 25 feet to 77 feet past the mud line in water depths of between 5 and 56 feet. Sample depths depicted on the boring logs are referenced to mud line. The elevation of the mud line in each boring is shown at the top of the boring log and is referenced to mean lower low water (MLLW) elevation. As the borings were advanced, samples were generally recovered at 5-foot depth intervals.

3.1.1 Geophysics

Arctic Geoscience, Inc (AGSI) conducted a geophysical investigation of each potential harbor site. The purpose of this program was to provide subbottom data in support of the geotechnical information collected during Shannon & Wilson's field program. AGSI provided 4,500 lineal feet of subbottom profile data at the North Creek Site and 1,000 lineal feet from the HAB site. In collecting this data AGSI mobilized a three-person team to Akutan. AGSI survey was completed using a Bubble Pulser, Chirp II subbottom profiler and CHIRP Technology Side Scan Sonar. A description of these instruments is included in the geophysical report in Appendix A. Upon completion of data reduction a draft copy of our boring logs was provided to AGSI as lithologic control. AGSI integrated our boring data with interpreted cross-sections of track lines at each location. The location of these track lines is presented in Figure 1 of AGSI's report in Appendix A.

3.2 2001 Explorations

A total of 10 borings, designated B-1-01 through B-3-01, B-5-01 through B-10-01, and B-12-01, were advanced at the site between March 21 to 27, 2001. Their locations are shown in Fig. 2. Borings were drilled to depths of between 25 and 51.5 feet. The exact depth of each boring can be found on the boring logs in Appendix B. At the same time that the borings were being drilled, a second Shannon & Wilson crew was digging 31 shallow test pits around the site for environmental sampling purposes. The test pits generally only advanced through the upper 4 to 6 feet of silty soil with intermixed organics due to the shallow ground water elevation. These data were considered mostly for their usefulness in determining the thickness of this unsuitable soil throughout the site.

Denali Drilling, of Anchorage, Alaska provided drilling services for this project, using a skid–mounted, Mobile B-61 drill rig. The borings were advanced with an 8-inch O.D. continuous flight hollow-stem auger. An experienced engineer from our firm was present continuously during drilling to locate the borings, observe drill action, collect samples and log subsurface conditions.

The locations of most of the borings and some of the test pits were determined using a differential GPS locating system. These boring and test pits are shown on the site plan of Figure 2. The lack of accurate locations by GPS for the rest of the test pits and borings was due to satellite inadequacy (ie: the GPS would not register repeatable results at some locations). The boring locations not determined by GPS were approximated relative to surface features at the site. Test pit locations that could not be determined either by the GPS system or approximated were marked in the field but are not shown. The GPS located borings are differentiated in the figure from those located relative to surface features by symbol color.

As the borings were advanced, samples were typically recovered at 5-foot depth intervals. All sampling was conducted using Modified Penetration Test procedures.

When the crew was preparing to leave Akutan, we found that approximately two thirds of the soil samples that had been collected were not where they had been stored in the Aleut Corporation warehouse. When we inquired about the samples with Corporation employees, we found out that someone had mistaken the bags for garbage, had removed and burned them. The samples that were returned to our Anchorage laboratory were recovered from the last three holes that were drilled, namely Borings B-10-01, B-1-01 and B-2-01.

4.0 LABORATORY TESTING

Soil samples were tested to develop index and physical parameters for use in evaluating subsurface conditions, determining material quality for reuse as backfill, conducting stability analyses, and preparing foundation recommendations for the proposed project. The laboratory testing program included visual identification, moisture content determination and grain size analyses of select samples. All tests were performed in the Shannon & Wilson, Inc. Anchorage laboratory and in general accordance with the American Society of Testing and Materials (ASTM) standard test procedures. Laboratory testing results are not included in this summary report, but were incorporated into the boring logs in Appendix B.

Grainsize classification tests consisted of mechanical sieve analyses and selectively, hydrometer analyses. These tests are used to confirm the field classification, evaluate permeability, drainage, and frost characteristics, to establish liquefaction potential, and finally, suitability for reuse as backfill for constructing roads and upland staging areas.

Grainsize classification tests for the 1998 project consisted of 24 mechanical sieve analyses and hydrometer analyses. These tests were conducted according to procedures described in ASTM D-422. Hydrometer analyses were performed on 10 samples that were observed to contain more than 10 percent fine material (passing #200 sieve). The remaining fourteen samples underwent mechanical sieve analysis only due to their obviously low fine content.

Grainsize classification tests for the 2001 project consisted of 4 mechanical sieve analyses. One of the grainsize analyses was performed on a combination of several samples. This combined sample was put together to make a Modified Proctor Analysis (ASTM D-1557) sample, from which one compaction test point was performed. This test was used as a simple method to estimate how much the soil grains will break down when the material is compacted into place as backfill. The compaction results from the combined sample indicated little breakdown of the soil particles. The specific gravity of this material was found to be about 2.7.

Twenty-one moisture content tests were performed on samples recovered from the 2001 borings. These tests were conducted in accordance with procedures described in ASTM D-2216-92. Results of moisture content tests are presented in the boring logs of Appendix B.

Two Atterberg tests were performed on samples from the 2001 program, from Boring B-1-01, Sample S-10 and from Boring B-10-01, Sample S-7. These tests were generally conducted according to procedures described in ASTM D-4318 to refine the visual classification of the cohesive soils and provide quantitative information about the engineering parameters of this soil. Test results indicate that the soil represented by both samples are non-plastic. The results of these tests are summarized on the boring logs in Appendix B.

5.0 REGIONAL GEOLOGY

Akutan Island is located at latitude 54°05' N, longitude 165°55' W, which is about 27 miles northeast of Unalaska Island. The island is about 17 miles long, 13 miles wide and is oriented roughly east to west along the longer axis. Akutan Volcano dominates the island. Most of the island is rugged and steeply sloping with shorelines consisting of steep cliffs and rocky headlands. Evidence of past glaciation is seen on the portions of the island not covered by recent volcanic flows. Glaciation has changed landforms in the area to produce serrated ridges, cirques (steep sided bowl shape depressions), hanging valleys, and broad U shaped valleys. The lower elevations have developed a soil profile overlying volcanic ash deposits. The vegetation generally consists of tundra and low-lying brush, except in the lowlands of the head of the bay, which is covered with tidal marsh type grasses. Akutan Harbor is a fjord or a U-shaped valley formed by glaciers that subsequent to the disappearance of the glaciers was filled in with seawater.

Mt. Akutan is a volcano that is at approximately 4,275 ft. elevation at its summit and is located about 6 miles west of Akutan Bay. It is one of the most active volcanoes in the Aleutian Arc, having erupted at least ten times since 1848. The most recent ash eruption occurred in 1979 and the most recent lava flow in 1929. Recently, the volcano has been seismically active.

The rock type is intermediate in composition (basalt/andesite) and the flanks of the volcano consist of alternating layers of pyroclastic debris and solidified lava flows. The volcano, like much of the Aleutian Islands, was formed by the convergence of the North American and Pacific lithospheric plates. This convergence produced a seismically active belt where the Pacific Plate is being subducted under the North American Plate. The eruption of the magmas and the seismic activity throughout the Aleutians, including Akutan Island, are intimately related to this process. The potential for seismically induced ground failures such as submarine landsliding, surface cracking, and liquefaction is moderate to high.

The typical surficial geology of the island is volcanic rock overlain with a relatively thin soil layer, generally consisting of volcanic ash, with rock outcrops and limited accumulations of organic silts. At this site, this soil unit was mostly sand of volcanic origin and at least 50 feet thick. The rock generally has an irregular surface in contact with the overlying sediments due to varying degrees of erosion and irregularity of deposition. Rocks on the island consist of andesite, basalts, welded and nonwelded tuffs. Rocks created by volcanoes generally range from granite to andesite to basalts. The granites typically have a higher percentage of quartz and are generally very durable for construction processes. The andesite is typically gray, brown, or reddish color and consists of a variety of minerals similar to granite. It is less durable than granite, due to limited amount of quartz within the rock. Basalt is usually black or dark brown and is enriched in iron and magnesium. Of the three types of rocks (granite, andesite and basalt) basalt is the least durable. The basalt flows generally have a moderate dip of about 20 to 30 degrees and are typically 20 to 40 feet thick. The welded and nonwelded tuffs are rocks created from the debris produced during a volcanic eruption. Welded tuffs are formed during the heat of the explosion actually welding the rock and ash particles together. Welded tuffs generally are durable and strong. Nonwelded tuffs are formed from compaction and solidification of the rock and ash particles after the eruption. Nonwelded tuffs generally weather easily, similar to sandstone or other sedimentary rocks.

6.0 SUBSURFACE CONDITIONS

6.1 1998 Explorations

6.1.1 North Creek Site Subsurface Conditions

The subsurface soils encountered at the North Creek Site were consistent with anticipated conditions in that loose to medium dense sands were encountered down to variable depths followed by denser material. In general the borings advanced in common tidal zones encountered similar soil conditions. The borings placed near shore (Borings BH-1, BH-A, BH-3 and BH-4), those advanced further out from shore (Borings BH-2 and BH-5) and those placed in front of the creek outlet along the eastern edge of the site encountered similar conditions.

Borings BH-1, BH-A, BH-3 and BH-4 were drilled near shore in water depths between 5 and 18 feet. These borings all encountered loose to medium dense sands underlain by very dense or hard layers. Borings BH-A and BH-3 were placed very near the shoreline in 6 and 5 feet of water, respectfully. In each of these borings very dense layers were encountered at or very near the surface, attempted sampling of these units resulted in refusal in most cases. These very dense layers consisted of gravel containing cobbles and boulders. Similar soils were discovered at greater depths in Borings BH-1 and BH-4. In these borings loose to medium dense sands and gravels extended down to approximately 20 feet below mud line (bml), sampling attempts past this point resulted in minimal sampler penetration. All of these near shore borings were finished in very dense materials that varied in lithology and description but yielded consistent blow counts.

Borings BH-2 and BH-5 were advanced further from the shore, in approximately 50 feet of water. Loose to medium dense sand was encountered down to about 15 feet bml in these borings where medium dense gravel was found. The last sampling attempt in Boring BH-2, at about 34 feet bml, was refused in gravelly boulders. Boring BH-5 hit a hard, silt layer at about 24 feet bml. In this case the silt unit extended to approximately 31 feet bml where solid rock was discovered. The core sample recovered from this unit was a brecciated conglomerate that exhibited little to no weathering and had a rock quality index of 72. Due to the limited length of the coring run (approximately 1.2 feet) this rock could not be confirmed as bedrock. Boring BH-5 was the only boring that encountered such solid competent rock material.

Borings BH-6 and BH-7 were located in the eastern portion of the development where the proposed constructed upland will be located as shown in the site plans of Appendix A. These borings encountered loose sediments down to approximately 40 feet bml. In Boring BH-6, medium dense gravel and sand was discovered at approximately 42 feet bml, these units increased in density with depth to the bottom of the boring. Boring BH-7 was advanced to 77 feet past mud line and like Boring B-6 found medium dense sands and gravels at approximately 40 feet bml. At about 70 feet bml the sands and gravels became denser and contained cobbles that resulted in refusal of the last two sample attempts.

AGSI's geophysical survey findings were fit with our boring data with geophysical boundaries correlating fairly well with the geotechnical information. The interpreted cross-sections provided by AGSI, with our boring data superimposed on them, are presented as Figures 13 through 15 of their report in Appendix A. Figure 14 illustrates the correlation between the thickness of the initial loose sediments encountered in Borings BH-2, BH-5, BH-6 and BH-7 and interpreted soil sections. Small discrepancies exist in the underlying denser material. The likely cause for these differences is the material retrieved from the split spoon sampler during our geotechnical investigation. Due to the regularity of cobbles and boulders in this soil, we often retrieved rock fragments in our sampler. The draft bore logs provided to AGSI had these sections classified as weathered rock units or possibly bedrock. It is more likely these rock encountered during exploration were cobbles and boulders suspended in the gravelly soil section. Overall the correlation of geotechnical field data and the resultant cross-section provided by AGSI was good.

6.1.2 Head of Akutan Bay Subsurface Conditions

The subsurface soil conditions at the HAB site were consistent between Borings BH-10 and BH-11. Water depths were 11 and 10 feet, respectfully for these borings. As expected, the soils we encountered during drilling were consistent with those of a depositional environment. Both borings discovered loose sands down to approximately 30 feet blm. The sand encountered throughout Boring BH-11 yielded consistent blow counts ranging between 4 and 10 blows per foot. The sand unit in Boring BH-10 was very loose from about 16 to 35 feet bml. A silty sand unit was encountered at the bottom of Boring BH-11. Boring BH-10 encountered similar silty sand at approximately 30 feet bml. This unit contained seashell fragments, gravel and was underlain by silty, sandy gravel with cobbles at approximately 40 feet. Blow counts within in these two units were slightly higher than in the overlying clean to slightly silty sand, as shown in the boring logs, Appendix A.

The geophysical survey conducted at the head of the bay by AGSI used the soil boring data to verify their results in comparison with the conditions encountered in our borings. The geophysical data, as interpreted by AGSI, exhibits soil conditions consistent with those found in our borings. Interpreting the sandy gravel encountered in bottom of Boring BH-10 in relation to the AGSI data, the loose sediment layer appears to thin out as one progresses shoreward. At depths below where our borings advanced, an interpreted layer from the AGSI data appears to contain boulders, and exists below a relatively thin layer of interpreted sandy gravel. If this strata sequence is consistent moving shoreward, it is possible the sandy gravel encountered in Boring BH-10 could be relatively thin and underlain by a denser unit with gravel and boulders.

6.2 2001 Explorations

The borings for this effort encountered similar soil conditions across the proposed (onshore) harbor site. We found 4 to 6 feet of silty sand or sandy silt with grassy organics over medium dense, clean to slightly silty sand. Based on Fig. 3, the grain size curves depict the sand as a well graded material with small amounts of gravel and silt fines. These same conditions of a thin silt/sand cap over native sand were verified throughout the site by the 31 environmental test pits, which were basically dug to depths that were at or just below the water table. Soil descriptions from the test pits are presented in Shannon & Wilson's companion environmental report titled "Environmental Site Investigation, Proposed Harbor Location, Akutan, Alaska".

The subsurface conditions at the site were better than anticipated in that the sands that were encountered were not consistently loose, as feared, but were in fact generally medium dense. The density is generally reflected in the uncorrected blow count summary in Fig. 4. This plot shows N values between 5 and 30 blows per foot (b/ft) with the average being 13 b/ft. In the program we planned to use the Standard Penetration Test method (SPT) to measure soil density but were forced to use modified procedures because the equipment could not be flown to Akutan with the time constraints. The inability to use the SPT means the N-values taken by the modified method needs to be corrected to more closely reflect equivalent SPT values and density conditions. Based on our experience at numerous other sites, SPT values normally exceed Modified Penetration Resistance values by 100 percent or more. This would increase the density from 13 blows per foot to an equivalent SPT 26 blows per foot. Recognizing that some conservatism is appropriate when using empirical correlations, we have based our follow-on recommendations on the assumption that the design N value (which is used to indicate the density of the sand) is 50 percent rather than 100 percent greater than our Modified Penetration results. This results in average N values of 19 to 20 blows per foot.

Borings B-1-01 and B-2-01 were drilled near shore within the beach environment so that the upper silty sand layer was not present. Beyond this difference, all of the borings encountered similar conditions and medium dense sands. Note that heaving sands were a hindrance in every boring, from about 10 feet below the ground surface (bgs) in virtually every boring. We did not encounter bedrock in our borings.

As noted in the boring logs, water was encountered at about 3 feet bgs in every boring except Borings B-1-01 and B-2-01, in which the ground water level was at 8 feet bgs. The ground water elevation in the vicinity of these two borings is more than likely dependent on the tidal influence of Akutan Bay. The water in soil samples taken from borings in the upland area seemed to be somewhat saline. No measurements were taken to verify this observation, or to measure salinity.

7.0 RECOMMENDATIONS

7.1 Seismic Considerations

Seismic mapping by the Alaska Department of Transportation & Public Facilities (ADOT) recorded one large (Richter Magnitude 7.1 to 8) earthquake with an epicenter within 25 miles radius of the City of Akutan and two earthquakes of Magnitude 6.1 to 7. The ADOT estimated that a peak acceleration force of 0.35g will have a 90% probability of not being exceeded in 50 years and could be used as a design earthquake force for this site. Tsunamis (earthquake generated waves) are also a potential for any of the sites within the bay.

For this design study, the geometry of slopes that were studied included 1 vertical to 2 horizontal (1V:2H) and 1V:3H, including both basin slopes and above ground slopes of berms to be used around parking/storage area the geometry of slopes that were studied included 1 vertical to 2 horizontal (1V:2H) and 1V:3H, including both basin slopes and above ground slopes of berms to be used around parking/storage areas.

We analyzed the stability of slopes using a seismic coefficient of 0.15g, which is between 1/3 and 1/2 of the maximum acceleration force estimated by the ADOT. This reduction is determined by factoring based on landform, slope height and length, and amplifications that are typical in slopes. Structures generally experience accelerations that are less than maximum values for much of the event. The following authors recommend this reduction in the peak acceleration: Marcuson, W.F. III "Moderator's report for the session on 'Earth dams and stability of slopes under dynamic loading'," Proceedings, International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, St. Louis, Missouri (1981); and Hynes-Griffin, M.E. and Franklin, A.G. "Rationalizing the seismic coefficient method," Misc. Paper GL 84-13, US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi (1984).

As a point of comparison, 0.15g corresponds to the magnitude of shaking that occurred in the 1964 Good Friday earthquake. The acceleration of the ground during an event can only be estimated based on observed damage, displacement of buildings or other structures or from an evaluation of compiled data from other earthquakes. Estimates of the Good Friday ground acceleration were made by diverse individuals such as William Cloud, past chief of the Seismological Field Survey, USGS (0.18g), Woodward Clyde Consultants (0.15 to 0.2g) and others whose estimates ranged from 0.14 to 0.17g. In a 1964 study of the Turnagain Landslide in Anchorage, Alaska, performed for the US Army Corps of Engineers, and several subsequent studies for development in the Turnagain area, Shannon & Wilson, Inc., used the value of 0.15g as the reasonable estimate for the Good Friday earthquake.

7.2 Breakwater Foundation

The bearing soils in the planned breakwater zone appeared to be typical of the site everywhere, and are medium dense, clean to slightly silty sand. The maximum breakwater height will be around 33 feet, at the leading edge (offshore) of the structure. The portion of the breakwater fill that will be founded near the existing ground surface at the onshore end of the structure will not reach a maximum height of more than about 15 feet, with a maximum bearing pressure of about 1 tsf. The maximum bearing pressure that the breakwater embankment is expected to exert on the soil is about 2 tons per square foot (tsf). The allowable bearing pressure that can be exerted on the soil will vary from about 1.5 tsf near the surface to 3 tsf depending on the amount of burial of the breakwater foundation. In our opinion, therefore, the medium dense sand at the site will provide sufficient bearing capacity for the breakwater. We understand that the breakwater will be constructed of rock riprap.

Slope stability studies for the breakwater embankment indicate that the medium dense native sands are not sufficiently compact to resist slope failure below the embankment under design seismic conditions. If the breakwater is constructed without treating the foundation soil, the amount of damage that will occur during a design earthquake event is variable, depending on the amount of compacted material that is used. In order to achieve a factor of safety of greater than 1.0, we recommend that the native sands in the offshore portions of the breakwater foundation area be over-excavated to 20 feet below the lowest adjacent ground surface elevation to the breakwater and replaced with compacted granular material to act as a buttress. The buttress material should be extended to a point where the proposed breakwater base reaches elevation 0.0 feet (MLLW), at which point the buttress excavation can transition to the surface at a 3:1 (3 horizontal to 1 vertical) slope.

Figure 6 gives the general geometry of the breakwater, and shows the estimated mass of soil requiring reconstruction. Using the failure envelopes from our analyses relative to the geometry of 12 versions of the proposed breakwater, the following table presents reconstruction requirements geometric configuration. The table presents the expected percentage of breakwater material needing reconstruction. This value is tabulated in relation to the length of bottom of embankment (a), and Factor of Safety (FS). The Figures in Appendix C relate to the tabulated results from A1 to A12 and from the left down and to the right. The reconstruction requirements that are indicated are extreme amounts expected for a large magnitude (design) earthquake. During the normal life of the project the likelihood of an earthquake of design magnitude is relatively small. Percentage of reconstruction under most seismic events expected at the site will be smaller than shown in this table.

Percentage of Reconstruction by Configuration											
Breakwater with Buttress						Breakwater w/out Buttress					
Slope						Slope					
2H:1V			3H:1V			2H:1V			3H:1V		
a (ft)	FS	Amt.	a (ft)	FS	Amt.	a (ft)	FS	Amt.	a (ft)	FS	Amt.
30	.95	25%	30	1.11	0%	30	.79	30%	30	.80	40%
50	1.0	12%	50	1.14	0%	50	.80	30%	50	.80	33%
70	1.0	10%	70	1.22	0%	70	.81	20%	70	.80	28%

The stability analysis results presented in the table are presented graphically in the figures in Appendix A.

7.3 Breakwater Settlements

The magnitude of settlements that can be expected within the breakwater fill is dependent on the applied loads, the density of the foundation soil, and the care with which the breakwater materials are placed and compacted. For loads not exceeding the expected loads above, we estimate that the total maximum settlements will be on the order of 4 inches. Most of this settlement should occur as the fill is being placed. Differential settlements will be gradual due to the anticipated load distribution, and should be highest near the center of the fill, where the load is greatest. Total and differential settlements within the embankment may be substantially higher if the fill is poorly placed. Because of the nature of the deposition of the sand (by volcanism) the consistency is comparable throughout the site and with depth. The settlements that would occur if no treatment of the foundation soils were conducted would depend on the net amount of material that is added to construct the breakwater. If this amount is considerable, the estimated amount of settlement could be as much as 6 inches overall.

7.4 Dredge Slopes

Interior harbor slopes will be formed by dredging the cap of silty sands and deeper clean sand to the basin elevation of –17.0 feet (MLLW) or roughly 25 feet bgs. Stability analyses were performed in order to determine the appropriate slope geometry, with particular emphasis on providing seismically stable slopes. The analyses were performed using the two-dimensional, limit equilibrium program, PCSTABL5M. This is a two-dimensional, limit equilibrium slope stability program that is used to model a slope and determine the factor of safety against sliding by the simplified Janbu, simplified Bishop, and Spencer method of slices, depending upon the routine selected. The program features random techniques for generating potential failure surfaces and identifies the ten most critical failure surfaces and their respective factors of safety. Techniques include generating circular, sliding block, or irregular failure surfaces. The program allows for heterogeneous soils systems, anisotropic soil strength properties, excess pore water pressure due to shear, static ground water and surface water, pseudo-static earthquake loading, and surcharge boundary loading.

In general our studies indicate that slopes that extend below water level need to be constructed on 1V:3H in order to have a factor of safety against failure in seismic conditions of at least 1.1. Slopes above the water table can be constructed on 1V:2H and based on our calculations, will have at least a 1.1 factor of safety. Under static loading, the factors of safety are much higher, on the order of 1.5 to 2.

7.5 Dredge Slope Protection

Slopes that will be subject to tidal and wave action need to be protected from raveling and material loss from negative pore pressures caused by rapid draw down. The most effective protection against wave action is rock riprap. The effects of rapid draw down (tidal influences) are managed by having a filter material between the native soil and rock rip rap. Riprap design requirements are variable depending on the design wave height, which is not known at this time. In general, filter material needs to be well graded such that the D_{85} (85 percent of the particles are smaller than this size) particle size is at least 1 inch. The native soil we encountered in our borings do not meet this standard (the particle sizes are considerably smaller by percentage). Since the native soils are generally porous, but are smaller gravel to sand sizes, we recommend that some method be used below the filter soil to decrease the porosity of the near surface soil below the riprap. This can be accomplished by constructing a minimum 1 foot thick layer of low permeability silt or clay layer beneath the filter material, or else by installing a low permeability geofabric in this zone.

7.6 Liquefaction Considerations

It is generally considered that sand soils that are prone to liquefaction are uniform (poorly graded) fine to medium sands with a mean grain size (D_{50}) that is around 0.25 millimeters (mm). This is illustrated in Fig. 5 which shows the gradations characteristics of soil from published case histories and laboratory tests that were prone to failure under strong earthquake shaking. The grain size analyses for this project, also shown in Fig. 5, indicate that although the soil is predominantly sand, it is slightly gravelly to gravelly, well graded (non-uniform) and the mean grain size is much greater than 0.25 mm (about 1 mm). This indicates that the sand soil at the Akutan Harbor site is at worst only moderately prone to liquefaction. Sustained ground movements will be necessary in order for these soils to liquefy. These coarser soils and gravelly sands are considered less likely to liquefy, because they possess a higher coefficient of permeability. More pervious soils tend to discourage the rapid build up of pressure and liquefaction because these pressures bleed off almost as fast as they build up during the earthquake.

The medium dense consistency of the clean sands also tend to make the soil be more resistance to a rapid build up of pore pressures and liquefaction than would occur in a looser deposit. Based on our analyses, if the sand lost strength locally as a result of liquefaction, the factor of safety of the submerged slopes would be less than 1.0, meaning the slope would fail. The potential area of strength loss, and failure, should be at the toe of the submerged slope, where confining pressures are minimal. The failure in this area would likely occur as bulging of the toe soils in a generally shallow slumping failure envelope. This undermining of the below water portion of the slopes would cause the soil and rock riprap in the upper region of the slope to slump and fall. In our opinion the riprap planned for the slope surface should be carried down to the toe of the slope to increase the confining pressure, discourage slumping and help minimize slope movement.

If, in the future, additional structures will be considered as improvements on the land around the harbor, it will be important to provide engineered foundations for these structures.

7.7 Dredging

The slightly gravelly to gravelly, well-graded sand encountered below the unusable, silty sand with organics in our borings is medium dense. This material will be relatively easy to excavate, however, it is mostly clean sand and when mixed with water may run as it is brought to the surface if clam buckets or drag lines are used for dredging. Probably the most efficient method to remove this material is to use a suction dredge, if the gravel is not too coarse, or a closed clam bucket. In either case, the dredge material will appear soupy because of excess water and will remain so until this water has a chance to drain out of the sand. If the dredge spoils are to be brought on land and reused, it may have to be contained for a short time or spread out to facilitate down slope drainage and solidification. Because the high water table will make slope development difficult in the inner harbor area, dredging should occur in the driest part of the year if possible. If used as structural backfill, this sand material would likely be free draining, and once excess water is drained from the soil matrix it should compact well.

The upper 4 to 6 feet of surface soil is silty sand with organics throughout. This surface material should be stockpiled so that a large face is produced, much like snow disposal berms are constructed. The large face will provide surface area for moisture to seep and evaporate out of the material. Once dried out, this material can be used at the base of proposed fill areas. As long as the filled surfaces will not be paved, the thickness of structural fill over this silty soil can be limited to a minimum of about 24 inches. If paving is planned, the structural cover should be at least 36 inches.

7.8 Staging Area

Along with the dredged harbor, there will be elevated uplands fills to be used as staging areas for fishing equipment and storage. These fills will be constructed with dredge material from the harbor excavation. As stated in the previous section, the material that will be dredged from the harbor area should be suitable for construction of the fills. The dredge spoils, including the upper 4 to 6 feet of native soil that has tideland grasses and small brush, should be stockpiled in such a way that the excess moisture can be drained out of the soil before the pads are constructed. We recommend that the upper silty soil with organics be used only in the very bottom portions if the fill.

The clean sand dredge spoils may be used above the siltier material as structural fill placed to level the site. All fill material should be placed in lifts not to exceed 10 to 12-inches loose thickness, and compacted to a density of at least 95 percent of the maximum density as determined by the Modified Proctor compaction procedure (ASTM D-1557).

7.9 Site Drainage

Drainage control will be most critical due to the large amount of dredged material that will be produced. The area used to store this excess dredge material will be substantial, so that normal runoff routes from the mountains will be cut off. Ditches and regularly spaced culverts will provide the most efficient way to direct runoff under and around the fill areas. If the ground water in the upland area truly exhibits salinity, the excess dredge fill material will be draining this water into the bottom of the fill. Culverts used to direct runoff water from the mountains into streams should be solid wall pipe so that saline water draining from the fill soils cannot mix with the fresh, surface runoff water. Perforated culverts should be used to help drain the fill soils, but should be directed into flat areas where the water can infiltrate into the native soil, or into the harbor.

8.0 LIMITATIONS

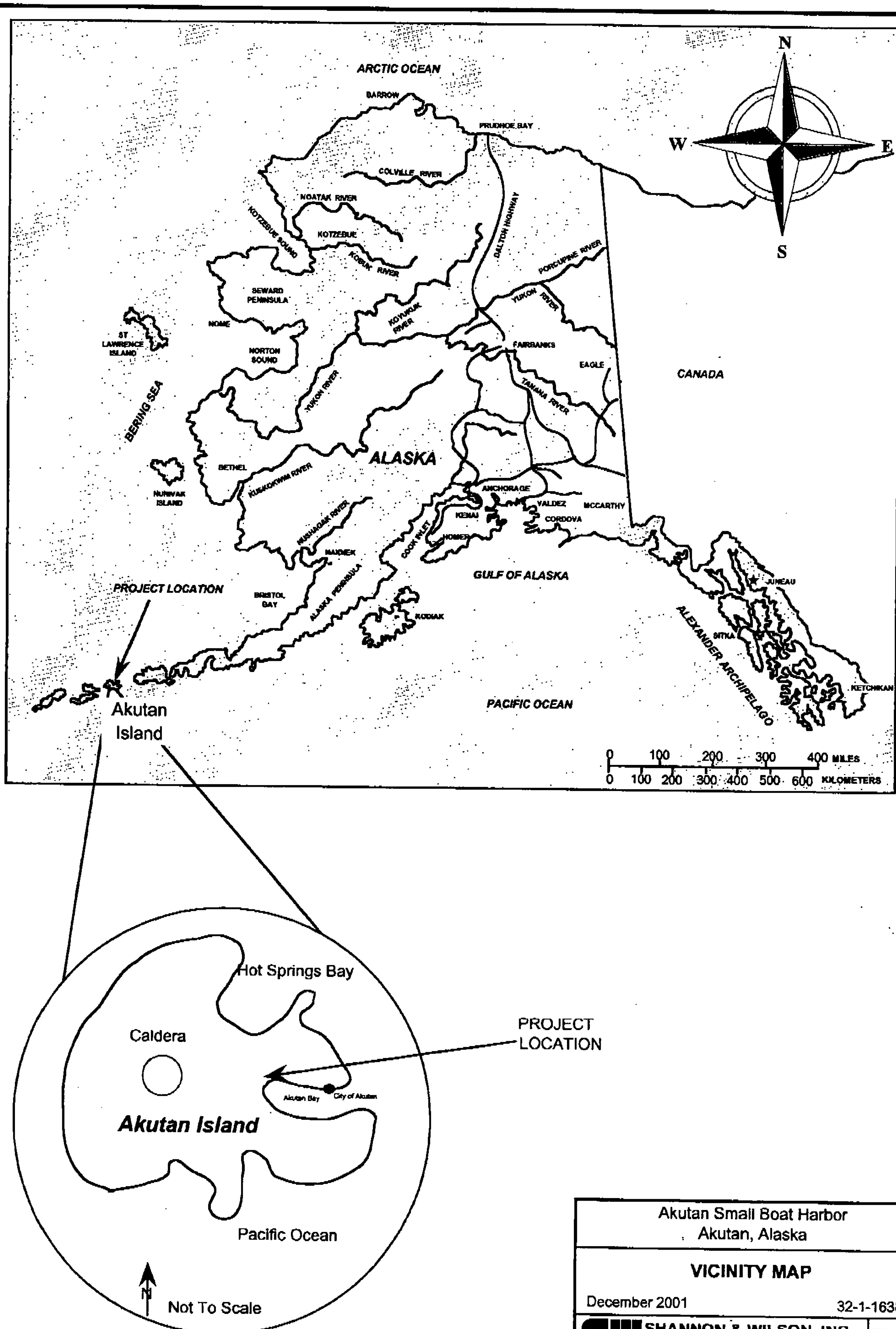
The analyses, conclusions, and recommendations contained in this report are based on site conditions as they presently exist and further assume that the exploratory borings are representative of the subsurface conditions throughout the site, i.e., the subsurface conditions everywhere are not significantly different from those disclosed by the explorations. A copy of "Important Information about your Geotechnical/Environmental Report" is attached in Appendix D for a clarification of the expectations that can be realized from this document.

If, during construction, subsurface conditions different from those encountered in these and prior explorations are observed or appear to be present, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submittal of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, it is recommended that this report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

Unanticipated soil conditions are commonly encountered and cannot fully be determined by merely taking soil samples or making test borings, particularly when attempting to develop in or near a slide mass. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

SHANNON & WILSON, INC.

Prepared By:	Reviewed By:
Grover L. Johnson, P.E. Principal Engineer	William S. Burgess, P.E. Associate



Akutan Small Boat Harbor Akutan, Alaska
VICINITY MAP
December 2001 32-1-16384
SHANNON & WILSON, INC. Geotechnical & Environmental Consultants — **Fig. 1**

Adapted from drawing by Tryck Nyman Hayes, Inc., 2001

LEGEND

- B-1E-01 — GPS located Boring by Shannon & Wilson, Inc., March 2001
- B-1-01 — Boring by Shannon & Wilson, Inc., March 2001
- TP-1 — GPS located Test Pit by Shannon & Wilson, Inc., March 2001
- TP-1 — Test Pit by Shannon & Wilson, Inc., March 2001
- 8100N6000E — GPS located COE Monument by Shannon & Wilson, Inc., March 2001

0 150 300 600
APPROXIMATE SCALE IN FEET

N

Akutan Small Boat Harbor
Akutan Bay, Alaska

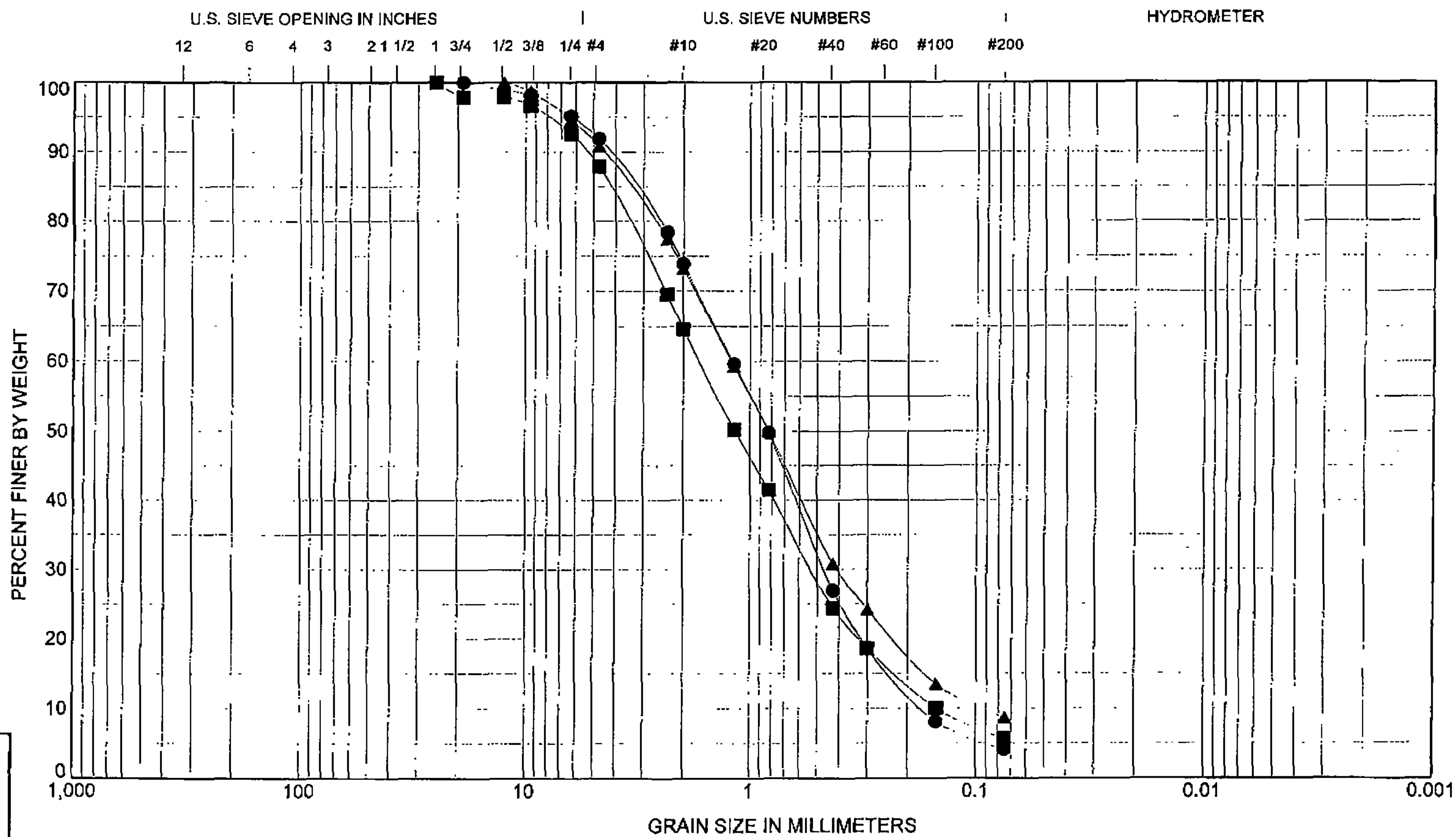
SITE PLAN

December 2001 32-1-16384

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

FIG. 2

6384site.dwg 1:1 Shannon & Wilson, Inc



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample		Depth, Ft	Classification	LL	PL	PI	Cc	Cu
●	B-1-01	15.0 - 16.5	**Slightly gravelly SAND (SW)**				1.1	7.0
■	B-1-01	25.0 - 26.5	**Slightly silty, slightly gravelly SAND (SW-SM)**				1.1	11.3
▲	B-10-01	10.0 - 11.5	**Slightly silty, slightly gravelly SAND (SW-SM)**				1.5	13.4

Sample		Depth, Ft	D100	D60	D30	D10	%Cobble	%Gravel	%Sand	%Silt	%Clay
●	B-1-01	15.0 - 16.5	19	1.2	0.46	0.17	0	8	88	4	
■	B-1-01	25.0 - 26.5	25	1.69	0.53	0.15	0	12	82	6	
▲	B-10-01	10.0 - 11.5	12.5	1.21	0.41	0.09	0	9	82	9	

Akutan Small Boat Harbor
Akutan, Alaska

GRAIN SIZE CLASSIFICATION

December 2001 | 32-1-16384

SHANNON & WILSON, INC.
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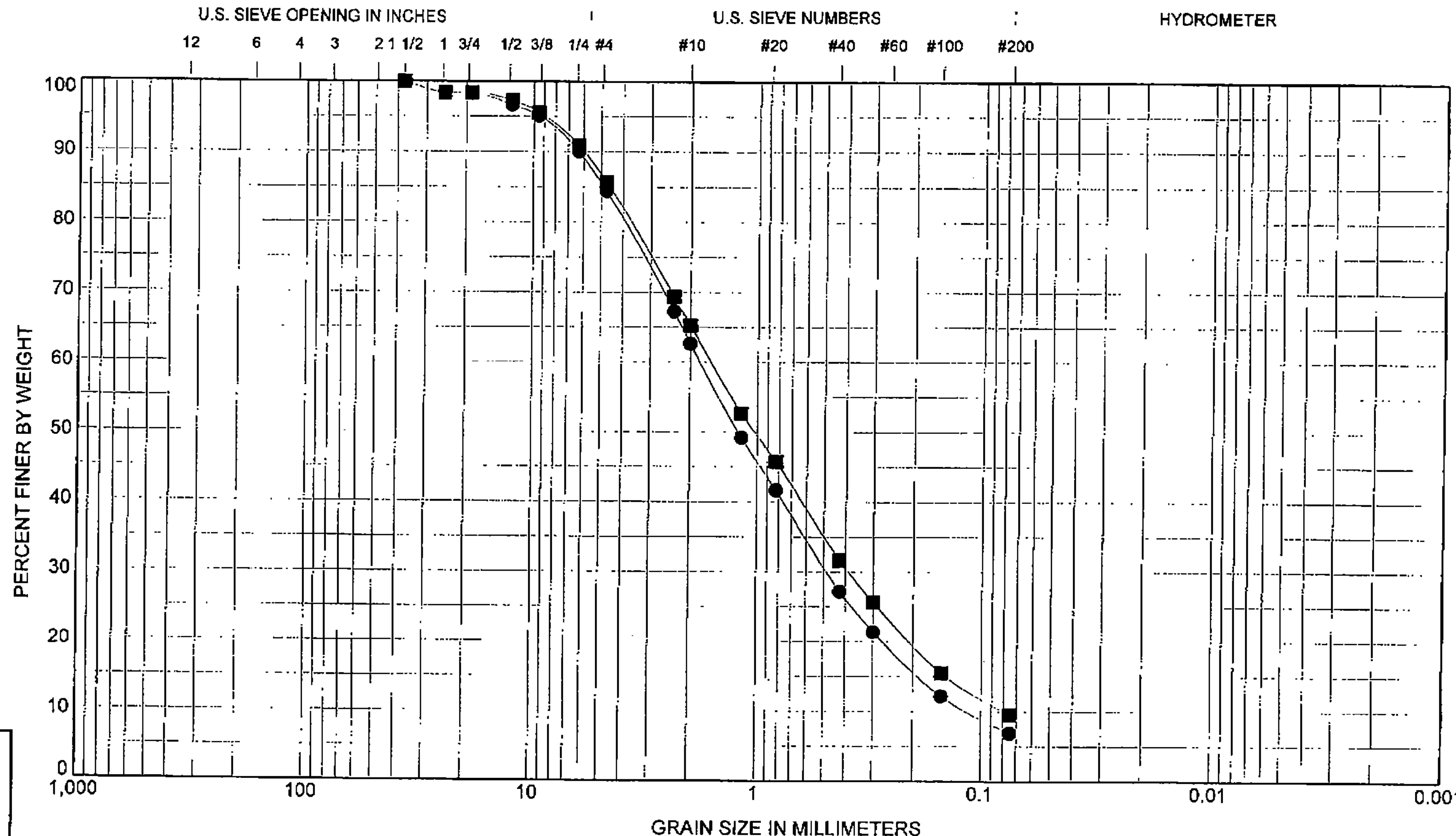
Fig. 3
Sheet 1 of 2



COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

Sample	Depth, Ft.	Classification	LL	PL	PI	Cc	Cu
● B-9-01	5.0					1.1	16.0
■ B-9-01	5.5					1.2	20.3

Sample	Depth, Ft	D100	D60	D30	D10	%Cobble	%Gravel	%Sand	%Silt	%Clay
● B-9-01	5.0	37.5	1.8	0.48	0.11	0	16	78	7	
■ B-9-01	5.5	37.5	1.61	0.39	0.08	0	14	76	10	

Akutan Small Boat Harbor
Akutan, Alaska

GRAIN SIZE CLASSIFICATION

December 2001 32-1-16384

SHANNON & WILSON, INC.
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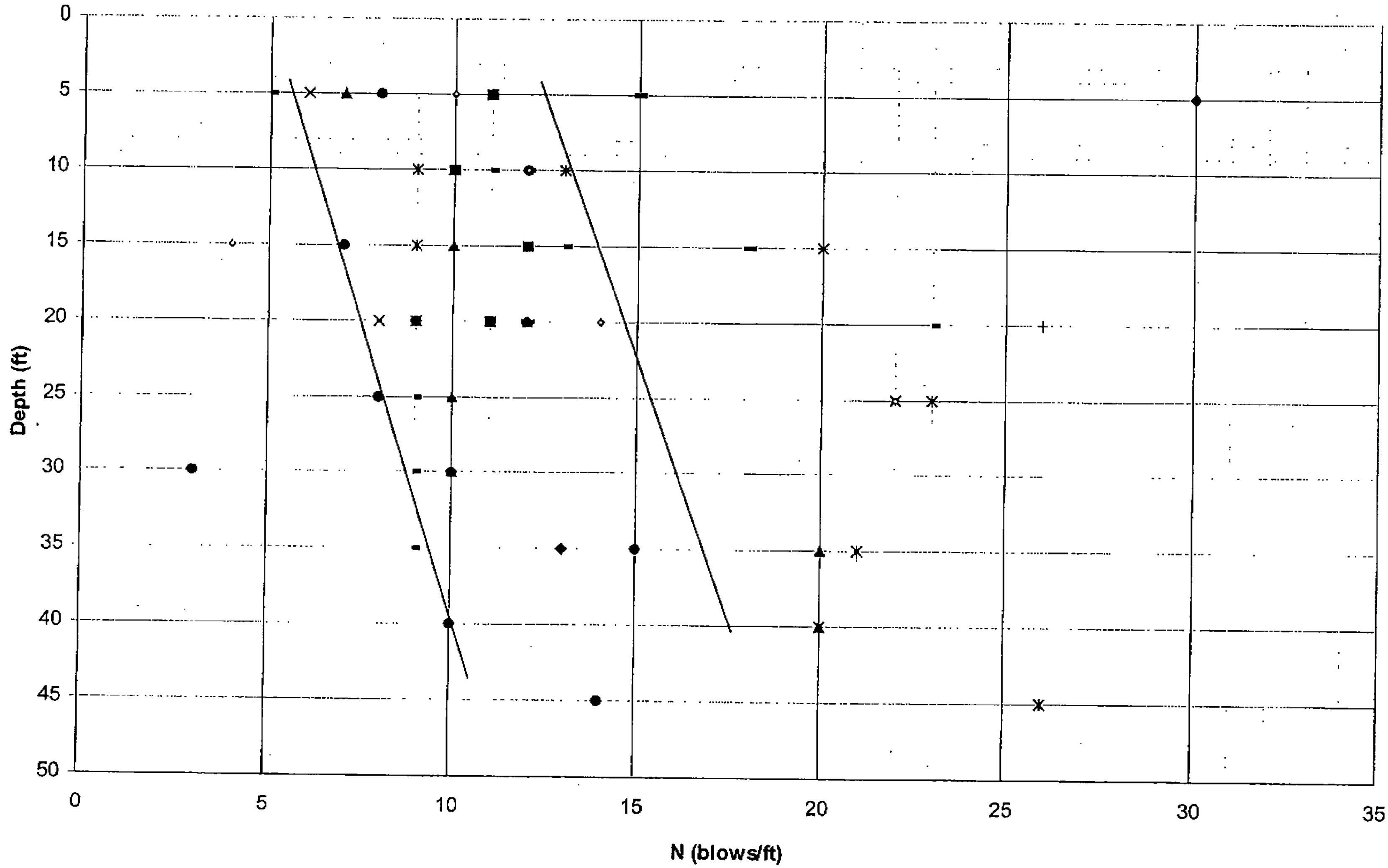
Fig. 3
Sheet 2 of 2



Legend

● Blow Count for Samples from Boring B-1

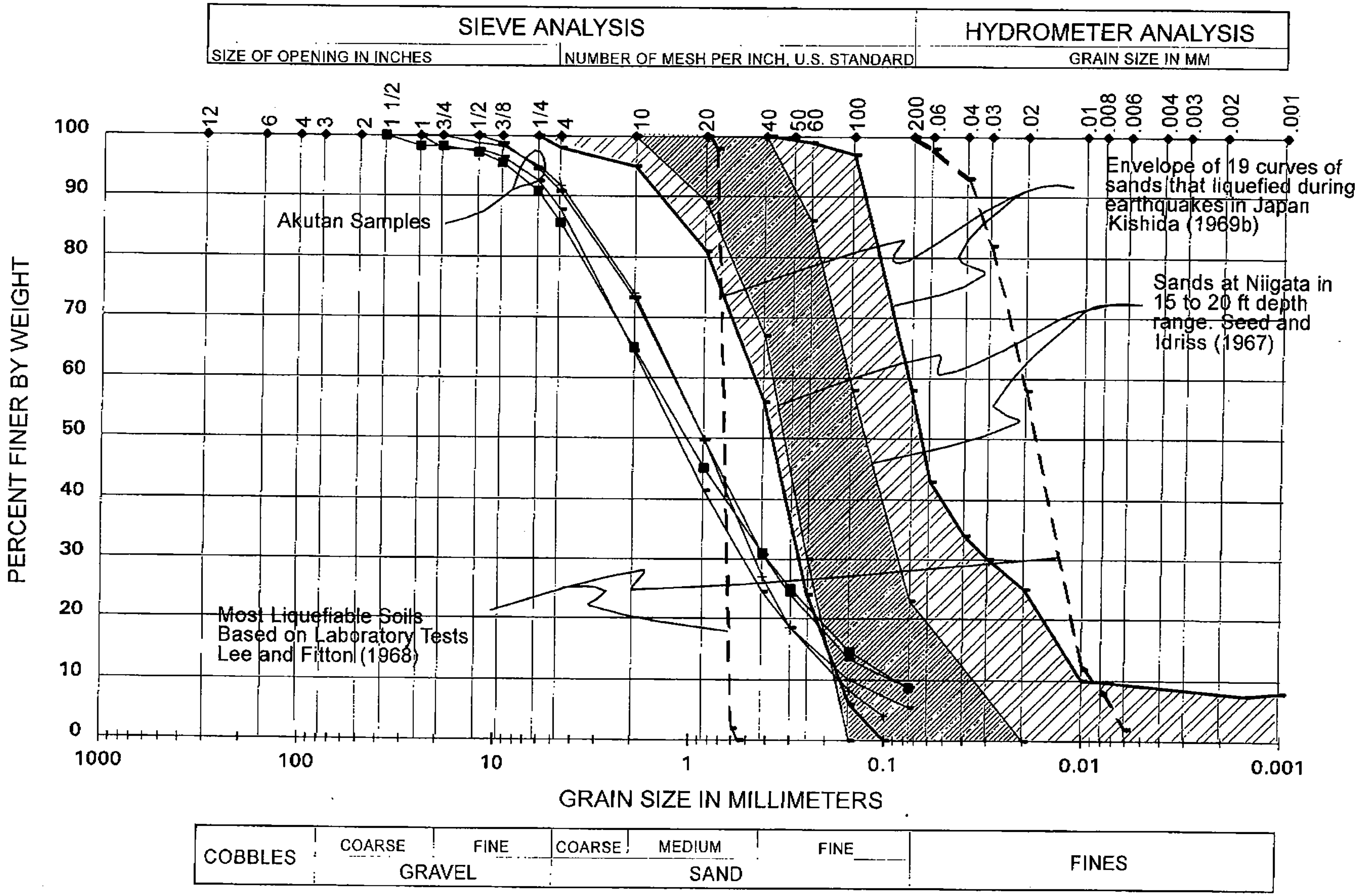
Akutan Small Boat Harbor
Akutan Bay, Alaska

PENETRATION RESISTANCE vs. DEPTH

December 2001 32-1-16384

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Fig. 4



Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAIN SIZES SUSCEPTIBLE TO LIQUEFACTION

December 2001

32-1-16384

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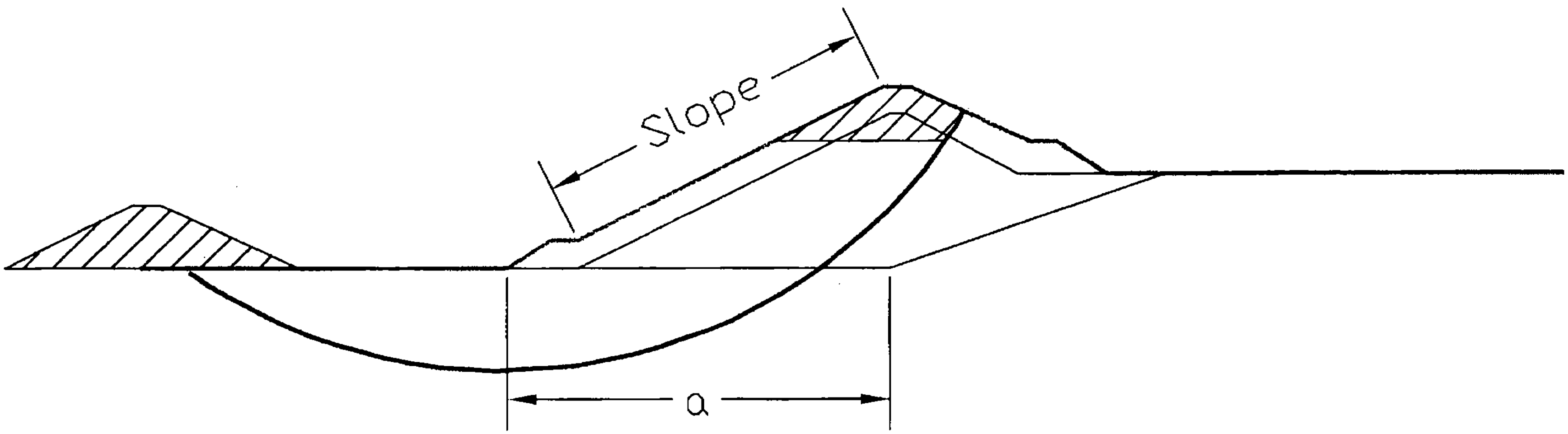
Fig. 5



Breakwater Geometry for Reconstruction Evaluation

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

BREAKWATER GEOMETRY

December 2001 32-1-16384

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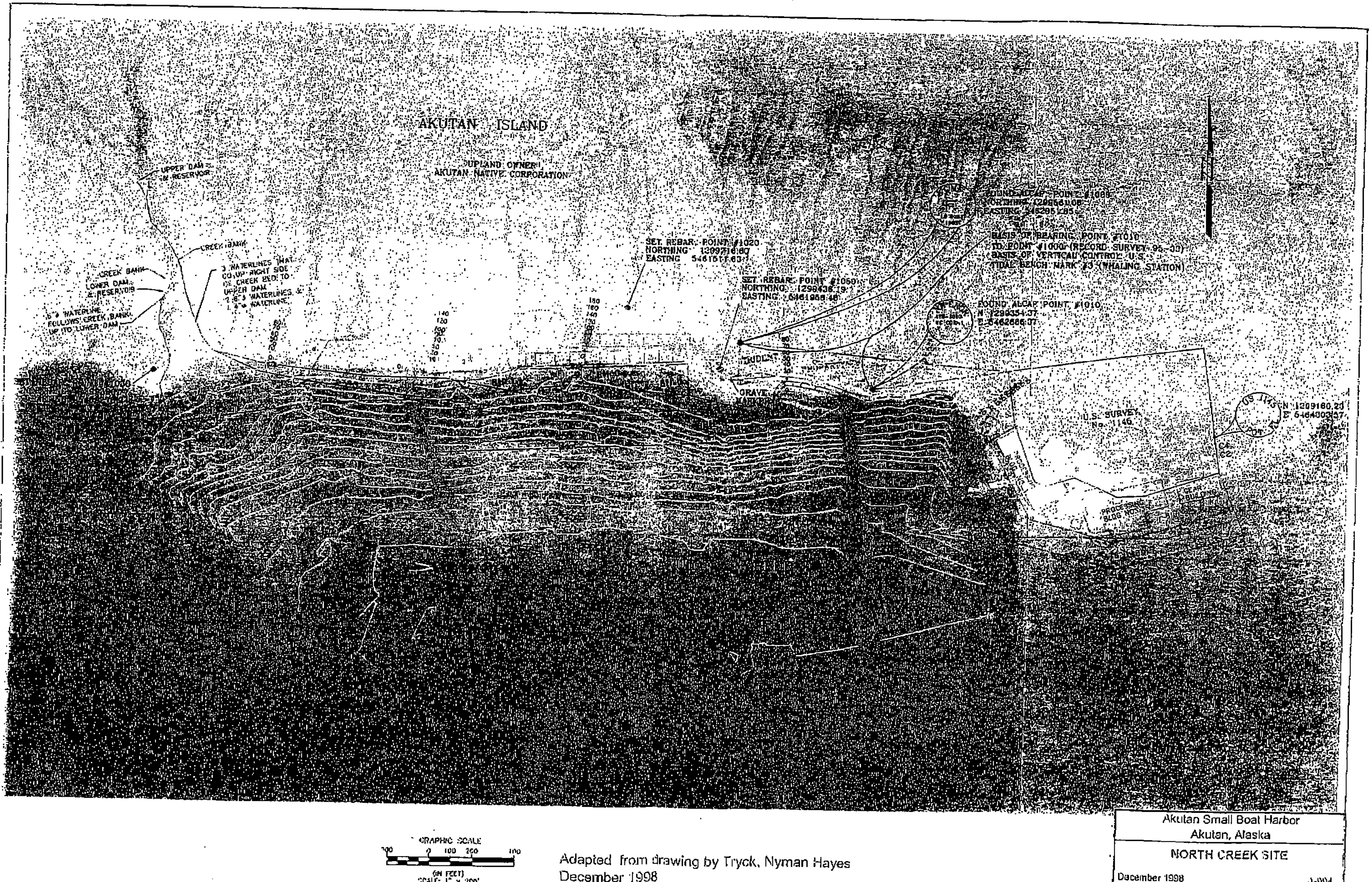
FIG. 6

6384geometry.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

APPENDIX A

1998 Exploratory Data
Site Plans
Boring Logs
Arctic Geosciences, Inc. Report



Adapted from drawing by Tryck, Nyman Hayes
December 1998

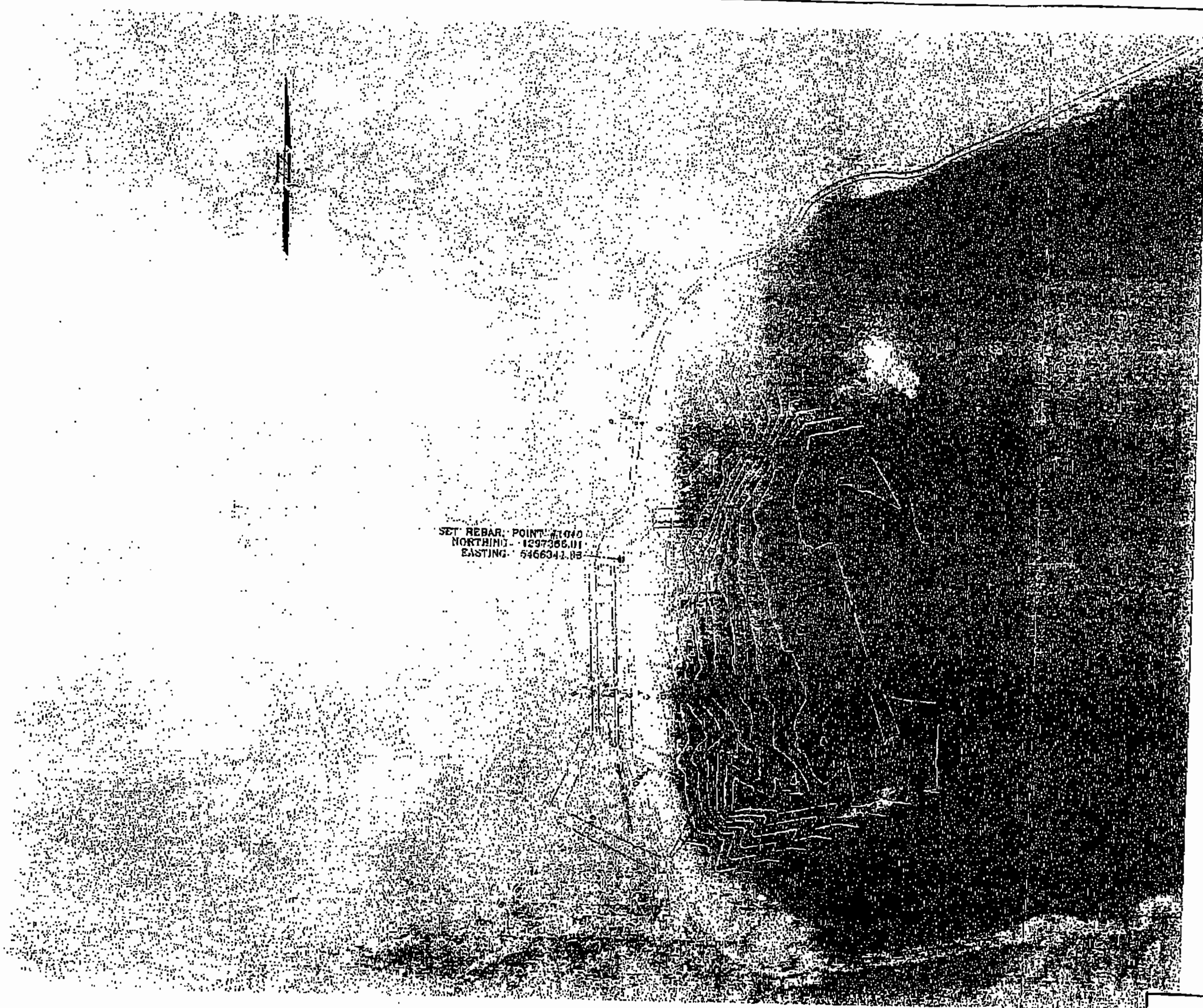
Akutan Small Boat Harbor
Akutan, Alaska

NORTH CREEK SITE

December 1998

SHANNON & WILSON, INC.

Fig. 2



GRAPHIC SCALE
0 100 200 400
(IN FEET)
SCALE: 1" = 200'

Adapted from drawing by Tryck Nyman Hayes
December 1998

Akutan Small Boat Harbor
Akutan, Alaska

HEAD OF AKUTAN BAY SITE

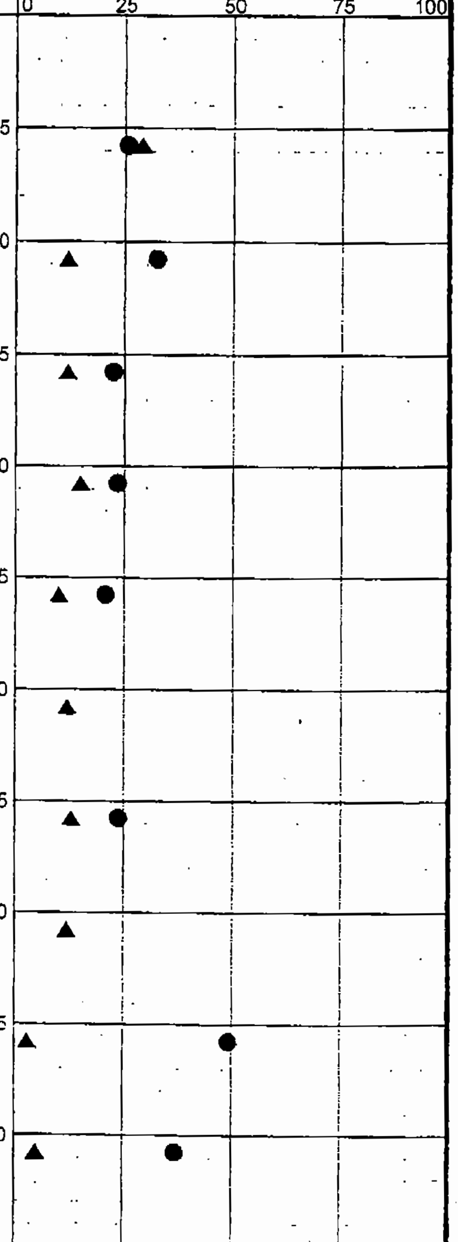
December 1998 A-394

SHANNON & WILSON, INC.

Fig. 3

MATERIAL DESCRIPTION Approx. Surface Elevation 2 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Well graded SAND with silt (SW-SM), medium dense, brown, wet to saturated			S-1	3/27/01	5
Increased gravel from 9 to 11.25 ft. Heaving sands during sampling efforts from 10 ft.	11.3		S-2		10
Well graded SAND with silt and gravel (SW-SM), medium dense, black, wet to saturated S-3; Gravel 8%, Sand 88%, Silt 4%			S-3		15
			S-4		20
S-5; Gravel 12%. Sand 82%. Silt 6%			S-5		25
			S-6		30
			S-7		35
			S-8		40
	46.0		S-9		45
SILT with sand (ML), soft to medium stiff, black, wet to saturated Sample S-10, Non-Plastic	51.5		S-10		50
Bottom of Boring Boring Completed 3/27/2001					

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

- Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Ground Water Level ATD
- Perched Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-1-01

December 2001 | 32-1-16384

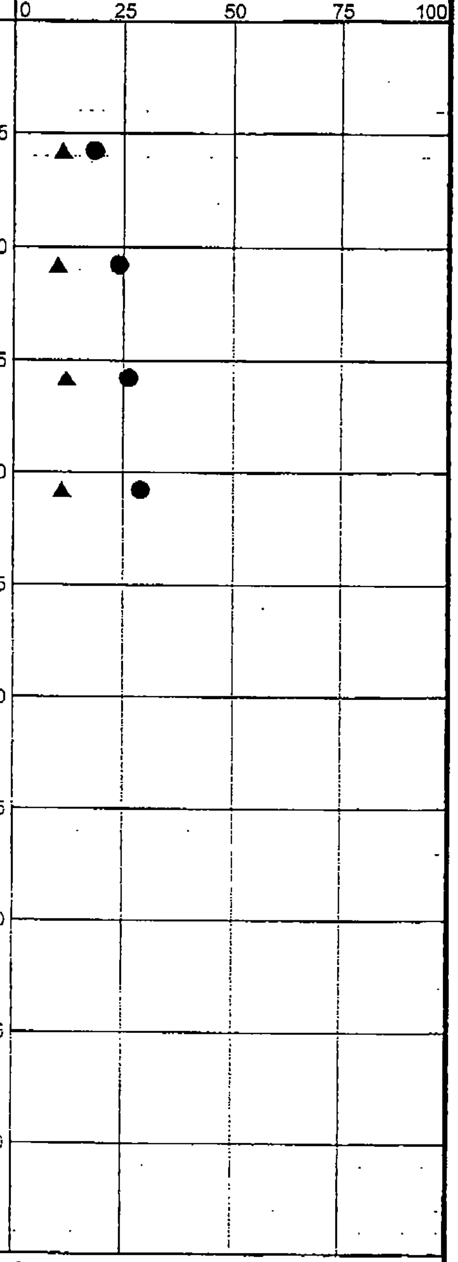
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-1

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

MATERIAL DESCRIPTION Approx. Surface Elevation 5 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Well graded SAND with silt (SW-SM), medium dense, black, wet to saturated Beach location Heaving sands during sampling efforts from 15 ft.	25.0		S-1 S-2 S-3 S-4	3/26/01	5 10 15 20 25
Bottom of Boring Boring Completed 3/26/2001					30 35 40 45 50

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Ground Water Level ATD
- Perched Water Level

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-2-01

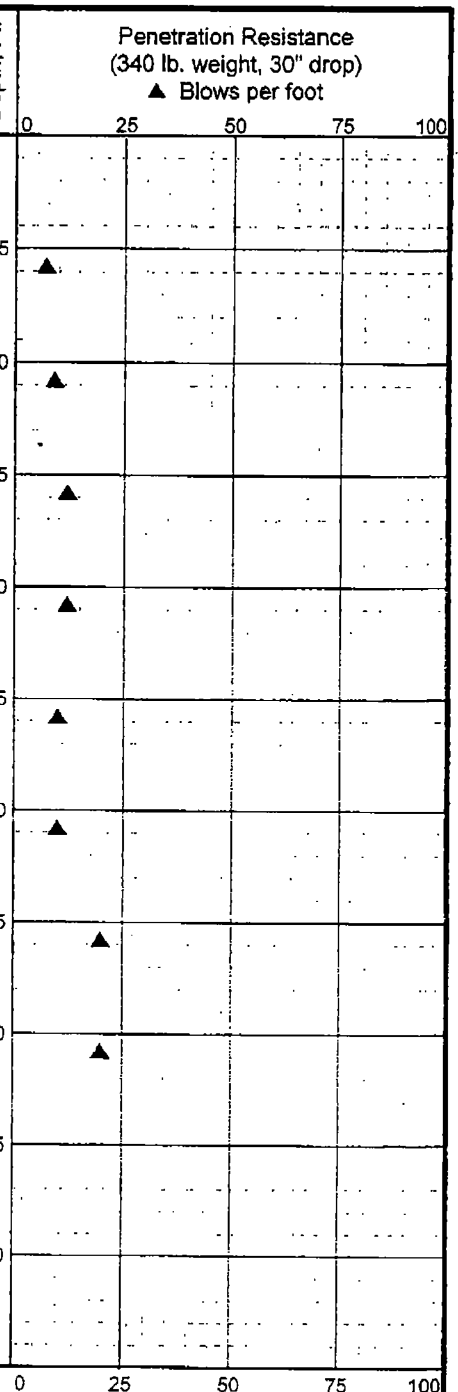
December 2001 32-1-16384

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-2

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

MATERIAL DESCRIPTION Approx. Surface Elevation 4 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Silty SAND or sandy SILT (SM or ML) with numerous organics throughout, loose to medium dense, brown, wet	3.5			3/25/01 ∇	
Well graded SAND with silt (SW-SM), medium dense, brown, wet to saturated			S-1		5
Heaving sands during sampling efforts from 10 ft.			S-2		10
	17.0		S-3		15
Well graded SAND (SW), medium dense, black, wet to saturated, with occasional layers of silt			S-4		20
			S-5		25
Layer of SILT (ML) from 29 to 32.8 ft., stiff, black, wet to saturated			S-6		30
			S-7		35
	41.5		S-8		40
Bottom of Boring Boring Completed 3/25/2001					45
					50



● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- ∇ Ground Water Level ATD
- ▼ Perched Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-3-01

December 2001 32-1-16384

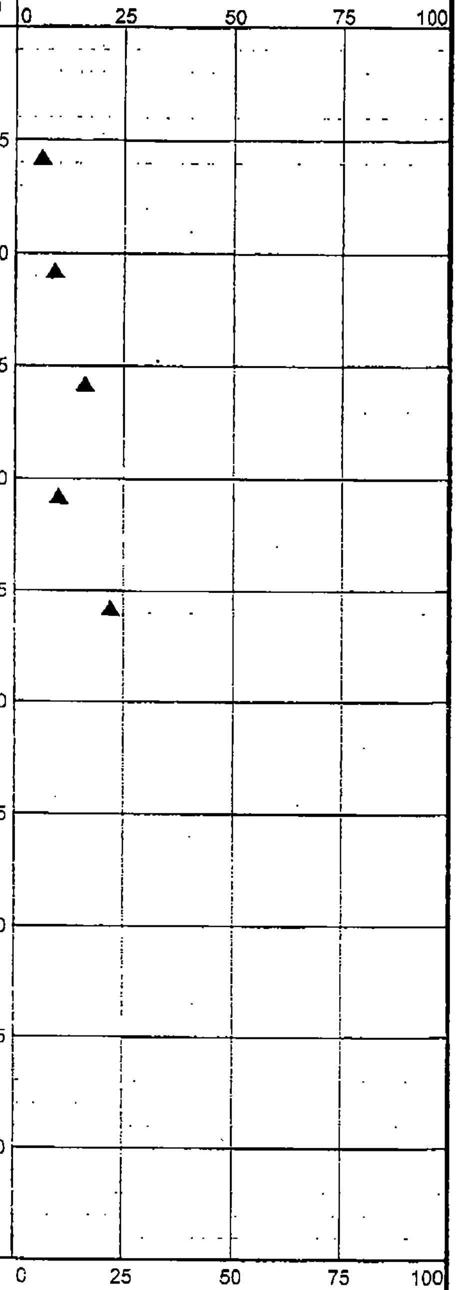
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-3

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

MATERIAL DESCRIPTION Approx. Surface Elevation 13 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Silty SAND or sandy SILT (SM or ML) with numerous organics, loose to medium dense, brown, wet				3/24/01	
Well graded SAND with silt and gravel (SW-SM), loose to medium dense, brown, wet to saturated	4.0		S-1 S-2 S-3 S-4		5 10 15 20
Well graded silty SAND with gravel (SW-SM), grading to silty SAND, medium dense, gray, wet to saturated Fine silty SAND with depth	21.1		S-5		25
Bottom of Boring Boring Completed 3/24/2001	26.5				30 35 40 45 50

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



LEGEND

* Sample Not Recovered
2" O.D. Split Spoon Sample
3" O.D. Split Spoon Sample
Ground Water Level ATD
Perched Water Level

● % Water Content
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-5-01

December 2001 32-1-16384

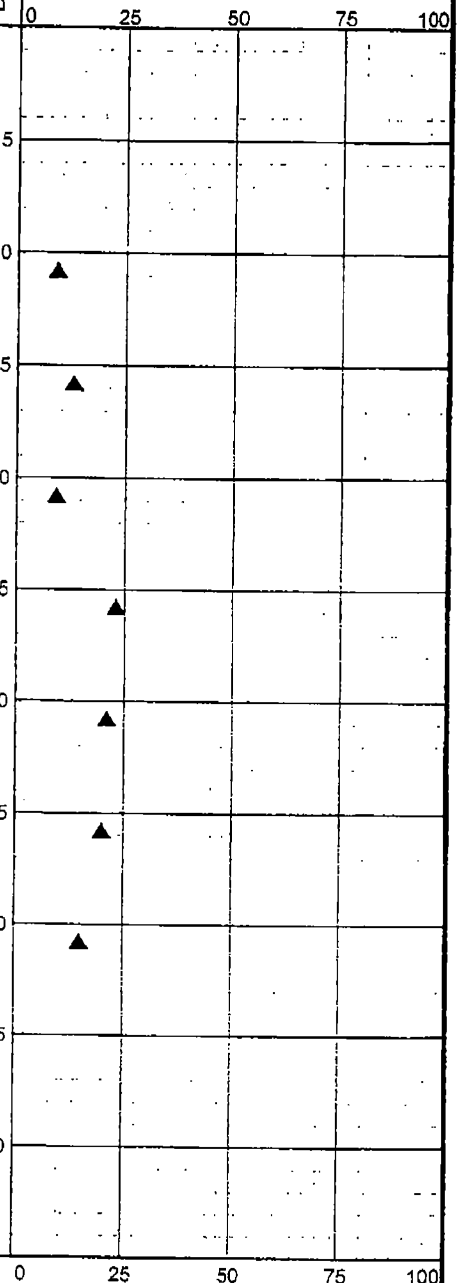
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-4

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

MATERIAL DESCRIPTION Approx. Surface Elevation 12 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Silty SAND or sandy SILT (SM or ML) with numerous organics, loose to medium dense, brown, wet				▽ 3/23/01	
Well graded silty SAND (SW-SM), medium dense, black, wet to saturated	4.5				5
Heaving sands during sampling efforts from 10 ft.			S-1		10
			S-2		15
			S-3		20
			S-4		25
			S-5		30
			S-6		35
			S-7		40
					45
Bottom of Boring Boring Completed 3/23/2001	46.5				50

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



● % Water Content

Plastic Limit ├──●──┤ Liquid Limit

Natural Water Content

LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- ▽ Ground Water Level ATD
- ▼ Perched Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-6-01

December 2001 32-1-16384

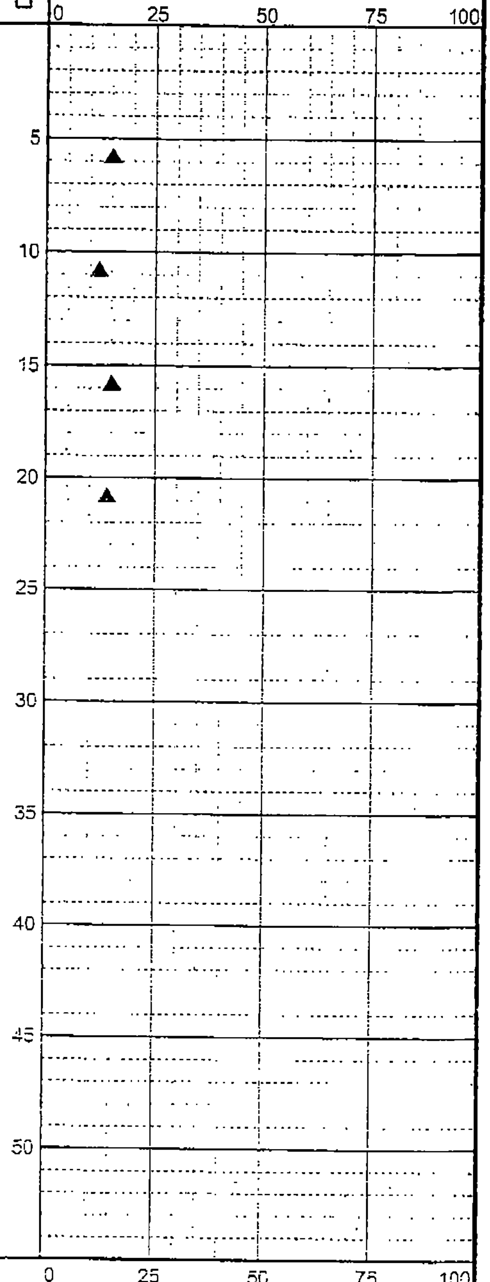
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-5

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

MATERIAL DESCRIPTION Approx. Surface Elevation 11 Ft.	Depth, Ft.	Symbol	Samples	Ground Water
Silty SAND or sandy SILT (SM or ML) numerous organics, medium dense, brown, wet				3/25/01
Well graded SAND with silt (SW), medium dense, brown, wet to saturated	4.0		S-1	
Poorly graded, silty SAND (SM-SM), medium dense, gray, wet to saturated, fine sand	10.0		S-2 S-3 S-4	
Bottom of Boring Boring Completed 3/25/2001	25.0			

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



LEGEND

- Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Ground Water Level ATD
- Perched Water Level

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-7-01

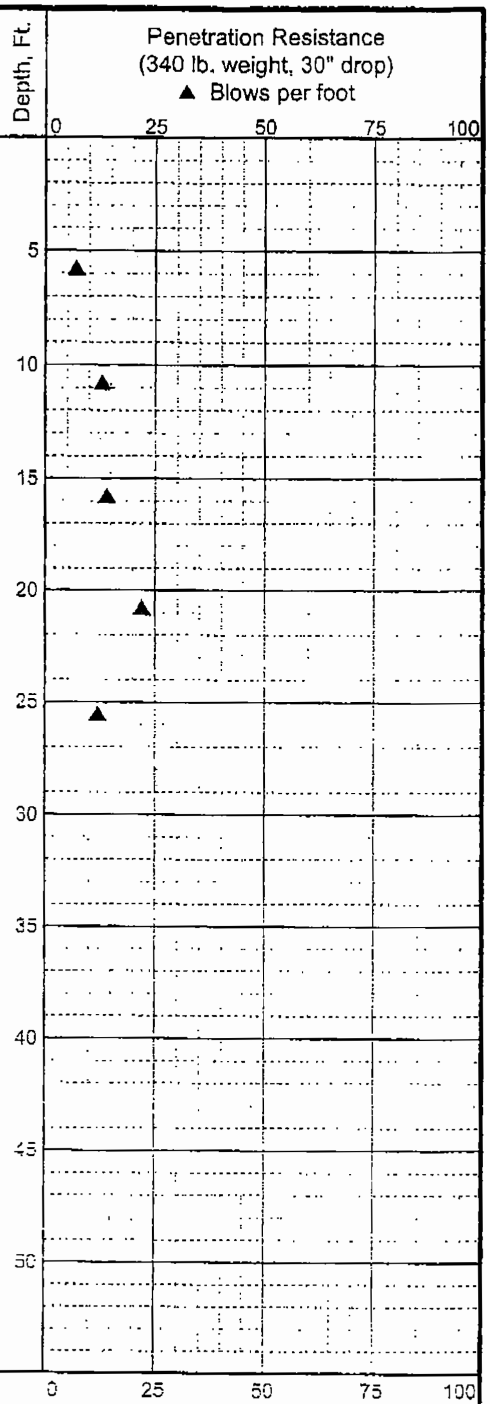
December 2001 32-1-15384

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-6

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

MATERIAL DESCRIPTION Approx. Surface Elevation 12 Ft.	Depth, Ft.	Symbol	Samples	Ground Water
Silty SAND or sandy SILT (SM or ML) with numerous organics, loose to medium dense, brown, wet				3/22/01
Well graded SAND with silt (SW), medium dense, gray, wet to saturated Heaving sands during sampling efforts from 15 ft.	5.5		S-1 S-2 S-3 S-4	
Well graded SAND with silt (SW-SM), medium dense, black, wet to saturated	23.0		S-5	
Bottom of Boring Boring Completed 3/22/2001	26.0			



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Ground Water Level ATD
- Perched Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-8-01

December 2001 | 32-1-16384

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-7

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

MATERIAL DESCRIPTION Approx. Surface Elevation 13 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.	Penetration Resistance (340 lb. weight, 30" drop) ▲ Blows per foot
Silty SAND or sandy SILT (SM or ML) with numerous organics, medium dense, brown, wet				3/21/01		
Well graded SAND with silt (SW-SM), medium dense, brown or gray, wet to saturated Heaving sands during sampling efforts from 10 ft.	6.0		S-1		5	
			S-2		10	
			S-3		15	
			S-4		20	
			S-5		25	
Silty SAND (SM) with shell fragments, medium dense, black, wet to saturated	30.8		S-6		30	
Well graded SAND with silt (SW-SM), medium dense, gray, wet to saturated	33.0		S-7		35	
Bottom of Boring Boring Completed 3/21/2001	40.0				40	
					45	
					50	

0 25 50 75 100

● % Water Content

Plastic Limit |—●—| Liquid Limit

Natural Water Content

LEGEND

- Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Ground Water Level ATD
- Perched Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-9-01

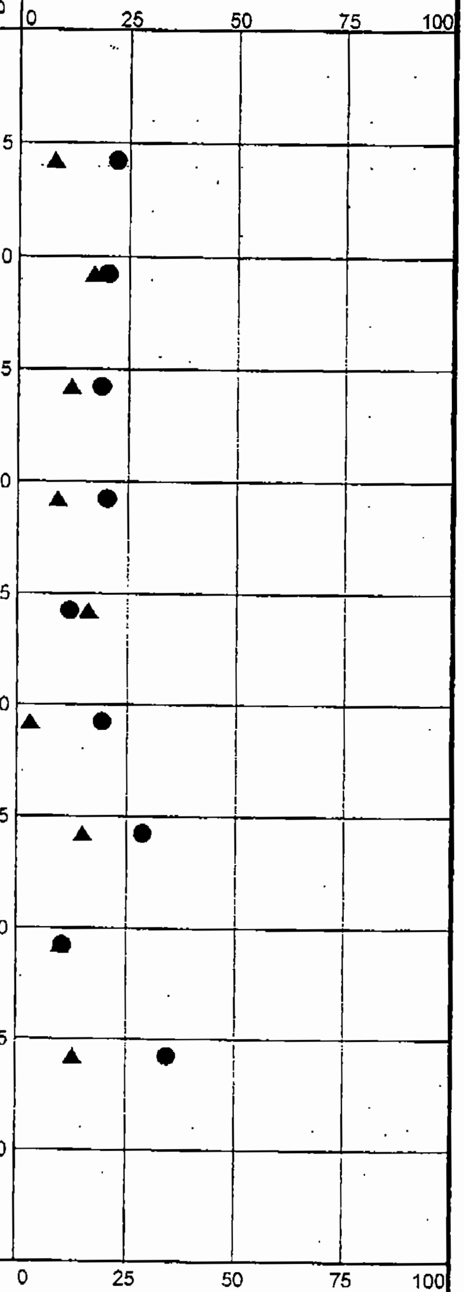
December 2001 32-1-16384

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-8

MATERIAL DESCRIPTION Approx. Surface Elevation 10 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Silty SAND or sandy SILT (SM or ML) with numerous organics throughout, loose to medium dense, brown, wet				3/26/01	5
Well graded SAND with silt and gravel (SW-SM), medium dense, brown, wet to saturated S-2; Gravel 9%, Sand 82%, Silt 9% Heaving sands during sampling efforts from 10 ft.	5.0		S-1 S-2 S-3		10 15
Well graded SAND (SW), medium dense, black, wet to saturated, occasional layers of silt Layer of SILT (ML) from 34 to 36.5 ft., stiff, black Sample S-7, Non-Plastic	19.0		S-4 S-5 S-6 S-7 S-8 S-9		20 25 30 35 40 45
Bottom of Boring Boring Completed 3/26/2001	50.0				50

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Ground Water Level ATD
- Perched Water Level

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-10-01

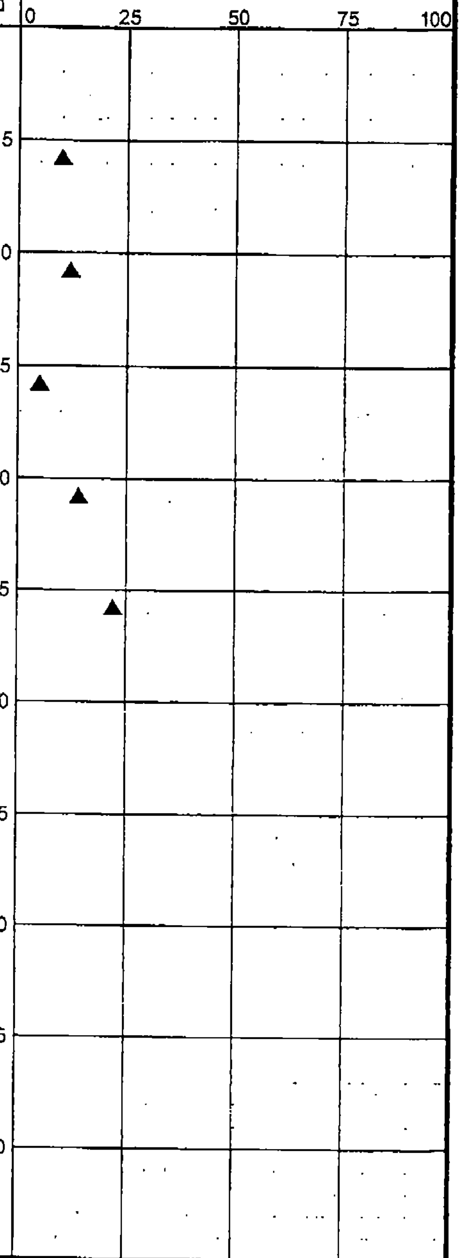
December 2001 | 32-1-16384

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-9

MATERIAL DESCRIPTION Approx. Surface Elevation 14 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Silty SAND or sandy SILT (SM or ML) with numerous organics throughout, loose to medium dense, brown, wet	4.0			▽ 3/24/01	
Well graded SAND with variable zones of silty SAND (SW-SM), medium dense, black, wet to saturated Heaving sands during sampling efforts from 10 ft.	26.5		S-1 S-2 S-3 S-4 S-5		5 10 15 20 25
Bottom of Boring Boring Completed 3/24/2001					30 35 40 45 50

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- ▽ Ground Water Level ATD
- ▼ Perched Water Level

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
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4. Pocket pen values are represented by PP. Torsional force vane values are represented by TV. Percent passing the number 200 sieve is represented by P200.

S&WGEO1 LOG ENGL.GPJ S&W GEO1.GDT 4/5/02

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING B-12-01

December 2001 | 32-1-16384

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-10

ARCTIC GEOSCIENCE, INC.
1000 O'MALLEY DRIVE, SUITE 205 • ANCHORAGE, ALASKA 99515-3069

December 9, 1998
98-0401

Shannon & Wilson, Inc.
5430 Fairbanks Street, Suite 3
Anchorage, Alaska 99518

Attention: Ms. Lorie Dilley, Project Manager

Final Report
Akutan Harbor Study
Geophysical Survey Services
Akutan, Alaska

Transmitted herewith are three copies of Arctic GeoScience Inc.'s final report for the Akutan Harbor geophysical survey. Arctic GeoScience, Inc. (AGSI) was retained to provide geophysical services in support of Shannon & Wilson, Inc.'s (SWI) U.S. Corps of Engineers Alaska District harbor study at Akutan Bay, Alaska. The purpose of this geophysical survey was to provide subbottom data in support of the geotechnical information sought for the design of a new small boat harbor in Akutan Bay, Alaska. During the execution of our services, AGSI's representatives consulted with Mr. Keith Mobley, Ms. Lori Dilly, and Mr. Mitch Miller of Shannon and Wilson Inc., and Mr. Mel Saunders, with Tryck Nyman Hayes, Inc. 's. This transmittal completes our scope of services.

Arctic GeoScience Inc. appreciates this opportunity to assist Shannon and Wilson Inc. We remain available to assist you in the future. Should you have any questions or require any additional information, please do not hesitate to contact the undersigned or Michael Schlegel at (907) 522-4300.

Sincerely,
Arctic GeoScience Inc.

Stephen F. Davies, MSc
Vice President

Phone (907) 522-4300 FAX (907) 522-4301

Akutan Harbor Study
Geophysical Survey Services
Akutan Bay, Alaska

Table of Contents

1.0 INTRODUCTION 1
2.0 PROJECT OBJECTIVE AND SCOPE OF SERVICES 1
3.0 GEOPHYSICAL PROGRAM SUMMARY 2
3.1 Field Operations Summary 2
3.2 Geophysical Data Acquisition 5
3.2.1 SPR 1200 Bubble-Pulser Seismic Profiler 5
3.2.2 Side Scan Sonar Data Acquisition 6
3.2.3 Chirp II Subbottom Profile Data Acquisition 7
4.0 FINDINGS FROM THE GEOPHYSICAL SURVEY 7
4.1 Geologic Setting 7
4.1.1 General Geology of Akutan Island 8
4.1.2 Surficial Geology of Akutan Island 9
4.1.3 Geology of Akutan Bay 9
4.2 Site Soil Conditions 10
4.3 Geophysical Interpretation 11
4.3.1 Presentation of Findings at Potential Harbor Site 1 12
4.3.2 Presentation of Findings at Potential Harbor Site 4 14
5.0 LIMITATIONS 14
6.0 CLOSURE 15
REFERENCES 16

Figures

Figure 1 Survey Track Line Presentation with Depth to Acoustic Base of Sediments
Figure 2 Geophysical Equipment Arrangement onboard Charter Vessel

Figure 3 Side Scan Sonar Record Line E0 +70 (Field Record)

Figure 4 Chirp II Acoustic Subbottom Profiler Record Line N3 +50 (Field Record)

Figure 5 Interpreted Regional Geologic Section of the Akutan Bay

Figure 6 Annotated Bubble Pulser Record Line NO-50, Site 1 North Creek

Figure 7 Annotated Bubble Pulser Record Line NO+00. Site 1 North Creek

Figure 8 Lithologic Summary of SWI Offshore Geotechnical Boreholes

Figure 9 Field Bubble Pulser Subbottom Profiler Record Line E1 +35, Site 1 North Creek

Figure 10 Field Bubble Pulser Subbottom Profiler Record Line E1 +20, Site 1 North Creek

Figure 11 Field Bubble Pulser Subbottom Profiler Record Line E1 +05, Site 1 North Creek

Figure 12 Field Bubble Pulser Subbottom Profiler Record Line S4-2, Site 4 Head of Bay

Figure 13 Annotated Bubble Pulser Subbottom Profiler Record Line E1 +35, Site 1 North Creek

Figure 14 Annotated Bubble Pulser Subbottom Profiler Record Line E1 +20, Site 1 North Creek

Figure 15 Annotated Bubble Pulser Subbottom Profiler Record Line E1 +05, Site 1 North Creek

Figure 16 Annotated Bottom Pulser Line S4-2, Site 4 Head of Bay

Appendicies

Appendix A Time and Event Summary

Appendix B SWI Boring Logs

Akutan Harbor Study
Geophysical Survey Services
Akutan Bay, Alaska

1.0 INTRODUCTION

Arctic GeoScience, Inc. (AGSI) was retained to provide geophysical services in support of Shannon & Wilson, Inc.'s (SWI) U.S. Corps of Engineers Alaska District harbor study at Akutan Bay, Alaska. Our geophysical services were authorized verbally by Mr. Keith Mobley of SWI, on August 14,1998. Arctic GeoScience Inc. executed our services in their entirety under this verbal agreement with Shannon and Wilson Inc. The purpose of this geophysical survey was to provide subbottom data in support of the geotechnical information sought for the design of a new small boat harbor in Akutan Bay, Alaska. During the execution of our services, AGSI's representatives consulted with Mr. Keith Mobley, Ms. Lori Dilly, and Mr. Mitch Miller of Shannon and Wilson Inc., and Mr. Mel Saunders, whom was Tryck Nyman Hayes, Inc. 's (TN&H) onsite representative during AGSI's geophysical survey, as well as, providing positioning services.

This transmittal completes AGSI's scope of services in support of SWI's harbor study at Akutan Bay, Alaska.

2.0 PROJECT OBJECTIVE AND SCOPE OF SERVICES

AGSI's geophysical services were directed at investigating proposed Harbor Sites 1 and 4, which are located at North Creek and the head of Akutan Bay, respectively (Figure 1). AGSI's scope of services were developed as a result of SWI's negotiations and program planning with TN&H and the US Corps of Engineers. AGSI did not participate nor provide consultation in support of developing the geophyiscal field program. The primary objective of the geophysical survey was to obtain subbottom data which could be used to interpret the acoustic base of sediments, which could approximate the depth to bedrock along the new dock face alignments. AGSI's geophyscial services were limited to providing 4500 lineal feet (1373 meters) of subbottom profile data at Site 1, and 1000 lineal feet (305 meters) of subbottom profile data from Site 4. Our geophysical services were to be logistically supported by SWI, which was inclusive of transportation for our personnel and equipment, accommodations for our personnel while on location, and navigation/positioning services to control our geophysical survey. As a result, AGSI provided all logistical support to accomplish our geophysical services, as well as, providing logistical support inclusive of transportation and accommodations to TN&H's positioning specialist and his field equipment. AGSI provided vessel support to TN&H's hydrographic survey.

3.0 GEOPHYSICAL PROGRAM SUMMARY

3.1 Field Operations Summary

AGSI mobilized a three-person field team and geophysical support equipment to Sand Point, Alaska via commercial airliner on September 23,1998. Upon arrival at Sand Point, Alaska, our field team and TN&H's onsite representative traveled to Akutan aboard AGSI's chartered 110-ft vessel, F/V Lady Simpson. During transit, AGSI and TN&H representatives coordinated project activities and conducted a health and safety review.

AGSI's geophysical survey lines were pre-plotted and oriented by TN&H's positioning specialist, such that they intercepted SWI's proposed drill hole locations. Navigational control for this survey was provided to AGSI in real-time latitude/longitude through TN&H's Ashtech Global Positioning System (GPS) instruments. Post-plot coordinates of the tracklines and fix points were provided in Alaska State Plane Coordinates to AGSI by TN&H upon completion and our return to Anchorage.

The F/V Lady Simpson and our field crew arrived onsite in Akutan Bay at 2330 hours, September 26, 1998. Upon our arrival, our field team immediately began assembling and calibrating AGSI's high-resolution geophysical equipment. An operations summary is presented in Table 1, a time and events summary is presented in Table 2, and a detailed time and events listing can be found in Appendix A. All geophysical survey operations were conducted aboard the F/V Lady Simpson. AGSI's 20-ft inflatable boat was available, but it was only enlisted to set up topographic survey control on the beach and deployment of oceanographic recorders. The S-4 Oceanographic Recorders began collection of tide data September 27, 1998 at approximately 1400 hrs, and completed the data collection at 0900 hrs on the 28th of September. A tide staff established at the coastline by TN&H's positioning specialist was used to monitor sea level change during survey activities on the 28th and the 29th of September.

Table 1

Summary of Survey Operations
Akutan Harbor Survey

DATE	FROM	TO	TASK/EQUIPMENT	SITES
September 27 1998	09:00 hours	18:00 hours	Establish survey control Deploy current meters	Site 1
September 28 1998	11:30 hours	15:30 hours	Sidescan, Chirpil	Site 1
September 28, 1998	16:00 hours	17:30 hours	Bubble Pulser	Site 1
September 28, 1998	20:45 hours	21:15 hours	Bubble Pulser	Site 4
September 29, 1998	11:30 hours	13:00 hours	Sidescan, Chirpil Retrieve current meters	Site 4

Table 2

Summary of Time and Events
Akutan Harbor Survey

Travel Summary	
Anchorage to Akutan	85 hours
Akutan to Anchorage	46.5 hours
Survey and Stand-By Summary	
Time surveying	8
Tide gauging	1
Onsite stand-by	12.5

Once survey control was established, the data acquisition program commenced. The geophysical survey lines originally pre-plotted in our Anchorage office were revised in the field to accommodate the site conditions present at the time of our survey. Because of the steep southerly dipping geologic structure and the resulting out-of-plane noise at Site 1, a survey grid for the Bubble Pulser data was developed onsite. A series of 13 tracklines were surveyed with AGSI's Bubble Pulser parallel to shore on 15-meter spacing (Figure 1). AGSI also surveyed 6, north south oriented, tie-lines spaced at 50-meter intervals.

The original survey plan for Site 4 was to shoot a total of 5 tracklines; 2 lines parallel to shore (north-south), 25 meters apart and 3 lines perpendicular to shore (east-west), 100 meters apart (Figure 1). AGSI's Bubble Pulser survey was reduced onsite to 3 tracklines, two primary lines with north-south orientation that were spaced 50 meters apart and one east-west bisecting cross line. The reduction in AGSI's planned coverage was due to the shallow water encountered with respect to the pre-plot location of SWI boreholes. The location of SWI's Site 4 boreholes originally plotted offshore on the pre-plot project site map were determined by TN&H surveyor in the field to be located on the beach based on coordinate relationship to the study area. The geophysical survey lines were run as close to the beach as logistically possible.

Sidescan sonar and subbottom data were collected simultaneously. Side Scan Sonar and subbottom data were collected along 20 tracklines based on the revised Site 1 survey plan. Seventeen primary lines were run perpendicular to shore, spaced approximately 25 meters apart, while the tie-lines were parallel to shore at 70-meter spacing (Figure 1). At Site 4, AGSI's survey consisted of 9 tracklines, three primary north-south lines spaced 50 meters apart, and six east-west tie-lines spaced 50 meters apart.

AGSI's geophysical team completed its field services September 29, 1998 at approximately 1430 hours. The field crew demobilized our equipment and traveled to Sand Point. From Sand Point, our crew returned to Anchorage via commercial airline.

AGSI collected approximately 22,967 lineal feet (7000 lineal meters) of Bubble Pulser data and 17,061 lineal feet (5200 lineal meters) of sidescan and Chirp II subbottom profiler data at Site 1. Approximately 2625 lineal feet (800 lineal meters) of Bubble Pulser data and 6890 lineal feet (2100 lineal meters) of sidescan and Chirp II subbottom data were collected at Site 4. AGSI attended a post survey briefing with SWI in their Anchorage offices at which time SWI's representatives selected three Bubble Pulser lines, lines 1+05, 1+120, and 1+35. The three bubble pulser lines at Site 1 total 4500 lineal feet. One bubble pulser line was selected for Site 4, line S4-2, to total 1000 lineal feet. This selected data set is presented and transmitted in this report, and this data set completes AGSI's scope of geophysical services. The additional Side Scan Sonar, Chirp II subbottom profiler, and Bubble Pulser data is available and in AGSI's files should SWI or its client require additional supporting information

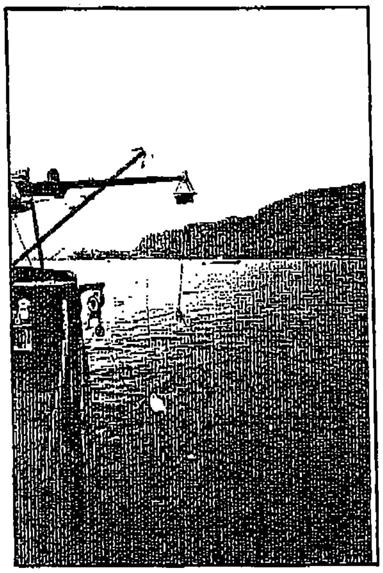
3.2 Geophysical Data Acquisition

AGSI mobilized a suite of high resolution geophysical tools in order to support our capabilities to accomplish the objectives of this geophysical survey. AGSI deployed these geophysical systems at the two proposed harbor locations in Akutan Bay. AGSI's geophysical survey in Akutan Bay included the use of our Bubble Pulser, Chirp II subbottom profiler, and CHIRP Technology Side Scan Sonar. These geophysical tools are briefly described in the following text. A schematic illustrating the deployment location of AGSI's geophysical tools off the survey vessel is presented on Figure 2.

3.2.1 SPR 1200 Bubble-Pulser Seismic Profiler

AGSI utilized our Data Sonics SPR-1200 Bubble Pulser System as the primary geophysical tool to collect subbottom profile data during this program. This system is manufactured by Datasonics Inc., and it is designed to penetrate to bedrock through a variety of sediment types, 50 to 150 meters of penetration. Its light-weight, electromagnetic transducer generates a narrow band 400 Hz acoustic pulse, and its power supply provides an acoustic source level of +200 dB ref 1μPa at 1 meter. This instrument was designed for towing in adverse sea conditions, while collecting data with a range resolution of ±2 meters.

Bubble Pulser data was collected for the purpose of determining the acoustic base of the sediments presented in Akutan Bay. The depth to base of sediments approximates the depth to bedrock. The bubble pulser acoustic source and hydrophone streamer were deployed on the starboard side of the charter vessel during the Akutan geophysical surveys. Prior to immersing the acoustic source, a series of pre-deployment checks were performed on deck. The source was positioned approximately 2 meters starboard of the boat and the hydrophone streamer was positioned about 1 meters aft of the acoustic source.



A 4 milliseconds time delay was used to correct for the distance between the tool and the navigation antenna (8 meters), Figure 2.

Bandpass filtering was the only processing performed for this program. A filter setting with frequency range from 300 Hz to 10,000 Hz was passed without attenuation. The upper 25-40 meters of subbottom data collected from the Bubble Pulser was readily interpreted without further signal processing.

3.2.2 Side Scan Sonar Data Acquisition

Side Scan Sonar Imagery was not included in AGSI's scope of services. AGSI mobilized our side scan sonar system to collected seafloor imagery to identify seafloor geohazards and debris that may interfere with future construction of a new harbor. The side scan data is available if in the future this proves beneficial to the dock/harbor designer. One representative trackline was selected and presented on Figure 3.

The side scan towfish was mounted on the starboard crane and deployed off the starboard side during both site surveys. Prior to immersing the towfish, a series of pre-deployment checks were performed on deck. The towfish was deployed with enough cable so that it hung approximately 2 meters below the water surface, below the hull of the vessel, and approximately 2 meters to starboard. The towfish was located approximately 11.5 meters forward of the navigation antenna, Figure 2. Weather conditions were favorable during data acquisition. Tide fluctuations were minimal. Survey vessel speed ranged from 1.5 - 3 knots during the acquisition of side scan sonar data.

3.2.3 Chirp II Subbottom Profile Data Acquisition

High-resolution Chirp II subbottom profiles were acquired to improve the interpretation of sedimentary layering in the upper 15 meters of seafloor. The Chirp II subbottom profiler data would provide high resolution records within the depth of investigation of SWI's planned soil borings. AGSI mobilized our Chirp II subbottom system to collect high-resolution subsurface data to identify seafloor geohazards and to improve interpretation of the near surface stratigraphy. The Chirp II subbottom profiler data is available if in the future this proves beneficial to the dock/harbor designer. One representative trackline was selected and presented on Figure 4.

The Chirp II subbottom towfish was mounted to the port crane of the survey vessel. Prior to immersing the Chirp II towfish, the field crew performed pre-deployment checks on deck. The towfish was deployed so that it hung approximately 1 meter below the water surface and about 5 meters to port. The towfish was located approximately 11 meters forward of the navigation antenna, Figure 2.

4.0 FINDINGS FROM THE GEOPHYSICAL SURVEY

4.1 Geologic Setting

Akutan Island is located in the eastern Aleutian Islands at latitude 54°05' N, longitude 165°55' W. The Aleutian Island Chain is a volcanic arc resulting from the subduction of the northern-moving Pacific Plate under the North American Plate. This subduction zone includes the Aleutian Trench, where the two plates converge, and the Aleutian Volcanic Arc. Magma resulting from the melting of the Pacific Plate at depth rises to the surface, creating islands dominated by volcanoes. Most of the major Aleutian Islands have active volcanoes, including Akutan Island. Akutan Volcano (1300 meters) lies on the west side of Akutan Island. The volcano is active and has had recorded eruptions more than thirty times in the last 200 years. Eruptions have included smoking, lava flows, release of ash, and full explosives.

Akutan Island is rugged and mountainous. The shorelines are mainly steep cliffs and rocky headlands. The central and eastern parts of the island consist of steep ridges separating valleys formed from glacial scouring. These valleys predate the formation of the Akutan Volcano. The drainage pattern of the island radiates from the volcano, suggesting that an old topographic high was located in the area now occupied by the Akutan Volcano. The western side of Akutan Island is gently sloped and drained by streams flowing off of the west flank of the volcano.

4.1.1 General Geology of Akutan Island

Akutan Island consists of volcanoclastic debris flows interbedded with lava flows. The debris flows are overlain with volcanic deposits associated with the Akutan Volcano. The volcanic units as defined by Motyka and Nye (Motyka, Nye, 1998) include the Hot Springs Bay volcanics, the Akutan volcanics, and general Holocene volcanics.

The Hot Springs Bay volcanics underlie most of Akutan Island, and have been found to be at least 700 meters thick. Exposures are seen on about half of the island. The dominant lithology is a poorly sorted and stratified volcanic breccia composed of fragments of basalt and andesite. No distinct internal bedding is apparent, but layers are marked by slight breaks in the slope of the deposit. Angular to rounded blocks of up to 3 meters in diameter are contained in a clay sized matrix. Porphyritic basalt and andesite dikes are also found in the Hot Springs Bay volcanic. The dikes range in thickness from 0.3 to 10 meters. The breccia outcrops are limited to the sea cliffs; inland the breccia forms the rounded grassy slopes. The more resistant dikes form the visible inland outcrops. The Hot Springs Bay volcanics have been interpreted to be Miocene to Pliocene in age.

The Akutan Volcanics unconformably overlie the Hot Springs Bay volcanics. The Akutan Volcanics consists of resistant ridge-capping lava flows ranging in thickness from 2 to 31 meters. The flows either lie directly atop another flow or are separated by thin layers of volcanic breccia. The flows consist of porphyritic basalt and andesite with up to 10%

phenocrysts in a holocrystalline groundmass. These lava flows form steep slopes and make good exposures. Potassium-Argon aging done on the Akutan Volcanics ranges from 1.1 +/- 0.2 to 1.5 +/- 0.1 m.y.

The Holocene Volcanic deposits consist mostly of blocky (aa) lava flows. Both the Akutan Volcano and a small cinder cone that developed around 1852 just northeast of Lava Peak have produced the deposits that make up this group.

4.1.2 Surficial Geology of Akutan Island

Late Wisconsonian-stage glaciation of Akutan Island has resulted in landforms such as cirques and aretes on the higher slopes and u-shaped valleys radiating from the west central region of the island. The u-shaped valleys have been modified by stream erosion cutting channels up to 150 meters deep and volcaniclastic deposition in the lower portions of the major valleys. Morphology of the major valleys and the fjord like features suggest that the glaciers terminated offshore of the present coastlines. Therefore, terminal moraines are not seen. Most lateral moraines have been covered with volcaniclastic debris.

Volcaniclastic deposits are widespread on the island. These deposits consist of layers of volcanic ash and lapilli with occasional bombs. The deposits range in thickness from 0 meters on steep slopes to 30 meters in valley bottoms. Some deposits suggest fluvial and mudflow reworking. This ash has been identified as poor foundation material because it is not dense and tends to liquefy when vibrated.

4.1.3 Geology of Akutan Bay

Akutan Bay is an 8 km long, east-west trending, deep, fjord-like structure that bisects the east end of the island. This fjord interpretation is supported by the data taken in the AGSI survey, where u-shaped structure is apparent, Figure 5. 1980 seismic studies, taken over a stream delta in the harbor, interpreted with a program developed by the U.S. Bureau of Mines, show a two layer model. Layer 1 is interpreted to be loose volcaniclastic ash deposited by the stream in a 3 meter thick layer. Layer 2 is interpreted to be a loose, saturated volcanic ash mixed with loose beach gravels in a layer that extends to a least 10 meters depth. These layers overlay volcanic bedrock.

Beach deposits in Akutan Harbor range from boulders to sand. The steep cliffs that surround the shoreline promote boulder beaches exposed at low tide. As distance increases from the cliffs, deposits range from cobbles to sand, grain size decreasing with distance from the cliffs. This interpretation is supported by the boreholes provided to AGSI by Shannon and Wilson. The three main lithologies consist of sand, gravels, and boulders. The sands correspond to volcanic ashes and reworked beach sands. The gravels correspond to cobbles and gravel located at intermediate distances seaward from the sea cliffs. The intermediate distances indicate some beach reworking causing the break down of larger boulders into the gravels and cobbles. The boulders correspond to sea cliff deposits caused by erosion of the steep surfaces. Because of the irregularity of the sea cliff surfaces, deposition of the sands, gravels and boulders (coarse clastics), will vary depending on the proximity to sources of deposition and stability of the submarine slopes, Figure 6 and 7. This causes the wedge structures and phasing in and out of lithologies seen in the boreholes and the Bubble Pulser's records at Site 1. It is also prudent to be aware of the potential slope instabilities when designing and implementing coastal structures and facilities.

The head of Akutan Bay trends in a straight line north-south, with stream deltas marking the north and south corners, and a third delta in the northern third of the head. The slope of the head dips gently to the east compared to the steep slope of the north and south facing harbor walls. This supports a glacial carving interpretation of the formation of Akutan Bay. The deposits at the head of the harbor consist of loosely packed volcaniclastics ash, sand, gravel, and cobbles. These deposits are up to at least 12 meters thick, as supported by SWI logs of the boreholes drilled and Bubble Pulser records at Site 4. These sediments most likely have been transported and reworked by the local streams.

4.2 Site Soil Conditions

SWI performed a geotechnical soil boring program at both potential harbor locations. The borehole logs compiled from SWI's geotechnical investigation were transmitted to AGSI in order to facilitate and support geologic interpretations. SWI's geotechnical program was performed after AGSI's field geophysical survey was completed and demobilized from Akutan.

A generalized lithologic summary has been prepared from SWI's soil boring logs. The generalized soil units and log sections are illustrated on Figure 8. The primary USC (Unified Soil Classification) soil units identified in SWI's logs consist of:

- silt,
- sand and silty sand,
- sandy gravel,
- gravel,
- gravelly boulders,
- weathered bedrock (undifferentiated bedrock),
- and bedrock (undifferentiated bedrock),

A copy of the borehole logs and supporting geotechnical data provided to AGSI from SWI is presented in Appendix B.

4.3 Geophysical Interpretation

The Bubble Pulser survey consisted of 22,967 lineal feet (7,000 lineal meters) of Bubble Pulser data at Site 1, and 2,625 lineal feet (800 lineal meters) of Bubble Pulser data at Site 4. SWI's three tracklines, selected for Site 1 that support the purpose of this investigation, are presented in Figures 9 through 11. Figure 12 presents S4-2 the representative geophysical survey line from Site 4. The Bubble Pulser subbottom profiling system was able to achieve penetration of approximately 200 feet (70 meters). In general, the quality of the data is good, allowing for the identification of the seafloor reflector (mudline), sedimentary layering, and the interpreted top-of-bedrock reflector used to provide the interpreted depth of sediments annotated on Figure 1, without performing extensive processing of the data record. Multiple reflections (i.e. multiples), which are artifacts created by the acoustic signal reverberating in the water column and between subbottom layers, were observed on most of the records and are annotated as such on the geophysical records presented with annotated interpretations.

AGSI is unable at this time to present a depth to bedrock isopach for the survey area as the bathymetry has not been provided to us at this time. AGSI has obtained copies of SWI's borehole logs from the geotechnical investigation performed at potential Harbor Sites 1 and 4. In lieu of the isopach mapping requested, AGSI has provided sectional interpretations, with SWI's borehole data annotated where applicable, along the selected geophysical records. Three selected bubble pulser records from lines E1+35, E1+20, and E1+05 are presented on Figures 13 through 15. AGSI only has provided our interpretation annotated on the bubble pulser line for Site 4, line S4-2, on Figure 16 as the boreholes identified and drilled by SWI were in shallow water near the beach, and AGSI geophysical survey lines do not pass through these locations at Site 4.

AGSI has also presented an interpreted "base of sediment" (from AGSI's interpreted mudline) along the three selected bubble pulser tracklines at Site 1 and along the selected trackline at Site 4, Figure 1.

4.3.1 Presentation of Findings at Potential Harbor Site 1

Harbor Site 1 is situated near North Creek at the base of a moderately steep to steep slopes, associated with a relic sea cliff. The steep cliffs at Site 1 that encompass and limit the shoreline to boulder beaches are typically exposed at low tide.

Four principle sedimentary intervals characterize the Bubble Pulser records at Site 1:

Interpreted Lithology

- Sand and Fine-Grained Sediment
- Sandy Gravel
- Gravel, Boulders
- Coarse-grained Sediment
- Sedimentary Wedge

The apparent sediment thickness was scaled from the Bubble Pulser data record at each event location and controlled by comparison with boring logs provided by SWI. A smooth and laterally continuously reflector correlates well with the base of a sand unit described on the SWI's boring logs (Appendix B). This sand interval, which is highlighted in light yellow on Figures 13 through 15, is found in SWI borings 2, 5, 6, and 7. It is described as brown to black, loose, wet, medium-grained sand, with some seashells. Boring logs describe the sand unit as being 15 to 50 feet (5 to 16 meters) thick, and it increases in thickness from west to east.

The underlying sedimentary unit appears to be continuous from east to west and maintains a thickness of 13 to 16 feet (4 to 5 meters). This unit, which is highlighted in green, occurs in SWI soil borings 2, 5, 6, and 7. SWI describes this interval as consisting of gray/green to black, sandy gravel of medium density.

Beneath the sandy gravel is a uniform layer, which is highlighted in pink on Figure 13 through 15. This unit maintains a nearly constant unit thickness of 5 feet (1.5 meters). Descriptions of this layer on geologist's logs from SWI borings 2 and 5 indicate that this unit consists of green/gray gravelly boulders or possible bedrock. Bedrock type or consistency is undifferentiated. Bedrock core obtained in SWI borehole 5 presents an RQD of 72 with no description.

AGSI interprets two units underlying the gravelly boulder unit on Lines E1+05 and E1+20. To the east is a wedge-shaped lithologic unit, which is highlighted in yellow. This wedge laps onto and truncates against the lowest interpreted sedimentary unit, which is highlighted in blue. It varies in thickness from 6 to as much as 16 feet (2 to 5 meters). Scattered, discontinuous, subhorizontal reflectors within the wedge-shaped unit suggest that it is composed of clastic sediments, but no soil boring data are available for verification.

The deepest interpreted sediments at Site 1 are highlighted in blue. This interval contains scattered, discontinuous, subhorizontal and occasional onlapping reflectors, which suggest clastic sediments, but no borehole data is available from this interval.

At Site 1, the dashed red line that forms the lower boundary of the blue interval represents the acoustic limit of interpreted sediments. The depth to this limit increases from west to east from 98 to 121 feet (29 to 37 meters). Depths to the acoustic limit of interpreted sediments are presented on Figure 13 and 15.

4.3.2 Presentation of Findings at Potential Harbor Site 4

Site 4 is situated at the head of Akutan Bay. The head of Akutan Bay is a depositional environment which should consist of loosely packed volcaniclastics, ash, sand, gravel and cobbles reworked by fluvial processes. Our interpreted record for Bubble Pulser Line S4-2 is presented on Figure 16. Two soil borings were completed at Site 4 by SWI, but neither of these borings were close enough to Line S4-2 to use as lithologic control for AGSI's interpretation of this record. AGSI has interpreted three sedimentary units on Line S4-2. SWI borehole logs for boring 10 and 11, drilled at Site 4, findings were predominately sand, silty sand with gravel to depth of 40 feet.

Interpreted Lithology

- Sand and Fine-Grained Sediment
- Sandy Gravel
- Gravel, Boulders
- Coarse-grained Sediment
- Sedimentary Wedge

The shallowest interpretive unit is characterized by strong, continuous, subparallel reflectors. This unit, which is highlighted in yellow on Figure 16, is interpreted to be sand. Underlying the sand is a lens-shaped unit characterized by hummocky internal reflectors that occasionally onlap onto the underlying sediments. This unit is interpreted to be coarser grained sediments, possibly sandy gravel. The lowest interpreted sedimentary unit is highlighted in pink. Based on its stratigraphic position, it is interpreted to consist of coarse sediments, likely sandy gravel to boulders. The acoustic base of deepest interpreted sediments is marked with a dashed red line on Figure 16. This surface represents the lower boundary of reflection characteristics (continuous reflectors, onlap, downlap) that can be reasonably interpreted to be of sedimentary origin. Depths to this interpreted lower sediment boundary are presented on Figure 1.

5.0 LIMITATIONS

AGSI performed these services in a manner consistent with that level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. AGSI's geophysical investigations are conducted within the design limitations of the equipment selected for the specific purpose described herein. However, no warranty, expressed or implied is made. This report is intended for the exclusive use of SWI for the purpose described herein.

6.0 CLOSURE

AGSI appreciates this opportunity to support SWI's small boat harbor study of Akutan, Alaska. Should you have any questions or require any additional information, please do not hesitate to contact Mr. Michael Schlegel or the undersigned at (907) 522-4300.

Sincerely,
Arctic GeoScience, Inc.

Stephen F. Davies
Geoscience Consultant
Vice-President

Reviewed by:
Arctic GeoScience, Inc.

Michael G. Schlegel
Geotechnical Consultant
President / CEO

REFERENCES

Selected Bibliography

Motyka, R.J., Nye, C.J., 1988, "A Geological, Geochemical, and Geophysical Survey of the Geothermal Resources at Hot Springs Bay Valley, Akutan Island, Alaska", Alaska: DNR Report of Investigations 88-3, Fairbanks, 115 p.

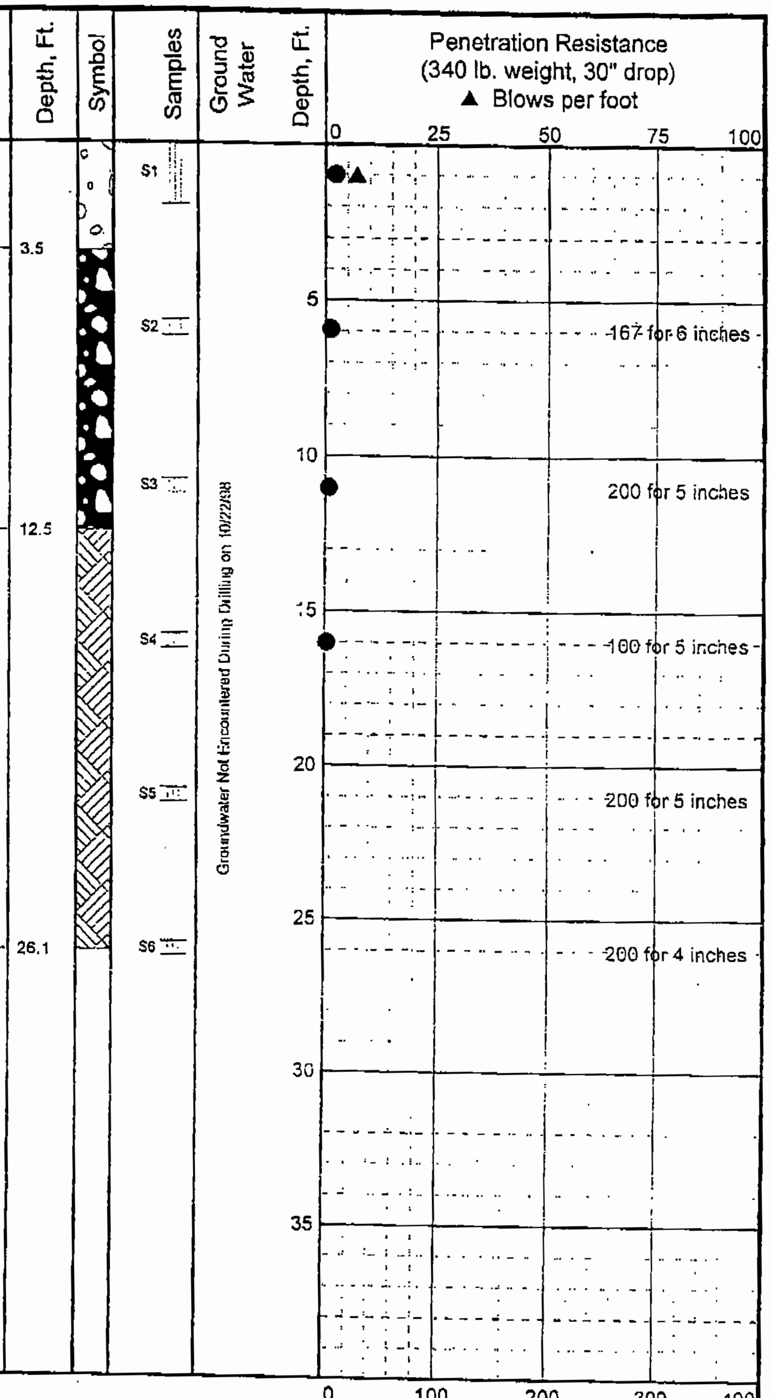
Humphrey, T. D., 1980, "Akutan Hydropower Preliminary Design Report", Ott Water Engineers for The City of Akutan, 115p.

Romick, J.D., 1982, "The Igneous Petrology and geochemistry of Norhtern Akutan Island", Alaska: Master's thesis, University of Alaska, Fairbanks, 151 p.

APPENDIX B

2001 Exploratory Data
Boring Logs

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -3.5 feet	Depth, Ft.	Samples	Penetration Resistance (340 lb. weight, 30" drop) ▲ Blows per foot
Loose, black, gravelly SAND; wet		S1	
Very dense, green/black, silty, sandy GRAVEL, with numerous cobbles; wet	3.5	S2	167 for 6 inches
		S3	200 for 5 inches
Black, soft, moderately weathered, rock	12.5	S4	100 for 5 inches
		S5	200 for 5 inches
		S6	200 for 4 inches
Bottom of Boring Boring Completed 10/22/98	26.1		



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-A

December 1998 A-994

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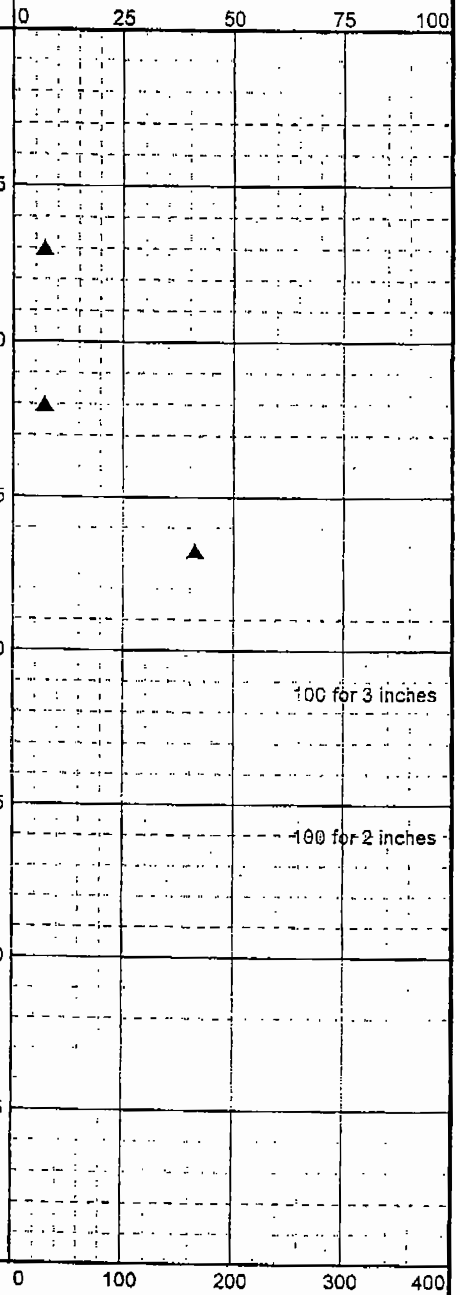
Geotechnical and Environmental Consultants

Fig. B-1

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -10.0 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Loose, gray, sligtly silty, gravelly, SAND (SW-SM), trace of clay; wet; seashells			S1, S2	Groundwater Not Encountered During Drilling on 10/24/98	5, 10
Dense, gray, slightly silty, sandy GRAVEL (GP); wet	14.5		S3		15
Hard, gray, clayey SILT; dry	19.3		S4		20
Bottom of Boring Boring Completed 10/24/98	26.0		S5 *		25, 30, 35

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



● PID Reading (ppm)

LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

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Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-1

December 1998 A-994

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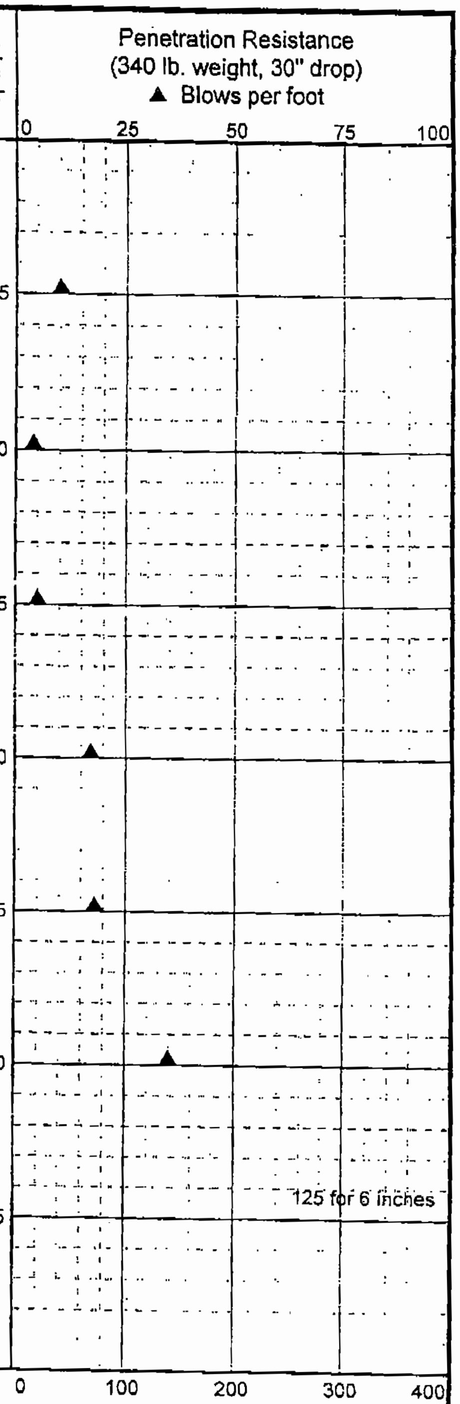
Fig. B-2

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -56.0 feet	Depth, Ft.	Samples
Loose, gray/black, SAND (SW), with occasional clay lenses and increasing gravel with depth; wet; with seashells		1, 2, 3
Medium dense to dense, gray/green, slightly silty, gravelly SAND (SW-SM); wet	17.5	4, 5, 6
Very dense, gray/green, gravelly BOULDERS(possibly soft bedrock)	31.0	7*
Bottom of Boring Boring Completed 10/24/98	34.5	

Groundwater Not Encountered During Drilling on 10/24/98



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

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Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-2

December 1998 A-994

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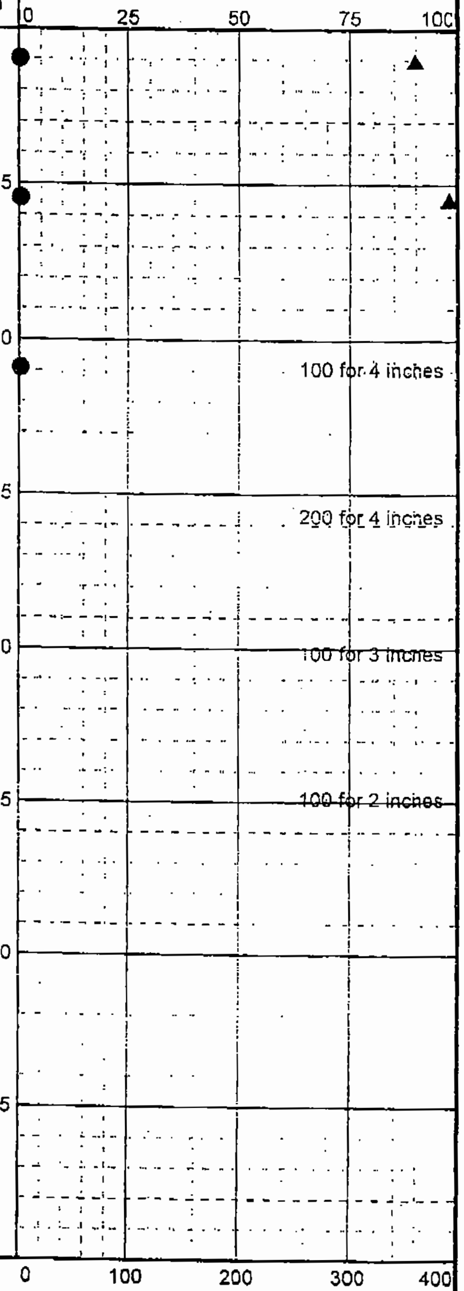
Fig. B-3

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -3.1 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Very dense, gray, slightly silty to silty, sandy GRAVEL (GW-GM), with numerous blue/grey weathered cobbles and boulders; dry to moist			S1, S2, S3, S4, S5, S6	Groundwater Not Encountered During Drilling on 10/18/98	0–25
Bottom of Boring Boring Completed 10/18/98	25.0 25.0				

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



LEGEND

- Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

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Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-3

December 1998 A-994

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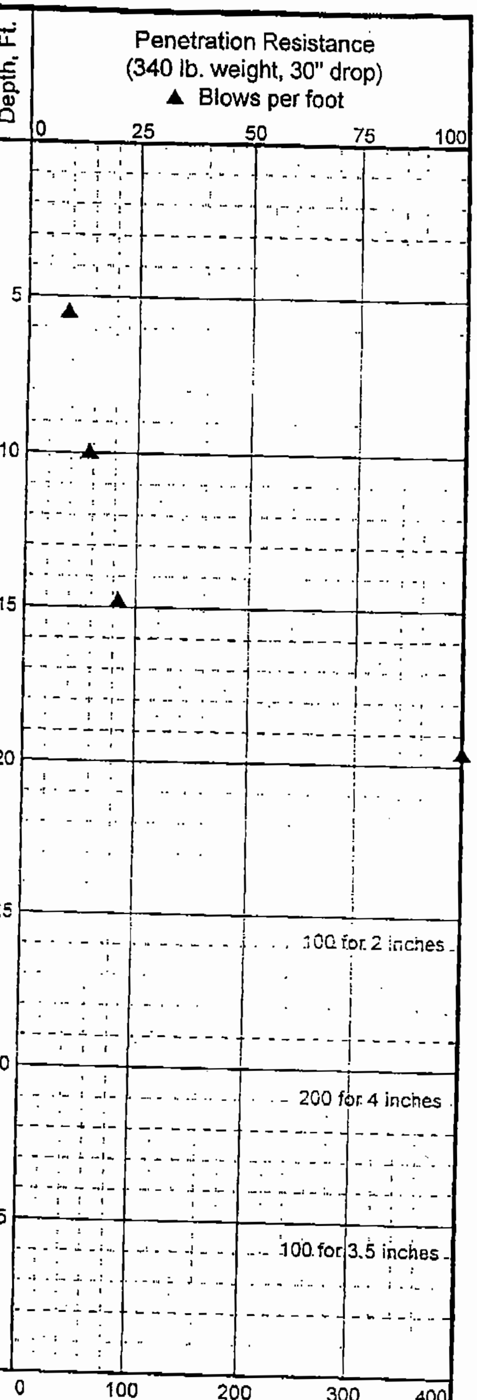
Fig. B-4

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -16.2 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Loose to medium dense, black, slightly silty SAND (SW);wet			1	Groundwater Not Encountered During Drilling on 10/17/98	5
Increased gravel			2		10
Medium dense, gray to black, sandy GRAVEL; wet	15.0		3		15
Very dense, gray/blue, silty, clayey, sandy GRAVEL, with weathered cobbles and boulders; wet	20.0		4 5 6		20 25 30 35
Bottom of Boring Boring Completed 10/17/98	36.0		7		



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

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Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-4

December 1998 A-994

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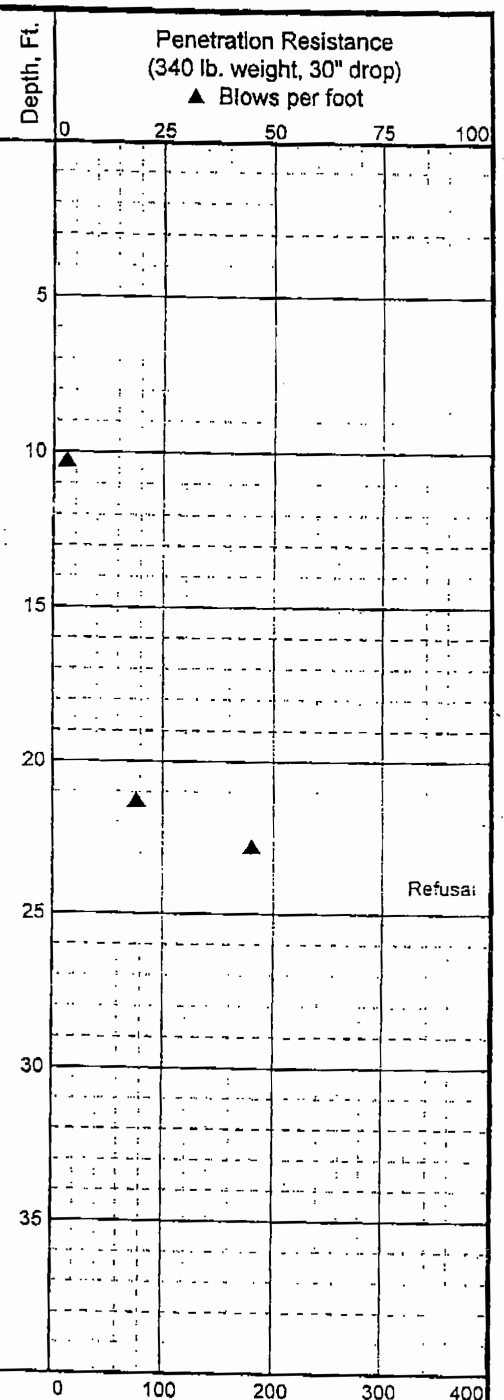
Fig. B-5

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION	Depth, Ft.	Symbol	Samples	Ground Water
Mud Line Elevation wrt mllw -49.1 feet				
Loose to medium dense, gray/black, gravelly, silty SAND (SP); wet; with seashells			1	Groundwater Not Encountered During Drilling on 10/15/98
Medium dense, black, sandy GRAVEL (GP), with weathered cobbles and boulders at approximately 25 feet bml; wet	15.0		2, 3, 4	
Very hard, gray/blue, gravelly, sandy, clayey SILT; moist	25.0			
Hard, fresh, brecciated conglomerate BOULDER	31.0		5	
	32.2			

Bottom of Boring
Boring Completed 10/15/98



LEGEND

- Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

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Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-5

December 1998 A-994

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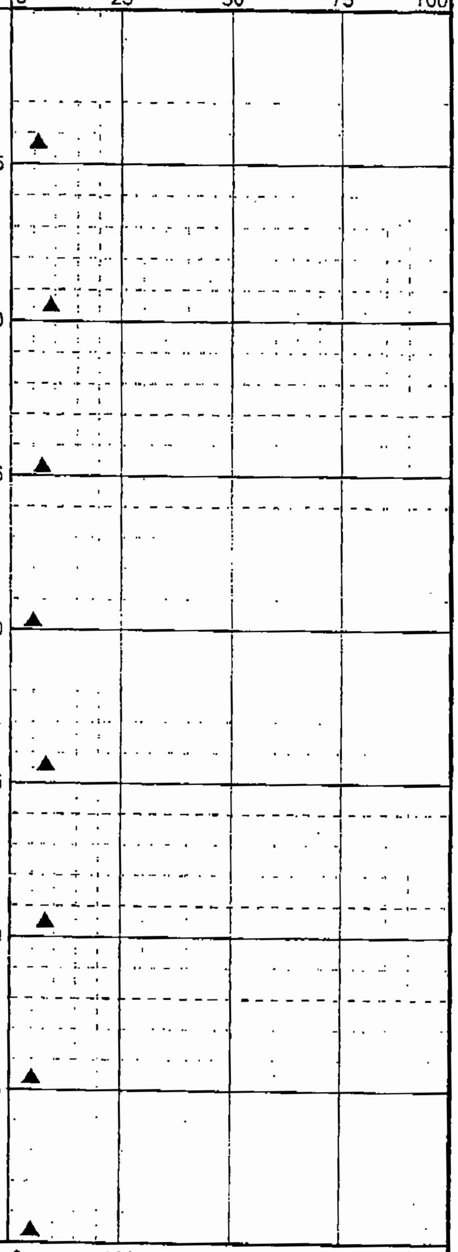
Fig. B-6

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Mud Line Elevation wrt mllw -14.7 feet					
Loose, black, slightly gravelly SAND (SP-SW); wet			1	Groundwater Not Encountered During Drilling on 10/21/98	5
			2		
Increased silt between 10 and 17 feet bml; wet	10.0				10
			3*		15
	17.0				
			4*		20
			5		25
			6*		30
			7		35
Increased silt and clay at 37 feet bml					

CONTINUED NEXT PAGE

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



● PID Reading (ppm)

LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

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Akutan Small Boat Harbor
Akutan, Alaska

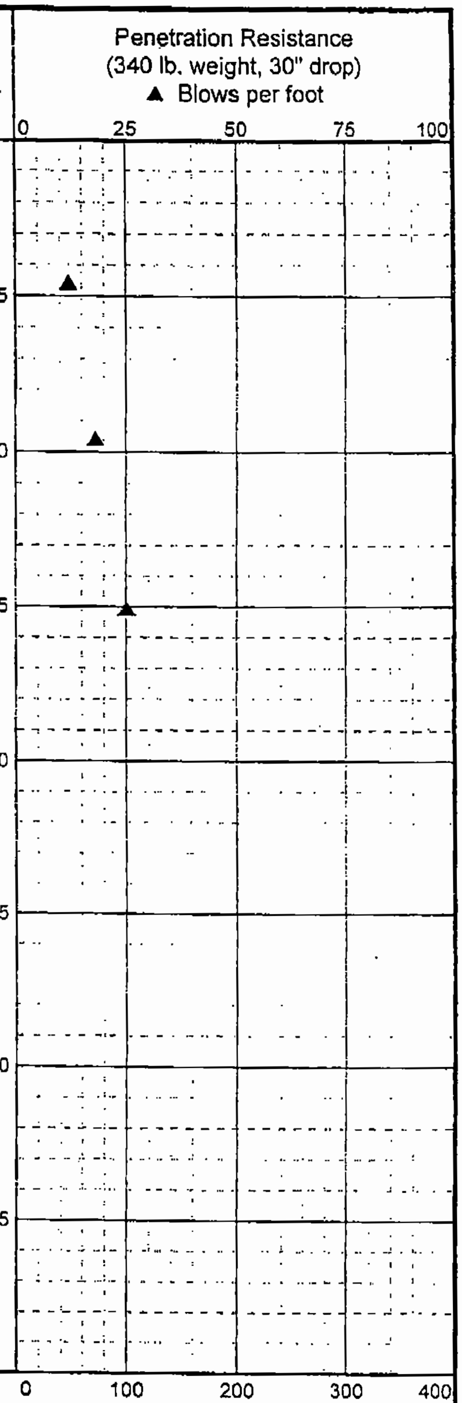
LOG OF BORING NO. BH-6

December 1998 A-994

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. B-7
Sheet 1 of 2

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -14.7 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
			8		
Medium dense, black, slightly sandy GRAVEL (GP); wet	42.0		9		45
Medium dense, gray, slightly silty, sandy GRAVEL (GP-GM), with cobbles; wet	47.0		10 11	Groundwater Not Encountered During Drilling on 10/21/98	50 55
Bottom of Boring Boring Completed 10/21/98	55.8				60 65 70 75



LEGEND

- Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

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4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-6

December 1998 A-994

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

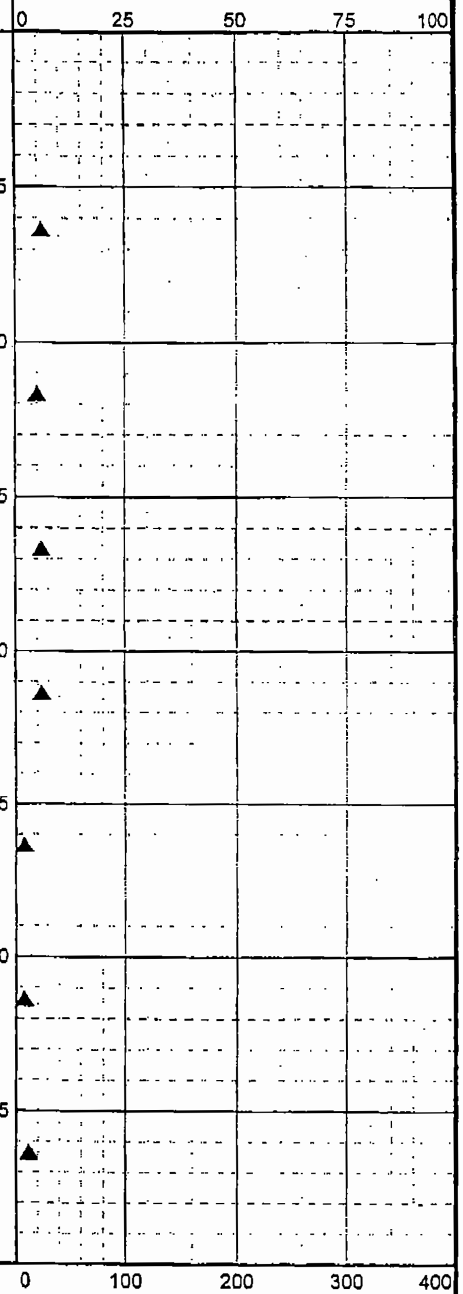
Fig. B-7
Sheet 2 of 2

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -28.6 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Loose, brown, slightly silty SAND (SW-SM); wet			1, 2, 3, 4	Groundwater Not Encountered During Drilling on 10/23/98	5, 10, 15, 20
Increased silt at 24 feet	24.0		5, 6		25, 30
Soft, gray, sandy SILT (ML); moist to wet	34.0		7		35
	39.0	C			

CONTINUED NEXT PAGE

Penetration Resistance
(340 lb. weight, 30" drop)
▲ Blows per foot



● PID Reading (ppm)

LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-7

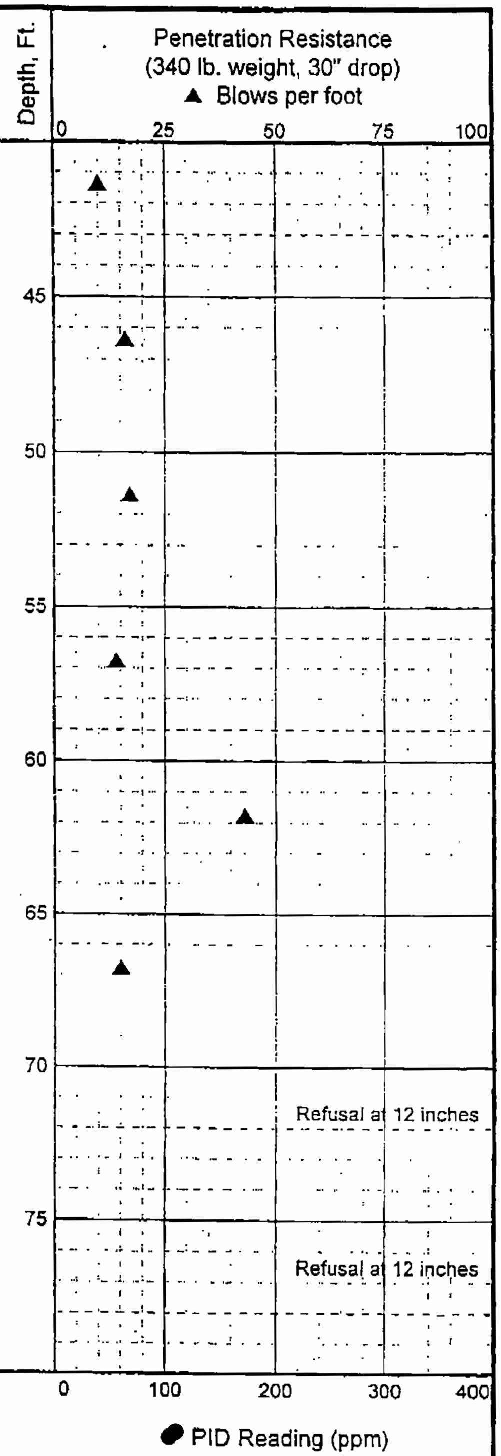
December 1998 A-994

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. B-8
Sheet 1 of 2

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -28.6 feet	Depth, Ft.	Symbol	Samples	Ground Water
Loose to medium dense, gray, slightly silty, gravelly SAND (SW); wet			8, 9	Groundwater Not Encountered During Drilling on 10/23/98
Medium dense, gray, silty, sandy GRAVEL; wet	51.5		10, 11, 12	
Loose to medium dense, brown, silty SAND (SW-SM); wet	67.0		13	
Very dense, gray, silty, sandy GRAVEL, with cobbles; wet	69.0		14, 15	
Bottom of Boring Boring Completed 10/23/98	77.0			



LEGEND

- Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-7

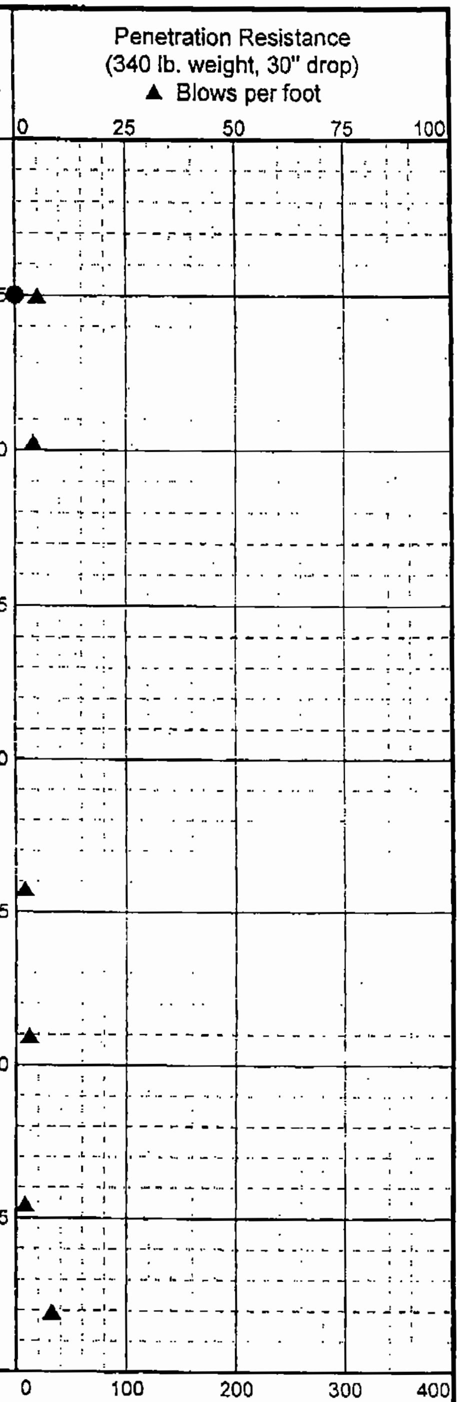
December 1998 A-994

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. B-8
Sheet 2 of 2

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -9.9 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Loose, black, slightly gravelly SAND (SP); wet			1, 2	Groundwater Not Encountered During Drilling on 10/15/98	5, 10, 15
Very loose, black, gravelly, SAND (SP); wet	16.0		3, 4		20, 25
Very loose, black, slightly gravelly to gravelly, silty SAND; wet, with shell fragments	29.5		5, 6		30, 35
CONTINUED NEXT PAGE	39.5				



LEGEND

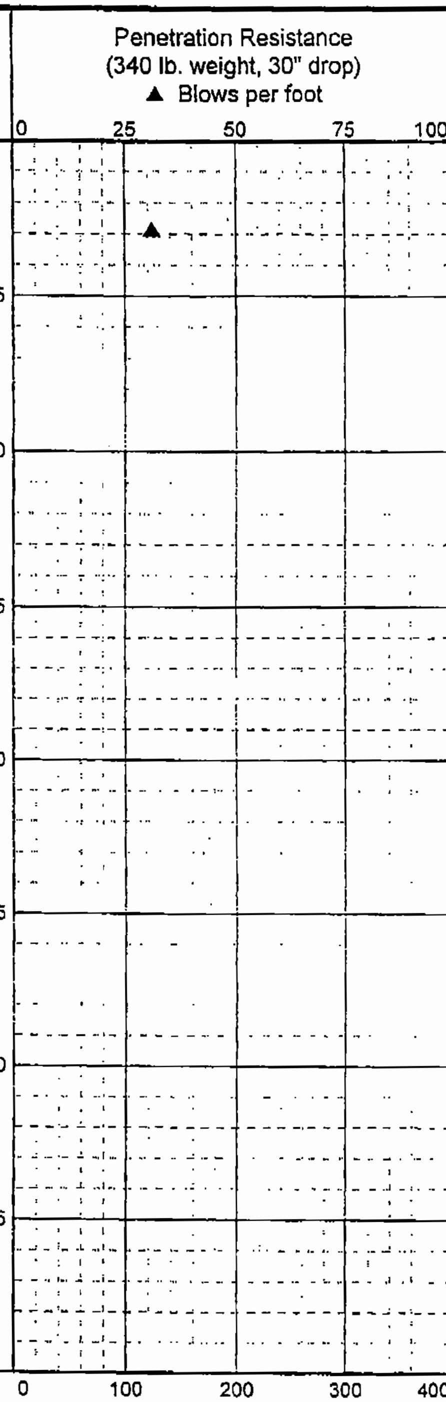
- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor Akutan, Alaska	
LOG OF BORING NO. BH-10	
December 1998	A-994
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	Fig. B-11 Sheet 1 of 2

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -9.9 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Medium dense to dense, silty, sandy GRAVEL, with cobbles; wet	43.6		7		45
Bottom of Boring Boring Completed 10/15/98				Groundwater Not Encountered During Drilling on 10/15/98	50 55 60 65 70 75



LEGEND

- • Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-10

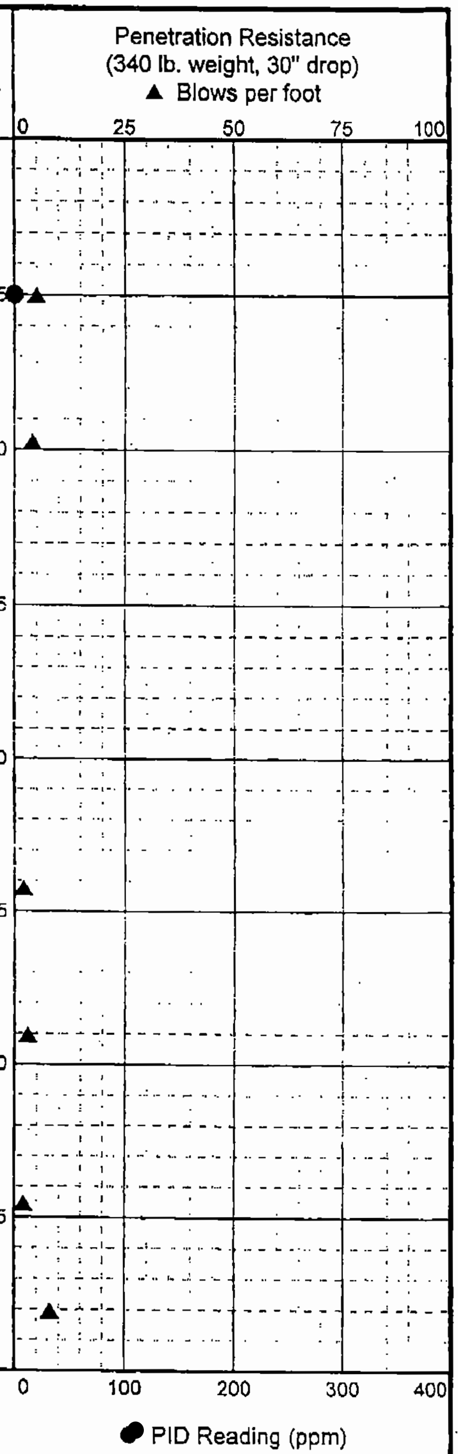
December 1998 A-994

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. B-11
Sheet 2 of 2

MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -9.9 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Loose, black, slightly gravelly SAND (SP); wet			1, 2	Groundwater Not Encountered During Drilling on 10/15/98	5, 10, 15
Very loose, black, gravelly, SAND (SP); wet	16.0		3, 4		20, 25
Very loose, black, slightly gravelly to gravelly, silty SAND; wet, with shell fragments	29.5		5, 6		30, 35
CONTINUED NEXT PAGE	39.5				



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor
Akutan, Alaska

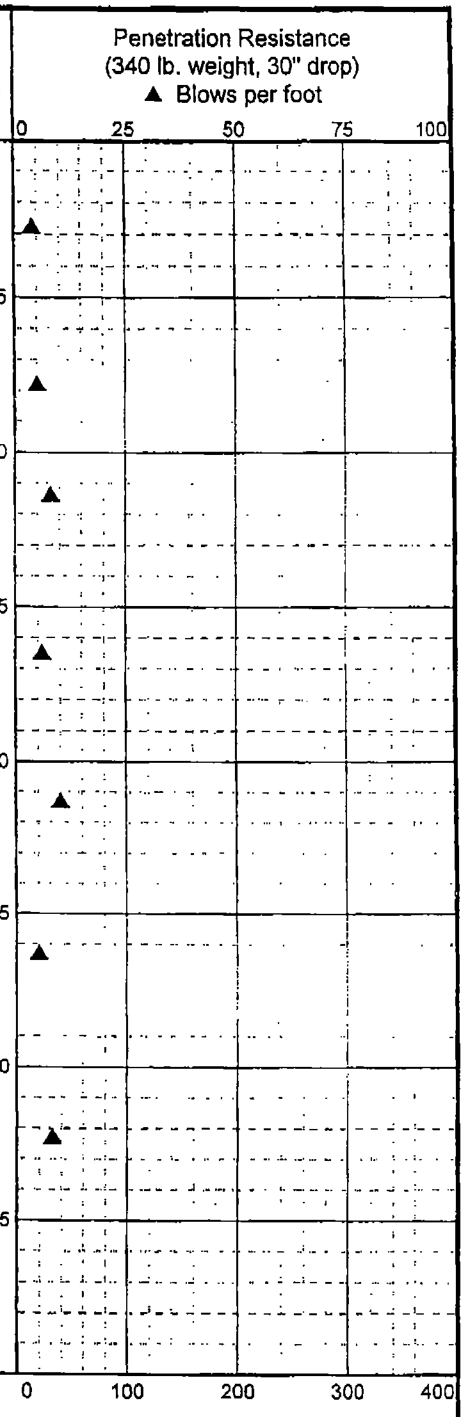
LOG OF BORING NO. BH-10

December 1998 A-994

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. B-11
Sheet 1 of 2

MATERIAL DESCRIPTION Mud Line Elevation wrt mllw -7.2 feet	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Very loose to loose, black, slightly silty, slightly gravelly SAND (SP); wet			1, 2, 3, 4, 5, 6	Groundwater Not Encountered During Drilling on 10/14/98	5, 10, 15, 20, 25, 30
Increased gravel at 31.5 feet bml			7		
Bottom of Boring Boring Completed 10/14/98	33.0				35



LEGEND

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Split Spoon Sample
- Rock Core
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- Ground Water Level ATD
- Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Akutan Small Boat Harbor
Akutan, Alaska

LOG OF BORING NO. BH-11

December 1998 A-994

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Fig. B-12

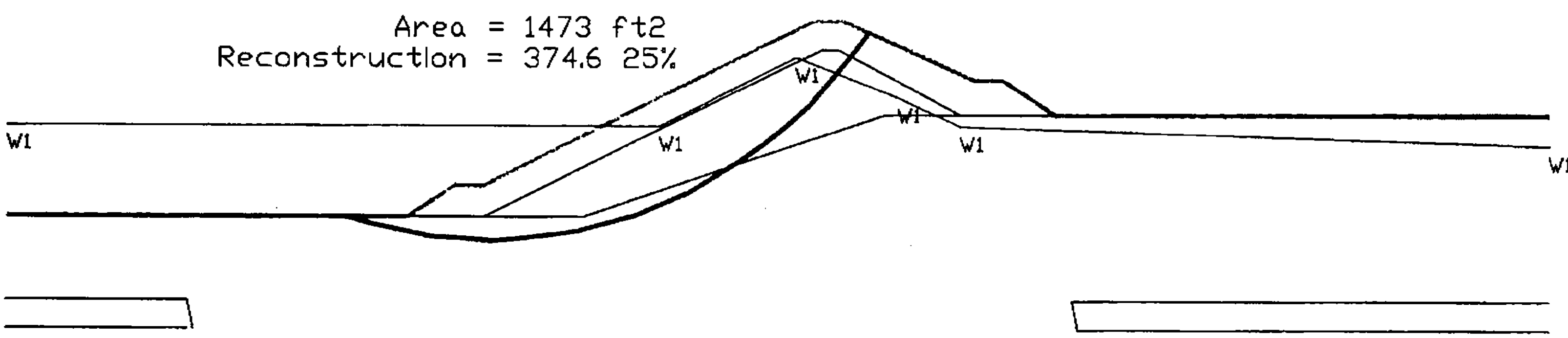
MASTER LOG A994.GPJ SHAN WIL.GDT 12/18/98

APPENDIX C

Stability Analysis Results

Akutan Breakwater, Buttress, a=30', slope 2:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=0.95
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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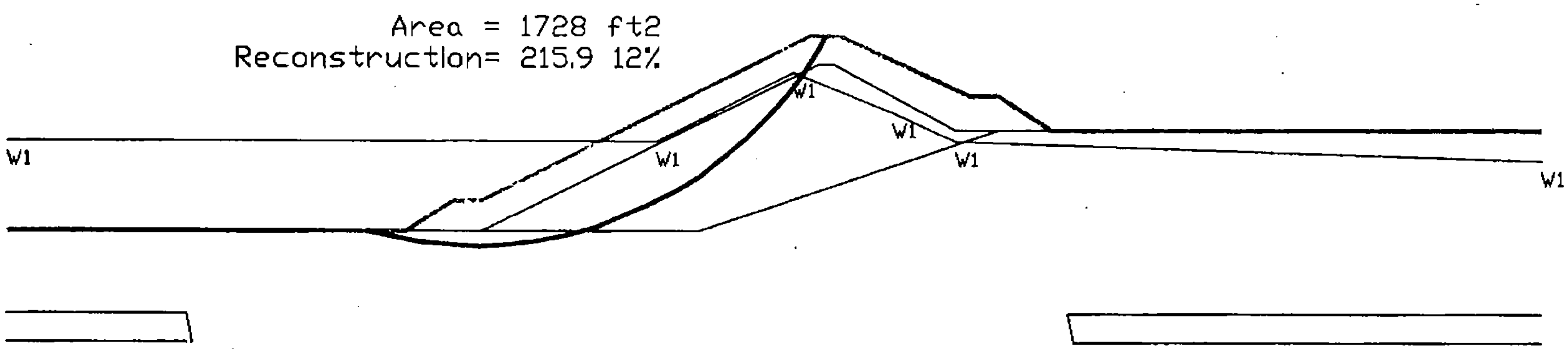
FIG. A1

Akutan Breakwater, Buttress, a=50', slope 2:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=1.00
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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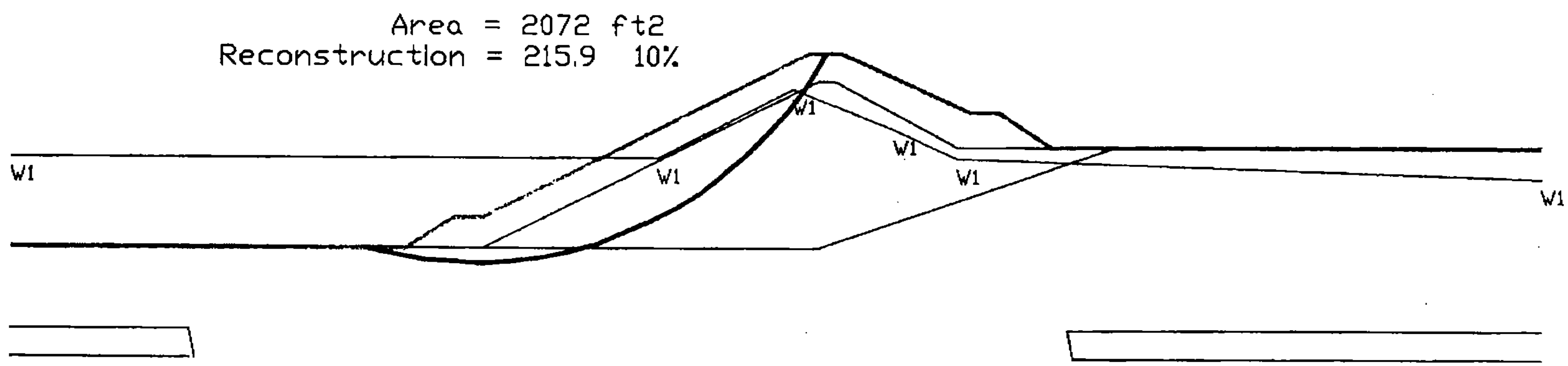
FIG. A2

6384geometry.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

Akutan Breakwater, Buttress, a=70', slope 2:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=1.00

Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60

APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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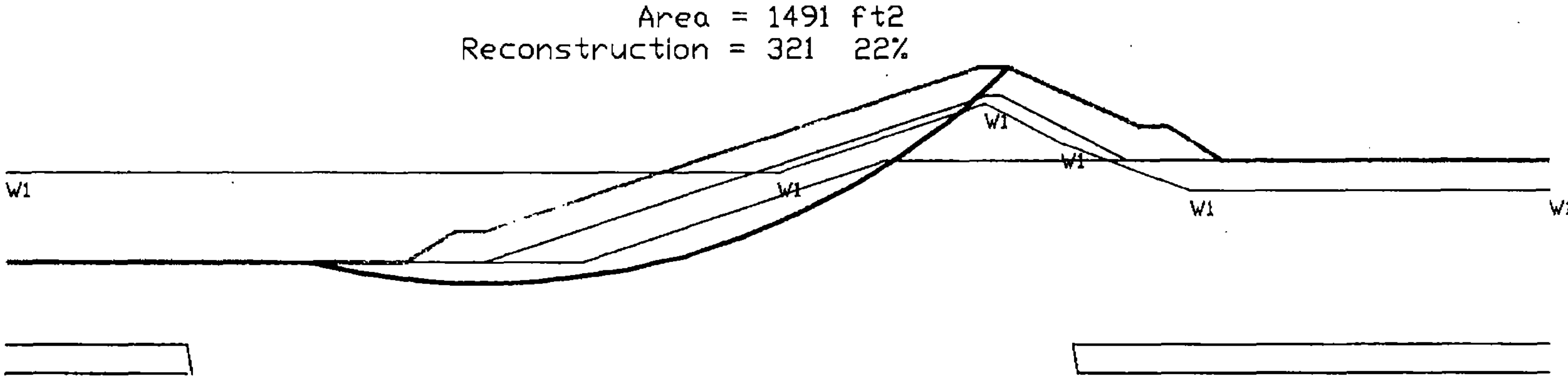
FIG. A3

6384geometry.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

Akutan Breakwater, Buttress, a=30, slope 3:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=1.11
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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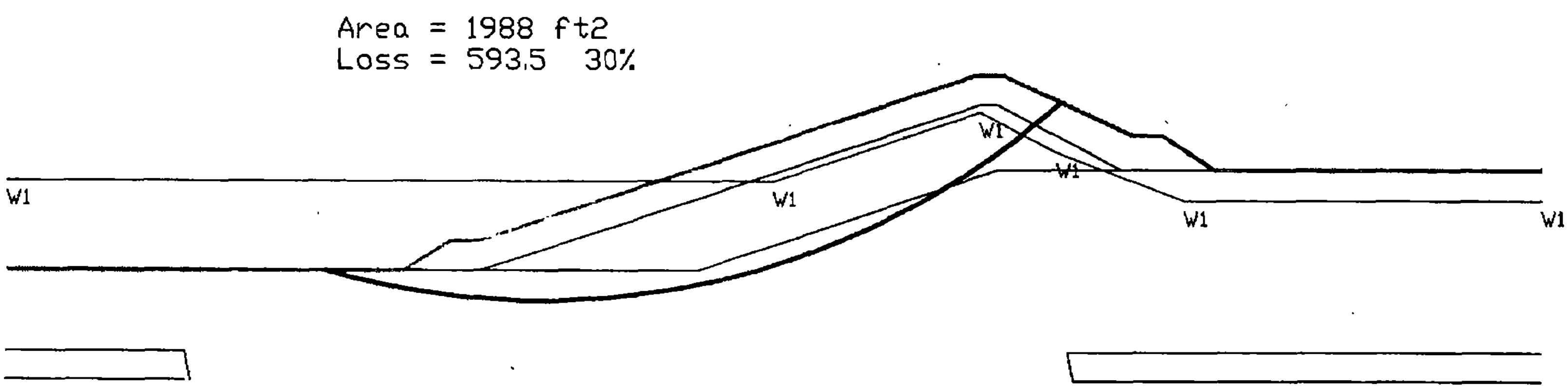
FIG. A4

16384geomwbty.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

Akutan Breakwater, Buttress, a=50, slope 3:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=1.14
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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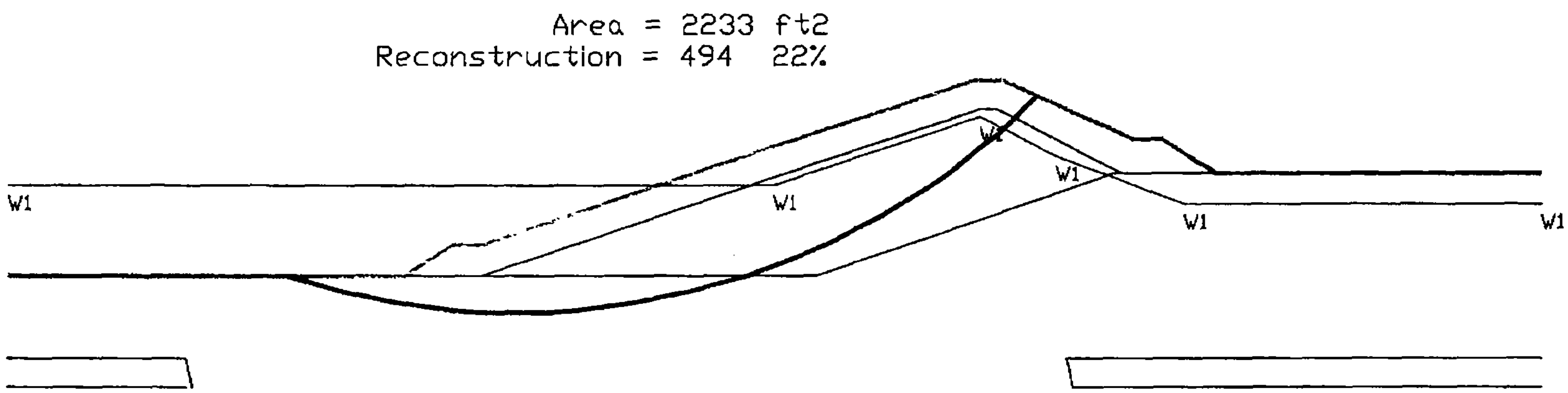
FIG. A5

Akutan Breakwater, Buttress, a=70, slope 3:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=1.22
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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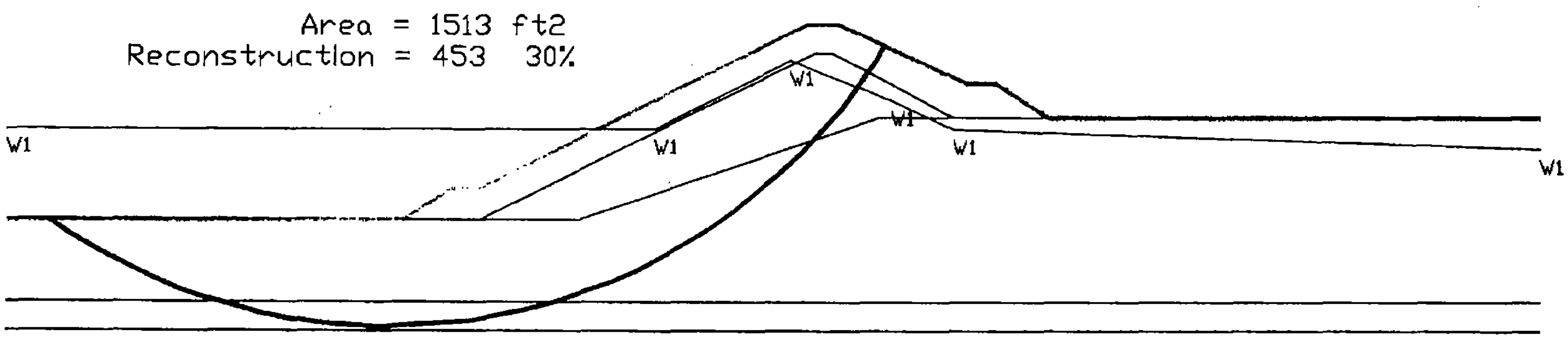
FIG. A6

6384geometry.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

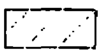
Akutan Breakwater, No Buttress, a=30', slope 2:1

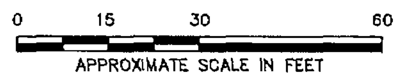
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=0.79

Safety Factors Are Calculated By The Modified Bishop Method





Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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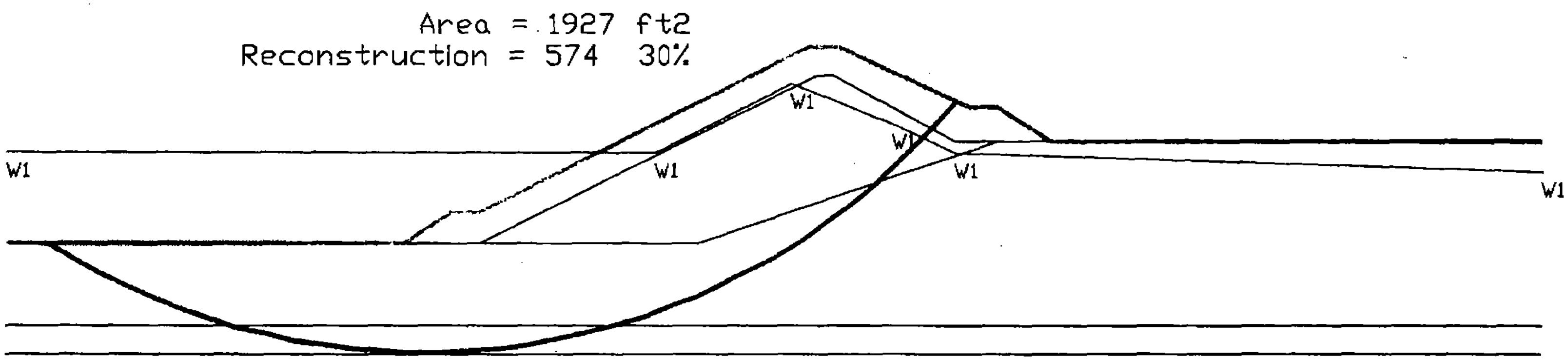
FIG. A7

6384geometry.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

Akutan Breakwater, No Buttress, a=50', slope 2:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=0.80
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 | 32-1-16384

SHANNON & WILSON, INC.
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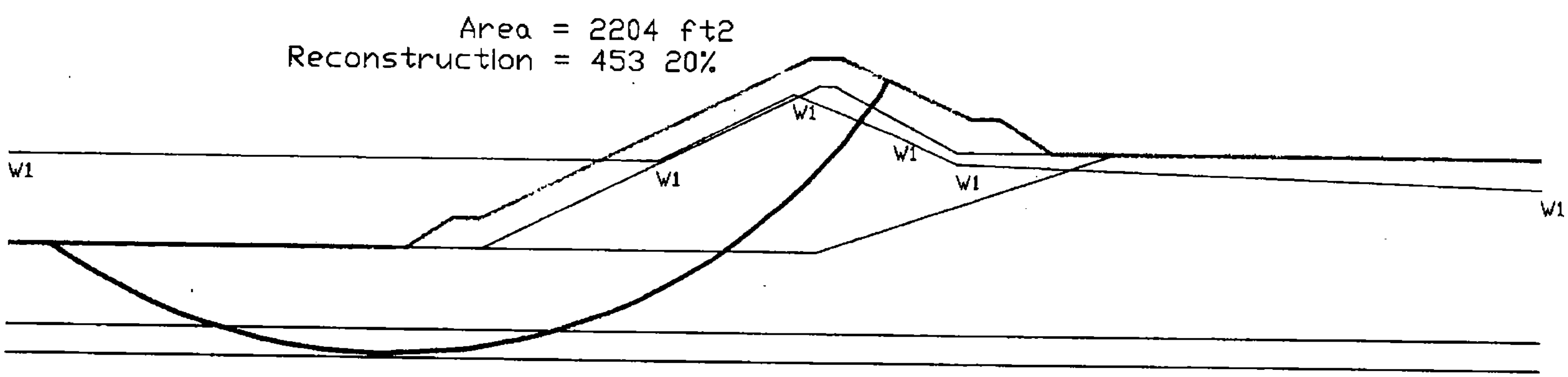
FIG. A8

Akutan Breakwater, No Buttress, a=70', slope 3:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=0.81
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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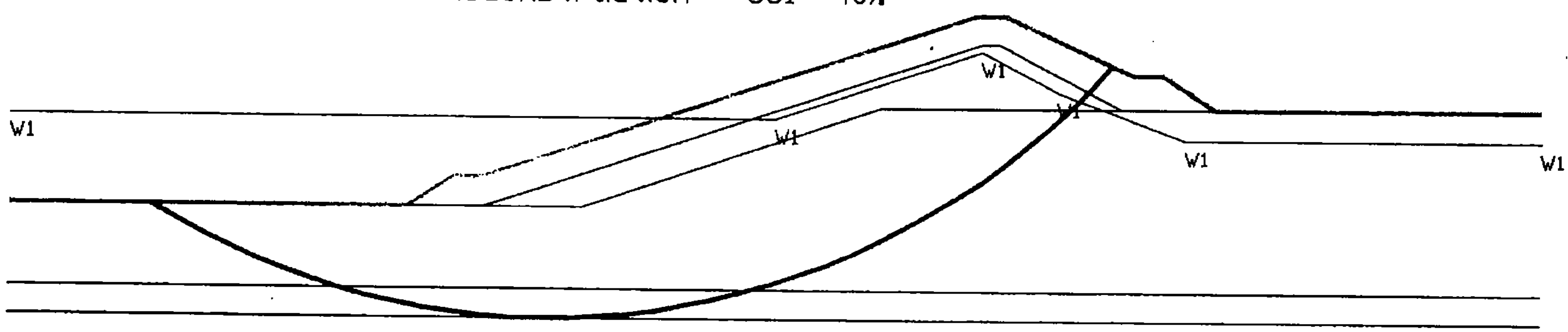
FIG. A9

Akutan Breakwater, No Buttress, a=30, slope 3:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1

Area = 1690.5 ft2
Reconstruction = 681 40%



GSTABL7 v.2 FSmin=0.80
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

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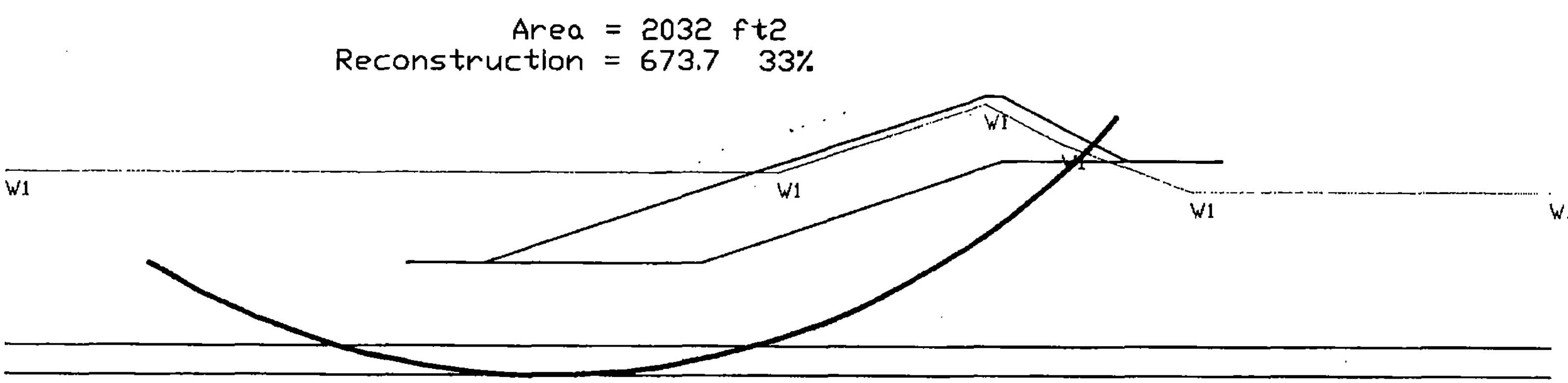
FIG. A10

6384geometry.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

Akutan Breakwater, No Buttress, a=50, slope 3:1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=0.80
Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement

0 15 30 60
APPROXIMATE SCALE IN FEET

Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

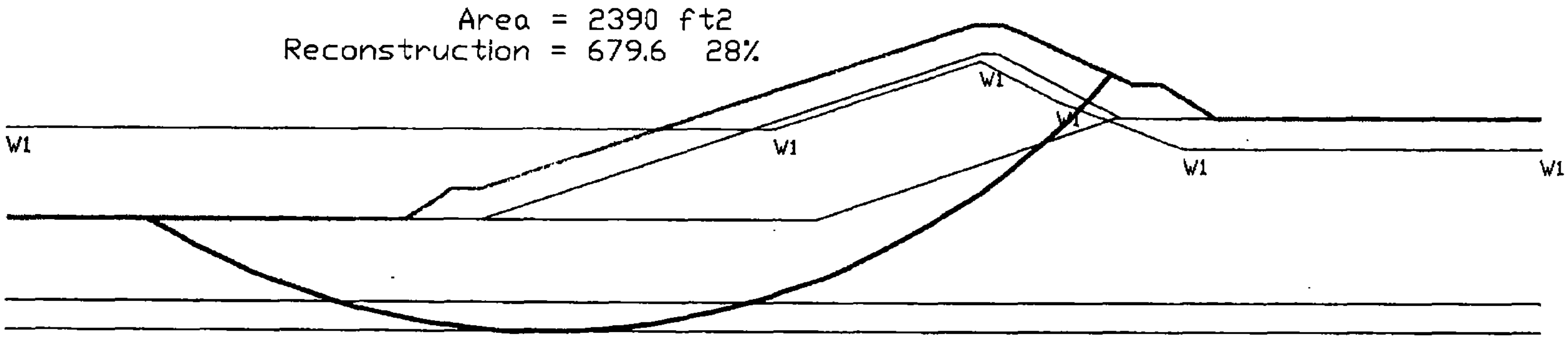
SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

FIG. A11

6384geometry.dwg 1:1 12/4/01 Shannon & Wilson, Inc.

Akutan Breakwater, No Buttress, a=70, slope 3:1

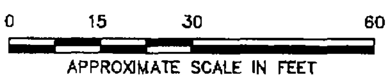
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Rip Rap	1	150.0	150.0	0.0	40.0	W1
Gravel	2	120.0	140.0	0.0	38.0	W1
Native	3	100.0	115.0	0.0	32.0	W1
Siltzone	4	90.0	105.0	250.0	0.0	W1



GSTABL7 v.2 FSmin=0.80

Safety Factors Are Calculated By The Modified Bishop Method

Approximate Reconstruction Requirement



Akutan Small Boat Harbor
Akutan Bay, Alaska

GRAPHICAL STABILITY ANALYSIS RESULT

December 2001 32-1-16384

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

FIG. A12

APPENDIX D

Important Information About Your Geotechnical/Environmental Report

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to Geotechnical Report
Dated: December 2001
To: John Daley, Tryck Nyman Hayes
Re: Akutan Small Boat Harbor, 32-1-16834

Important Information About Your Geotechnical/Environmental Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

APPENDIX D
CIRCULATION STUDY
NAVIGATIONAL IMPROVEMENTS AT
AKUTAN, ALASKA

1. Introduction

1.0 Akutan Setting

Akutan Harbor is located on Akutan Island in the Fox Island group of the Aleutian Islands (Figure 2.). It is about 40 nautical miles east-northeast of Unalaska. The harbor's longitudinal axis lies almost east-west and the harbor is 3.5 n.m. long and 0.5 n.m. wide at its head, on the west end, and increases to about 2 n.m. wide near its open, eastern end. It is just over 200 feet deep near the central portion of its mouth. There are two small fresh-water streams that enter the harbor near the head of the bay; one on the north side and one on the south.

The only industry is the Trident Seafoods fish processing plant located on the north shore between a half and three-quarters of a mile west of the Community of Akutan (Figure 1).

Figure 1. View of Akutan Harbor looking east toward the mouth of the harbor.

Fishing is the principal livelihood for the Akutan locals. Akutan is included in the Aleutian East Borough. It is serviced on a daily basis by floatplane from Unalaska. There are no airport or harbor facilities. Inclement weather routinely causes major delays or cancellations of these flights. There is a community dock where fuels and other materials are offloaded.

The harbor is bordered on both sides by mountain ridges with peaks that are 1,500 to 2,000 feet high. The elevations between these peaks can be on the order of 1,000 feet. These features channel the winds up and down the harbor in an east-west direction. Only close to the shoreline and due to the shoreline orientation is the wind direction likely to vary from this channel wind direction. Occasionally, winds may sweep down from lower portions of the ridges and approach the harbor from the side. These are probably short-lived, localized events that do not contribute much to the harbor circulation.

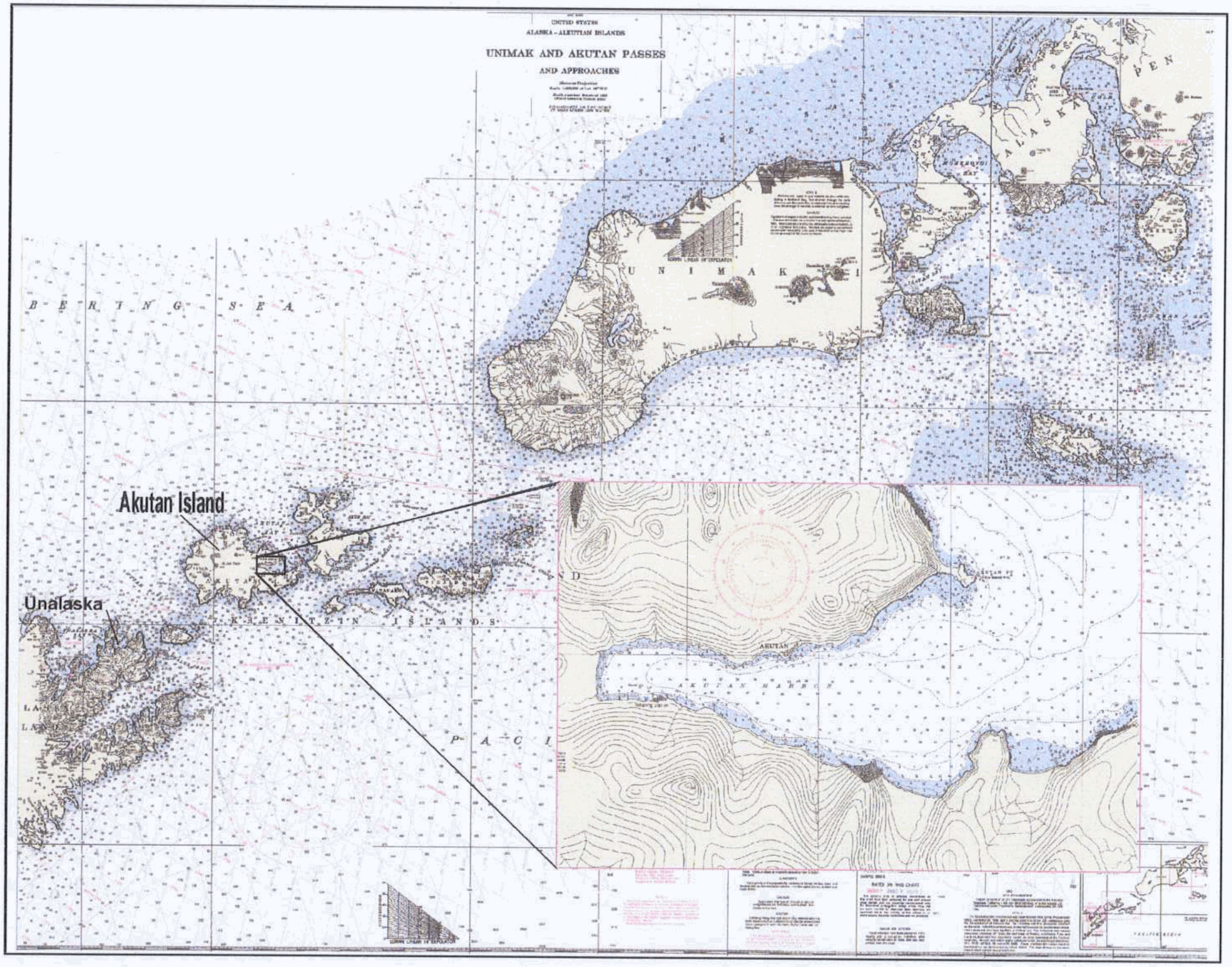


Figure 2. Portion of Aleutian Islands containing Akutan Island and enlargement of Akutan Harbor

The Aleutians are known for their winds and Akutan is no exception. There is generally a wind of a few knots blowing up or down the harbor.

1.1 Small Boat Basin Study

The U. S. Army, Corps of Engineers (Corps) is investigating the feasibility of a small-boat-harbor at the head of the harbor. The design being considered consists of a 12-arce, rectangular basin about 300 meters (1,000 feet) long by 245 meters (800 feet) wide. The longer axis runs north-south. The entrance is located on the northeast corner and is about 60 meters (200 feet) wide and 150 meters (500 feet) long. The entrance is directed roughly to the southeast from the basin into Akutan Harbor. The basin is subdivided into three distinct regions that differ from one another by depth. The shallower inner basin has a design depth of –4.3 meters (–14 feet) relative to mean-lower-low-water the middle and outer basins are –4.9 and 5.5 meters (–16 and -18 feet), respectively. The plan is to allow smaller boats access to the entire basin and restrict the access to larger vessels.

To reduce the marine footprint of this project, the basin is to be dredged completely from upland real estate. Some of dredge spoils will be used for constructing upland facility sites and the remainder dumped offshore. There is considerable likelihood that fresh water will enter the basin through its side slopes.

1.2 Potential Concerns

The outfalls at the Trident plant discharge significant quantities of possessing wastes directly into Akutan Harbor. Those discharges have been the subject of past studies during the process of securing NPDES discharge permits by various processors. These concerns will not be revisited in this report.

The Corps is primarily concerned with what effects these discharged wastes may have on the boat harbor project and, in turn, what impacts the boat harbor might have on Akutan Harbor water quality and on certain bird species that are known to over-winter in the southwestern portion of the harbor. There has been no effort to attempt to correlate the discharge distributions with timing or type of plant or animal activities.

Mixing in boat harbors in Alaska and elsewhere is highly dependent on tides. Generally speaking, larger tidal ranges produce better water quality in a boat harbor than do smaller ranges. However, there is ample evidence that harbor design shape and entrance configuration can substantially impact water quality.

The tides in Akutan Harbor are mixed showing about equal contributions by diurnal and semidiurnal components. The diurnal range is 1.2 meters (3.9 feet) and the semidiurnal range 0.73 meters (2.4 feet). This is small in comparison to most of the mainland sites in south-central and southeast Alaska. Added to this is the large entrance width to basin cross-sectional area ratio. The smaller this ratio, the greater the chance of developing momentum in the incoming and outgoing flow. Higher momentum generally results in better mixing. To accommodate larger vessels and still create a basin that is reasonably priced, this ratio needs to be relatively high but unfortunately, at the expense of improved mixing.

The Corps also expressed concern about the fate of spilled substances that tended to float on the water column. Such spills might occur at the boat basin or from vessels traveling to or from the basin. There are certain areas near the proposed basin where birds are known to over-winter. The Corps wanted to be able to observe the trajectory of this material to determine when and under what conditions a spill could come in contact with these areas used by birds. Presumably the primary concern here is with petroleum products. A series of questions were developed to address these and other issues. They will be stated in the following section.

1.3 Purpose of this Report

Several issues will be addressed in this report some probably with more clarity than others. For example, a primary concern is whether fish wastes from Trident's operation can buildup in the boat harbor. To assess this, at least three discharge types may need to be investigated: the soluble portion, the suspended material and the heavier fraction that comprises the solids piling up on the bottom of the harbor directly under the discharge. Clearly, this latter portion cannot directly affect the boat basin that will be located over a mile to the west. The suspended material might travel this distance but if it does reach the basin, will it remain in the basin? Finally there is the dissolved fraction characterized by its BOD content. This is the fraction that will likely have the greatest impact to the boat harbor (it is the most easily transported) and it is the fraction that has been considered in the greatest detail.

The questions that have been addressed include:

1. The possible buildup of fish processing wastes in the harbor.
2. The flushing rate/volume exchange that is anticipated in the boat basin due to tides and winds.
3. The direction of flow of the effluent from the boat basin.
4. The potential for exceeding the State's water-quality standards for certain substances within the basin.
5. Under what conditions would there be a BOD/DO problem in the mooring basin.
6. If settleable solids have enough residence time in the basin to accumulate in the basin sediments.
7. The influence of freshwater intrusion into the mooring basin on the possible enhanced buildup or discharge of contaminants.

Some of these questions will be answered directly such as fish waste concentrations in the vicinity of the boat basin and the flushing characteristics of the basin. Others like the likelihood of material settling in the harbor and of freshwater effects in the harbor are more subjective. An attempt will be made to address each issue on some level.

The next section will present the **Methodology** used to conduct the analysis. The **Results** section will describe the information that was generated and conditions under which it was developed. The **Conclusions** section readdresses each of these concerns in order and presents the best explanation in view of the analysis conducted. There are two appendices: The **Equations of Motions** which is a compilation and description of the equation used and solved in the model POM; **The POM Code** is a listing of the Fortran code that POM requires to solve the pertinent equations. There is also a CD Rom containing a **Spill Trajectory Model**. When installed on a standard PC, it will permit a user to investigate the fate of a spill consisting of a floating substance by tracking its trajectory. The spill can be transported by a combination of winds and currents.

1.4 Past Studies

Studies associated with Trident's operations date back to 1983; Trident began its shore-based operation in 1982. Tetra Tech (1993) summed up the past studies quite succinctly.

> "The adverse effects on benthic biota of the accumulation of seafood waste solids on the harbor bottom has been documented in previous studies (Jones & Stokes Associates 1983, 1993; Jones & Stokes Associates and Tetra Tech 1984a,b, 1989; Tetra Tech 1986). The effect of these seafood waste piles on overlying water quality has also been investigated; particularly the effect of release of ammonium nitrogen and hydrogen sulfide from the waste piles on water column dissolved oxygen (DO) concentrations (Jones & Stokes Associates 1983; Jones & Stokes Associates and Tetra Tech 1984b; Tetra Tech 1986) "

The Environmental Protection Agency, Region 10 (Seattle) conducted further water-quality modeling of Akutan Harbor (1996). The velocities used for the model were predicated on the assumption that circulation in Akutan Harbor (in the absence of wind) is assumed to resemble a 2-layer system driven by outflow on the surface caused by land runoff and flow in at the bottom to account for entrainment by the outflow. This probably over-simplifies the process and the combination of wind and tidal action appears to generate a horizontal gyre that assists in flushing pollutants from the harbor.

1.5 Spill Trajectory

In an attempt to determine the fate of spill substances in the harbor, a spill trajectory model was developed that could be run as a stand-alone program. It provides users with input controls for wind speed and direction and a means to adjust spill properties. The spill model uses a general circulation pattern developed with the hydrodynamic model POM (an acronym for Princeton Ocean Model). In addition the random motions associated with turbulence are taken into consideration. This model can quickly look at combined wind and current scenarios to determine areas that might be more or less exposed to the effects of a spill.

2. Methodology

2.1 General

In this project, two 3-dimensional models have been constructed: a 100-meter grid element by 20 layers for the outer harbor and a 7.62-meter (25-foot) grid element by 10 layers for the boat basin. They are used to calculate velocities and material transports. In the Akutan Harbor case, an assumed discharge of biological oxygen demand (BOD-taken from past documentation and Trident's NPDES permit) at the Trident Seafoods outfall is used as the material substance. We have treated the BOD as a conservative property, but to the extent that it is reduced, a like reduction in dissolved oxygen (DO) can probably be assumed.

In the boat basin, the problem is treated differently. A initial basin concentration is assumed for all points in the basin (3-dimensionally distributed) and the change in this concentration is tracked over time by modeling the primary processes affecting this distribution.

A basic difference between these models and of those of earlier studies is the fact that wind and other forcing functions can cause the water at different depths to move in different directions; material transports similarly and show marked vertical variation.

2.2 Princeton Ocean Model

The model chosen to use for this study is often referred to as the Princeton Ocean Model (POM). The principal attributes of the model are as follows:

- It contains a turbulence closure sub-model to provide vertical mixing coefficients. In other models it is necessary to guess the values of these parameters.

- It is a sigma coordinate model in that the vertical coordinate is scaled on the water column depth.

- The horizontal time differencing is explicit whereas the vertical differencing is implicit. The latter eliminates time constraints for the vertical coordinate and permits the use of fine vertical resolution in the surface and bottom boundary layers.

- The model has a free surface and a split time step. The external mode portion of the model is two-dimensional and uses a short time step based on the CFL condition and the external wave speed. The internal mode is three-dimensional and uses a much longer time step.

- This model has the largest user base of any 3-D ocean model and as such has been subjected to considerable and constant scrutiny for nearly 20 years. This scrutiny includes verification of velocities and material transport.

Some of the following information is from the "User's Guide for a Three-Dimensional, Primitive Equation, Numerical Ocean Model" by George Mellor. This report can be found at the home page for the Princeton Ocean Model (http://www.aos.princeton.edu/WWWPUBLIC/htdocs.pom/).

The layers in the model are incorporated using a so-called Sigma-coordinate system that is described briefly in Appendix A, Equations of Motion, which is available upon request. To use the model it was necessary for Coastline Engineering to make significant modifications to the model to make it usable for the application in Akutan. To use the model it was necessary to:

- Construct a numerical depth grid for Akutan Outer Harbor and for the small boat basin.

- Generate appropriate subroutines to input the depths and other information and output velocities, concentrations, times, and other output.

- Create the necessary tidal boundary conditions for the outer solution. Create boundary conditions for the inner or layered solutions. These include: water velocity, salinity, temperature, material to be transported.

- Create suitable subroutines to provide a material source for the model.

The reader is probably not interested in the details of this code. Following are brief comments on the parts that are pertinent to a review of the output. It is anticipated that the code will not be of significant interest; however, it is available upon request to answer any questions that may arise.

2.3 Grid Development

Being a finite-difference model, POM requires an external, rectangular grid; intersection points form nodes. The model generates the vertical nodes internally. The grid is generated in the program MapInfo after a NOAA chart of the area has been displayed as a raster image. Using MapInfo, two grids are generated; the first is a rectangular grid encompassing the entire model area and the second is a "clip-out" of that grid and encompasses only the watered area of that grid. The nodes' positions are converted to UTM coordinates. A flag is attached to each of these to indicate whether the node is a land (0) or a water node (1) point and then output as text (ascii) files. Outside of MapInfo these are combined into a single file, but the appropriate value for the flag will be retained. This is, in essence, just changing the flag value in the original grid from 0 to 1 if it is located in water. To get the depths for these points then requires that it be combined with a bathymetry file.

The digitized chart depths (bathymetry) were acquired from NOAA and the program GEODAS was used to output the depths and their position (in latitude and longitude) that specifically pertain to the model area. These positions are then converted to UTM in

MapInfo and then output as text files. Using this depth file, software was then written to associate depths for each of the grid points that have a flag value of 1. Several grid sizes were used from 25 meters between nodes to 400 meters between nodes before the final sizes used for the two applications were chosen.

2.4 Akutan Harbor

The grid for the outer harbor is 64 grids in the X or east direction and 39 in the Y or North direction. The grid spacing is 100 meters. The grid also contains 20 layers for a total of 49,920 grid cells. The grid is shown in Figure 3.

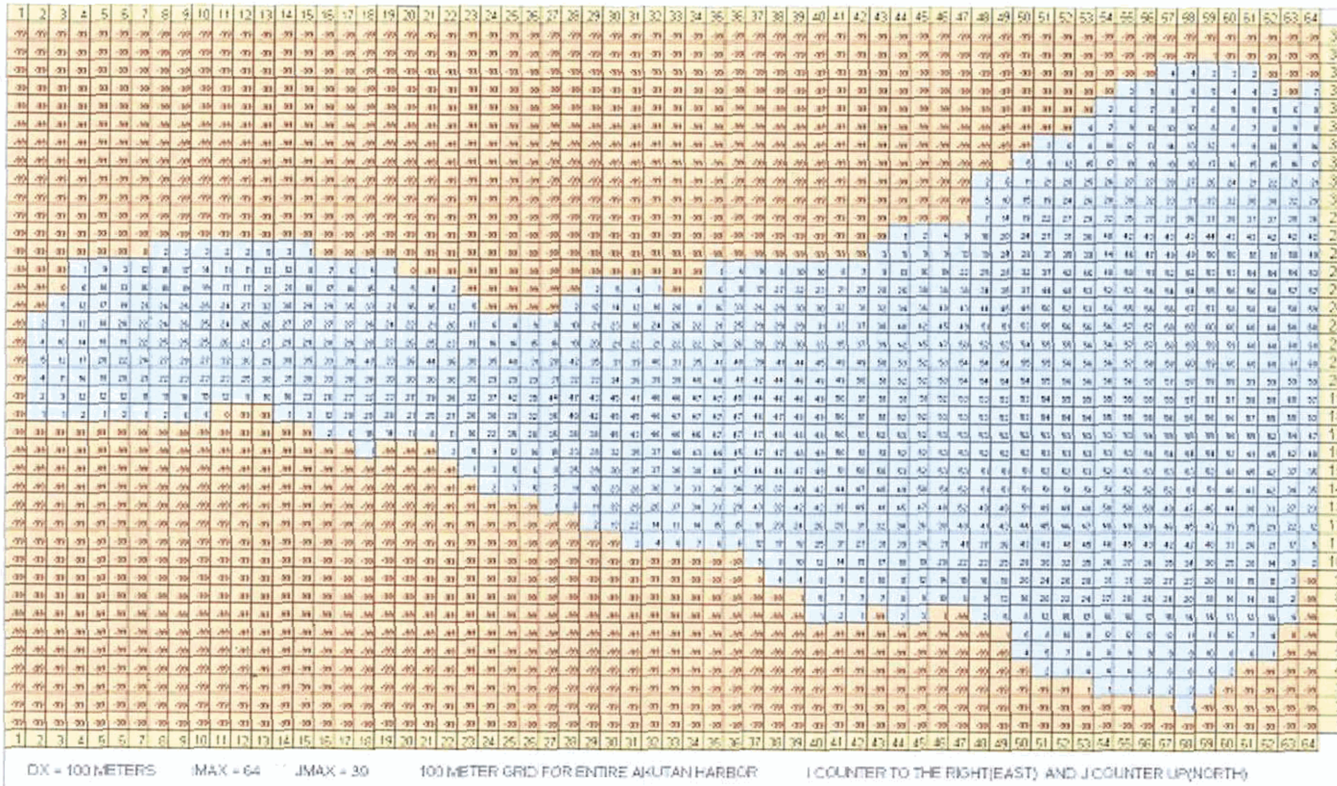


Figure 3. 100 meter grid of Akutan Harbor—depths in meters.

Part of the solution (external) used by POM is completely explicit and requires that the computational time step must be related to the water depth and the grid size. Given the selected grid size and the maximum water depths in Akutan Harbor, this required that the time step for this external part be no larger than one second. Therefore to produce a simulation of one tidal cycle (12.4 hours), 44,640 calculations over the entire grid must be accomplished. For each run (most of which were never used) about 20 tidal cycles were simulated. Fortunately, not every parameter needed to be calculated with this frequency; salinity, temperature, and material substance concentrations, which are part of the internal solution, are calculated at each 30th step of the external solution. However, even with the availability of today's rapid computers, each run consumed about 8 hours.

A simplification of the two modes is shown in Figure 4. In the figure the external mode is 2-dimensional and calculates the average (vertically) velocities and the surface elevations. The time step is limited by the Courant-Friedrichs-Lewy (CFL) condition, as briefly described above. Many external time steps are made for each internal-mode step. In that time step, the velocities and concentrations are calculated for each layer. For each grid cell the velocities, surface elevations, and concentrations are calculated as shown in Figure 5.

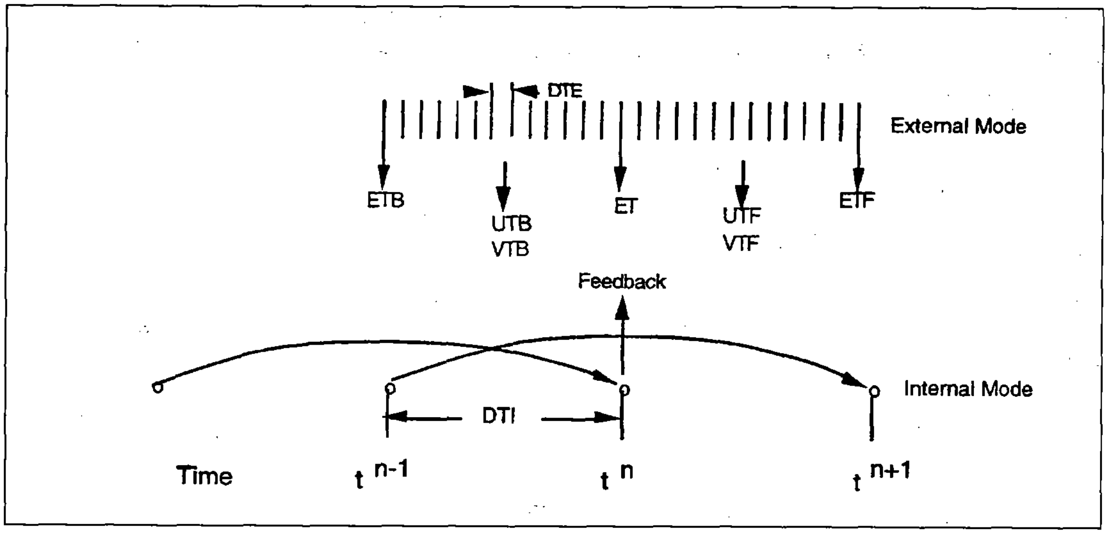


Figure 4. Time step scheme for the external (explicit) and internal (semi-implicit) modes.

2.5 Boat Basin

The small boat bain envisioned for development at Akutan is shown in Figure 4. The grid used to generate flows and concentration pattern in the boat basin was different, and much simpler, than for Akutan Harbor. To attain reasonable resolution in the boat basin, a node spacing of 7.62 meters (25 feet) was used. This produced a 45 by 42 point horizontal grid to capture the entire basin and entrance. Ten layers were used to describe the vertical distribution. A time step of 0.333 seconds was permitted by the CFL condition for the exterior mode of POM. The grid used for the boat basin is shown is Figure 6.

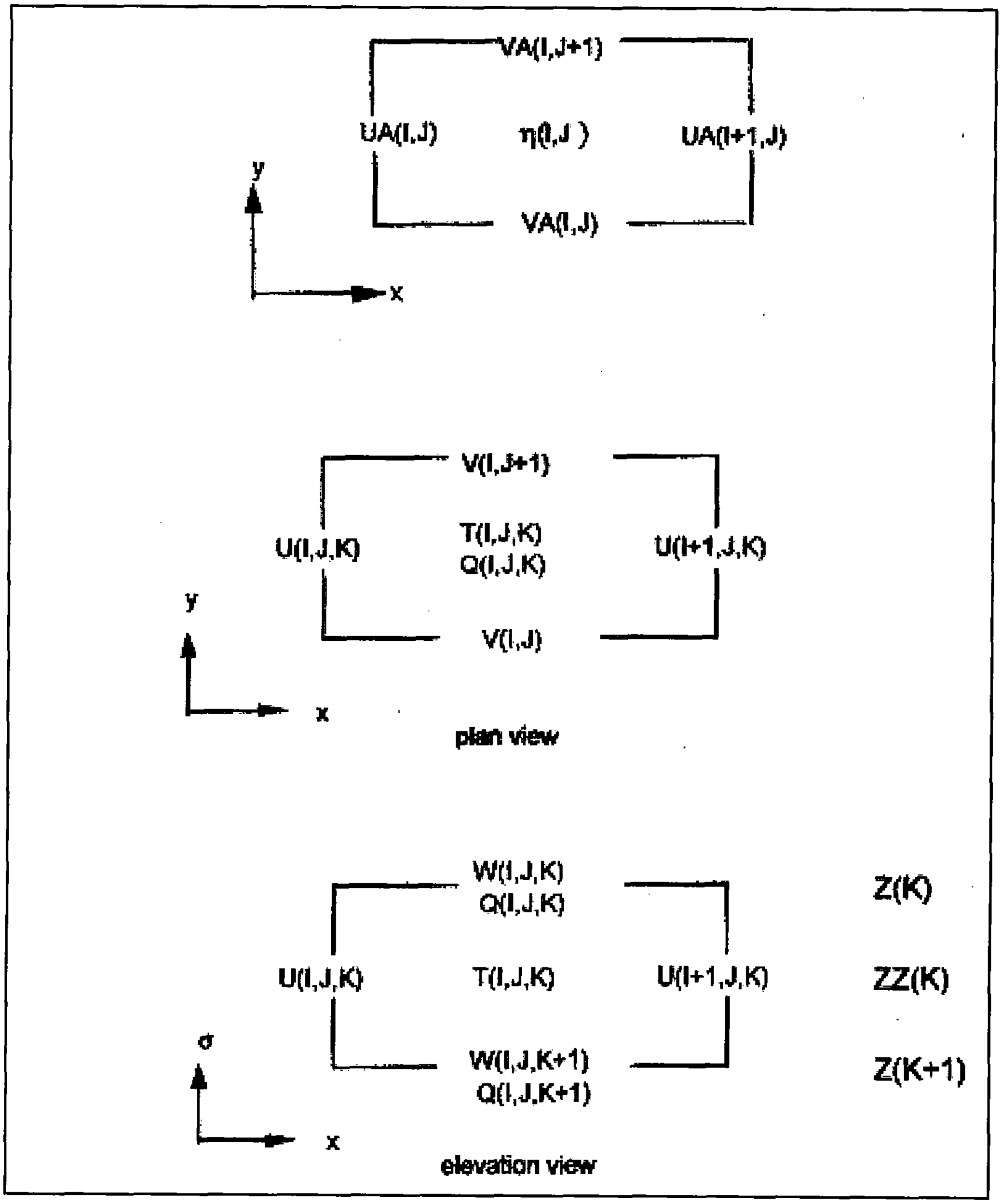


Figure 5. The grid cell at the top shows what parameters are computed and where (relative to grid cell) in the external mode and the bottom two cells show calculations and their locations in the internal mode.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
45	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	45
44	-3	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	-3	-3	-3	44
43	-3	-1	0.1	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	-1	-1	43
42	-3	-1	1.6	2.8	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	4	1.6	1.6	1.3	1.3	42
41	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.2	6.5	6.5	6.5	6.5	4	4.3	4.3	4.3	41
40	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	40
39	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	39
38	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	38
37	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	37
36	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	36
35	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.6	5.2	5.9	6.5	6.5	6.5	6.5	6.5	35
34	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	4.9	2.5	2.8	4.3	5.2	6.5	6.5	6.5	6.5	34
33	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	4.9	1.3	1.6	1.9	1.9	4	5.2	6.5	6.5	33
32	-3	-1	1.6	3.7	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	4.3	1.3	0.4	0.4	1.6	2.8	5.2	6.5	6.5	32
31	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.6	3.7	1.3	-1	-1	-3	0.7	1.6	4	4	31
30	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.4	0.7	-1	-3	-3	-3	-2	0.4	0.4	30
29	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	0.7	-1	-3	-3	-3	-3	-2	-2	29
28	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	0.7	-2	-3	-3	-3	-3	-3	-3	28
27	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	0.4	-2	-3	-3	-3	-3	-3	-3	27
26	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	0.4	-2	-3	-3	-3	-3	-3	-3	26
25	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	1	-1	-3	-3	-3	-3	-3	-3	25
24	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	1	-1	-3	-3	-3	-3	-3	-3	24
23	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	1	-1	-3	-3	-3	-3	-3	-3	23
22	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	1	-1	-3	-3	-3	-3	-3	-3	22
21	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	1	-1	-3	-3	-3	-3	-3	-3	21
20	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	1	-1	-3	-3	-3	-3	-3	-3	20
19	-3	-1	1	3.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	3.1	1	-1	-3	-3	-3	-3	-3	-3	19
18	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	18
17	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	17
16	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	16
15	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	15
14	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	14
13	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	13
12	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	12
11	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	11
10	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	10
9	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	9
8	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	8
7	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	7
6	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	6
5	-3	-1	1.3	3.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	3.3	1.3	-1	-3	-3	-3	-3	-3	-3	5
4	-3	-1	1.3	2.5	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.5	1.3	-1	-3	-3	-3	-3	-3	-3	4
3	-3	-1	0.7	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	0.7	-1	-3	-3	-3	-3	-3	-3	3
2	-3	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-3	-3	-3	-3	-3	-3	2
1	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	

Akutan Small Boat Harbor Grid
Depths are in Meters

Up is North (J Counter)
Right is East (I counter)
JMAX=45 IMAX=42

Grids are square with dx = 25 feet or 7.62 meters

Figure 6. 7.62-meter grid used for Akutan boat basin model—depths are in meters.

One of the concerns in the boat basin is water quality. Basins often restrict flow and therefore limit the amount of mixing that can occur. The mixing efficiency will be investigated by describing the flow in the basin and by predicting how the assumed concentrations will change due to the exchange of water between the basin and Akutan Harbor.

For this analysis, the initial concentrations of a generic conservative pollutant (no bio-chemically changes nor other sources or sinks present) were set to a value of 1 which represents 100 percent. All incoming water was assumed to be of value 0, that is completely devoid of the pollutant. The change in the concentrations within the basin were then tracked with time through several tidal cycles. The rate of change of the concentration can be related to a mixing efficiency through an exchange coefficient (Nece, et. al., 1979) calculated as:

$$E = 1 - \left(\frac{C_n}{C_o} \right)^{\frac{1}{n}}$$

Where C_o is the initial concentration and C_n is the concentration after n tidal cycles. This coefficient is established for each measurable point in the basin. It can be shown that, if the residence time of a contaminant in the basin is defined as the time required to decrease the concentration by 1/e (where e is the constant 2.718) of its original concentration, the residence time can be expressed as:

$$T_f = -\left(\frac{T}{\ln(1-E)} \right)$$

Where T is the tidal period.

According to Cardwell et. al. (1981), in a report for the State of Washington's Department of Fisheries the basin wide-averaged exchange coefficient should be equal to or greater that 0.30 for the basin to be considered sufficiently well mixed to maintain adequate water quality. He further recommended that at least 95 percent of the points sampled should have individual exchange coefficients of 0.15 or larger.

Besides mixing in the harbor, there was concern that whether suspended material that enters the harbor would likely settle in the basin and require periodic dredging. Mobilizing a dredge to this part of Alaska would be expensive, and if required frequently, could have serious consequences to the overall cost of the project as well as reducing water quality if this material was predominately suspended organic material resulting from fish process at Trident Seafoods plant. To investigate this possibility, the dispersion of soluble and suspended material that is discharged at Trident will be tracked for various conditions. The purpose will be to determine the potential quantities that could arrive near the mouth of the basin.

During the modeling of the basin, no consideration was given to possible entrainment of the outgoing flow from the basin by the return flow. It is assumed that the incoming flow is a completely new batch of water that was never in the basin. As we shall see, this may be a little unrealistic unless wind is assumed to be present.

Also the primary pollutant concern is with BOD. The longer this water remains in the shallower, more agitated waters of the basin and at the head of the bay, the greater the likelihood that dissolved oxygen will enter the through surface and reduce its deleterious effects.

2.6 Spill Trajectory

The spill model included as a part of this report is a program created with Micosoft's Visual Basic. The model provided is still in development, but, in the present form, it functions sufficiently well to provide the user with a visual interpretation of the path that a spilled substance might take should its source be anywhere within Akutan Harbor. It seemed that, given the infinite number of places that a spill could occur, it would be more informative to provide the Corps with a method for testing nearly any scenario that they believed to be possible.

Certainly many assumptions went into developing this program. For instance, the spill substance is assumed to float on the water within the surface boundary layer. Without wind, the transport will be entirely dictated by tidal current. The currents within Akutan Harbor have been described using a 3-dimensional, finite difference hydrodynamic program referred to as POM and described above.

POM is appropriate for describing these processes in a deterministic mode, but a portion of the motion of a particle in a fluid is based on random turbulence. This turbulence aids in the spreading of the substance as it is carried along by wind and tide-generated currents. This can be cast as a random process based on physical realities.

To incorporate this non-deterministic part, the random walk theory is employed. The use of random walk presumes that the spreading substance has reached a stage where the physical processes in the ocean such as wind, waves, and currents are more important than the flow of the substance governed by gravity and molecular viscosity. That is, the substance is not simply piling up on the water's surface and flowing "downhill" and the spreading of the mass is not being resisted by viscous attraction.

The dynamics of substance transport by winds and waves are complicated. It is probably easier to discuss the processes than to quantify them (Delvigne, 1993; Overstreet and Galt, 1995). Some particles become entrained by waves and once entrained, because of buoyancy, slowly return to the surface. At this point some particles are at the top of the wind-generated, surface layer while other particles are deeper. This results in the particles moving horizontally at different speeds. The net result of the wind-generated boundary layer and wave entrainment is to usually move the particles from about 1 to 4 percent of the wind speed relative to the water column. To provide a conservative estimate of the range of movement of the spill, a scheme used by NOAA HAZMAT has been adopted where each particle is randomly assigned an additional speed of between 1 and 4 percent of the wind speed.

To keep the model as simple as possible, a linear decay to account for weathering has been used. In addition, when a particle tries to "jump" onto land, it is either stuck to the shore and lost from the simulation or returned to the simulation based on the probability that it will stick to the shore. Both of these processes have built-in default values but can be easily modified by the user.

The model consists of five windows. The primary window that is used to interact with the model is the "Main Window." It is here that the user sets the source location of the spill, the weathering and sticking properties, the time of the spill (relative to the tidal stage), the mode of the spill, and several other parameters that are all described in the

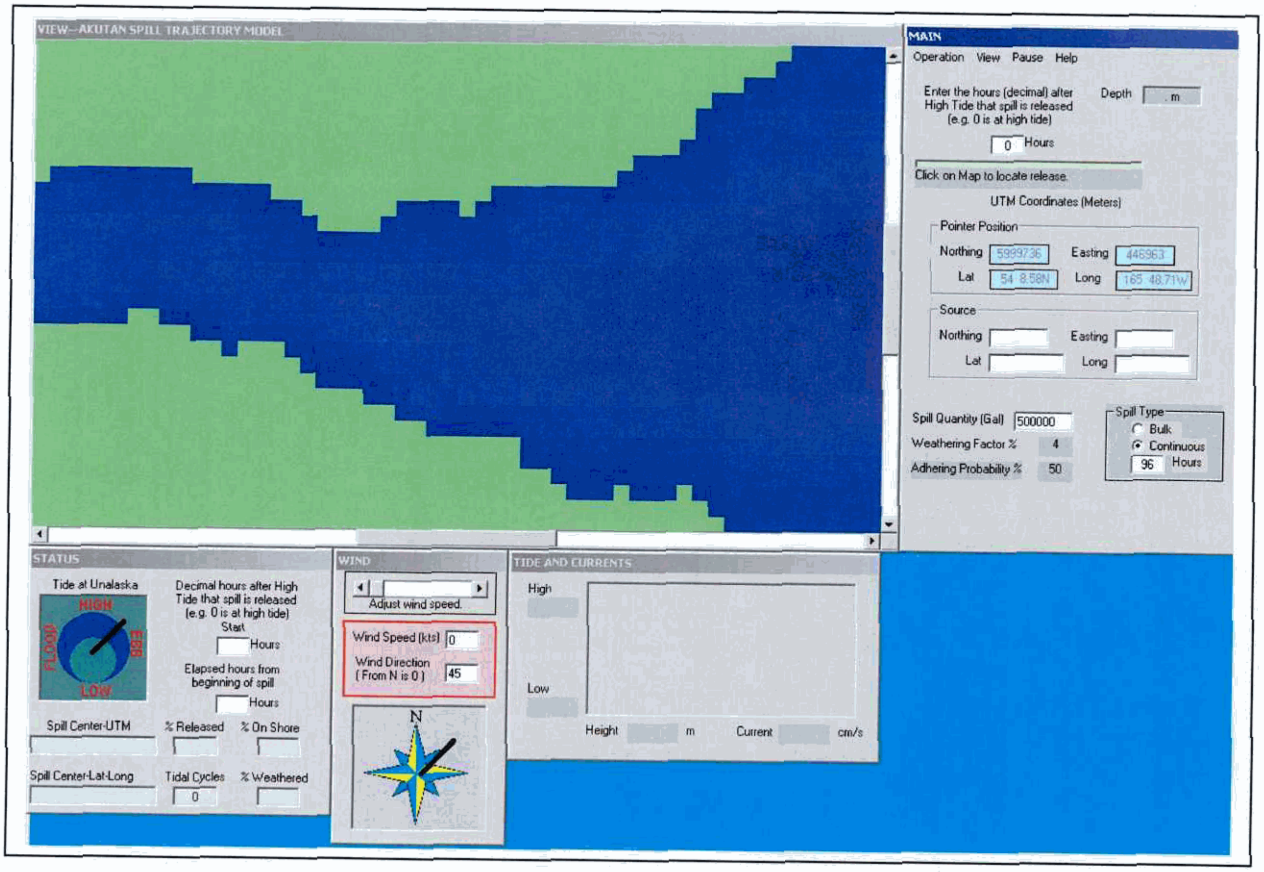


Figure 7. Screen image of windows of Akutan Spill Model

"Help" section of the model. Each spill is described by 1,000 individual points which the model accounts for independently. In the instantaneous mode, all 1,000 points are released at a single instant in time. In the continuous mode, the 1,000 points are released uniformly over time.

The "Status Window" keeps track of the fate of the spill both its and the simulation time. While a file is created that records the spill location in latitude and longitude as well as UTM coordinates, the most practical way to maintain a history of the spill's track is by turning on the "Trace" mode. A track of everywhere the spill has been is then visible on the screen. Also shown on this window is the percentages of oil that have weathered and been lost by sticking to land.

Using the "Wind Window," the user can set the wind speed and direction and change these properties at any time during the run. It should be kept in mind the steep slopes surrounding Akutan Harbor channel the winds so that they are quite constrained to be either easterly or westerly. The model is able to track wind from any direction, but the user probably should exercise some care in generating realistic conditions.

The "Tide and Current Window" provides an interface to check the currents and tidal heights at any location within the harbor. Since Akutan Harbor is small, tidal heights will vary only a small amount throughout the harbor. More variation will be seen in currents as they respond to water depths, proximity of side boundaries and the varying cross-section.

All of this is displayed, as it occurs, on the "View Window." This is the window that displays the spill's trajectory, and provides the user with up to 100 (user selected) locations where velocity "telltails" can be positioned to demonstrate the velocity vectors (not to any scale). The model is "user friendly" and it only takes a few tries to learn how operate.

3. Results

3.1 Akutan Harbor Modeling

Cases were run for no wind and for 20-knot winds from the east and west. Clearly, Akutan is a windy location and, according to the NPDES permit, winds occur over 70 percent of the time, but rarely exceed 20 knots. It was the intent to bracket the no wind case, which is suspected to have the least amount of mixing, with the extreme wind cases from the directions expected to have the largest effect on mixing in the harbor. Several figures will be presented that attempt to display the spreading process occurring in the harbor.

To observe the material spreading, it is necessary to introduce a material with a given concentration into the harbor at a particular location. The location chosen was the grid cell at or close to the present Trident Seafoods outfall. Referring to the Harbor Grid (Figure 3), this would be grid cell I=22, J=23, and K=20; where I is the grid counter in the X (east) direction, J is the counter in the Y (north) direction, and K indicates the grid at the bottom layer. An error of a couple of grid cells in either direction should not have any significant effect on the outcome.

There are several substances that are discharged at the outfall(s) that are quite different in character. There is soluble material that simply becomes part of the water column either immediately upon contact with the receiving waters or shortly thereafter. There is also a suspended constituent, generally referred to as the total suspended solids or TSS. Other solids settle directly and join the waste pile on the harbor bottom. These probably continue to emit BOD with time at a rate dependent on several variables. There is a floatable fraction that probably consists primarily of oil and grease. What the first three all have in common is biological oxygen demand (BOD or BOD_5). The subscript is often used to distinguish the consumption mode of BOD; the "5" being the amount that is consumable in 5 days. Generally, this part is consumed by dissolved oxygen. Hereafter, it will simply be referred to as BOD.

For the purpose of running the model, a value of 10,000 pounds per day of BOD is the assumed discharge from the plant operations. In reviewing the permit, this seems to be a reasonable amount. The permit states that a monthly average of 115,314 pounds per day of BOD is discharged, combined among the constituents already described. Part of this is as 148.933 pound per day of TSS. This is screened before reaching the receiving waters and more than 75 percent of the BOD is removed and more than 97 percent of the TSS is removed. Therefore. the total daily BOD reaching the harbor is about 29,000 pounds, and the total TSS is about 4,500 pounds. Of that BOD quantity, some contributes directly to the waste pile. We suspect that the 10,000 pounds per day is a reasonable number that will be transported by the currents in the harbor. It is also a convenient number to multiply by any number if another is believed to be more reasonable.

3.1.1 Maximum Concentrations

One of the first runs was to follow the maximum BOD concentrations that could be found anywhere within a particular layer as a function of time. The set of three plots (Figure 7) shows these maximum concentrations for two layers (10 and 20 meters) for the three different wind conditions. The BOD source strength is assumed to be 10,000 pounds per day. The fact that flooding and ebbing bring different layers through those particular elevations is evidenced by the variations on the tidal frequency. The actual depth of the discharge is assumed to be about –20 to –22 meters. The purpose of including these plots is two-fold: first it demonstrates the concentration level of the introduced material (the

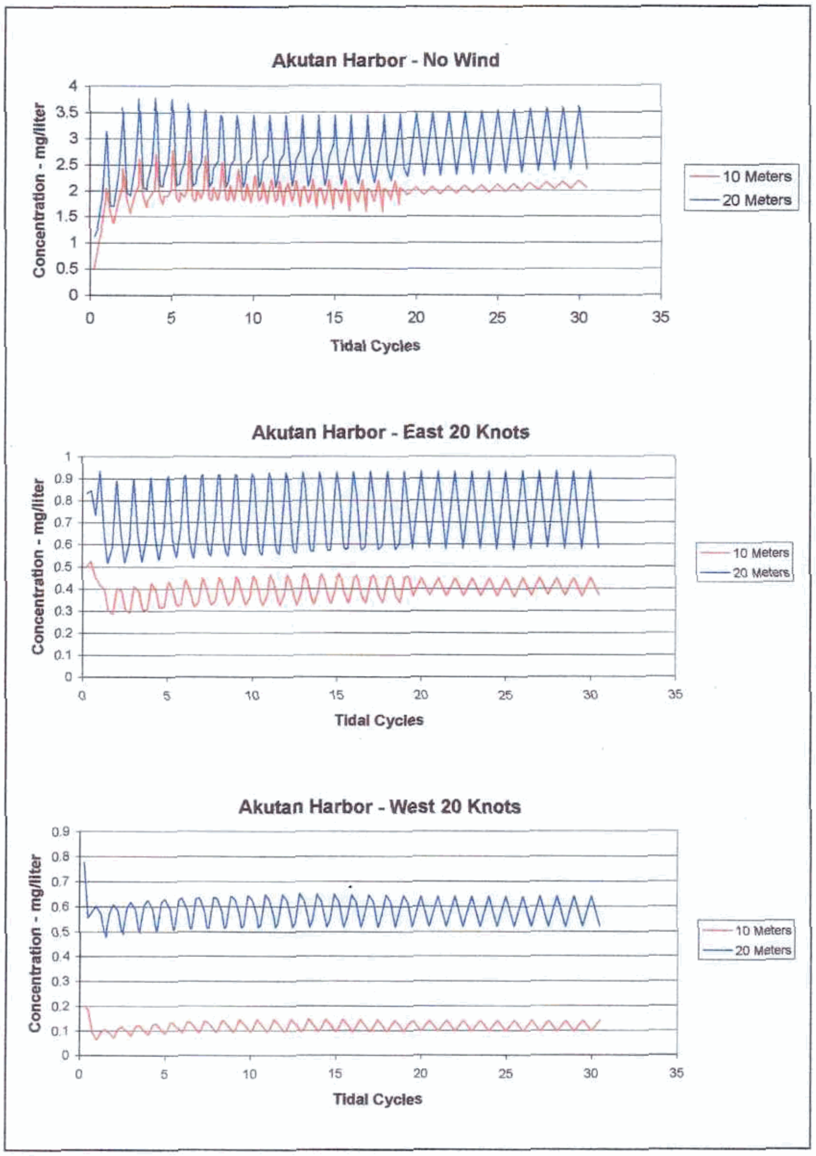


Figure 8. Maximum concentrations at each depth versus tidal cycles for Akutan Harbor for given winds.

pounds per day have been converted to mg/liter), and it shows that, at least for the wind situations, a steady state condition will eventually be reached. It also shows that winds are effective in reducing maximum concentrations in the harbor.

This should be of no great surprise when the wind-generated currents are compared with tidal currents (with no wind). Figure 8 shows the maximum surface currents (should be similar throughout the water column) in Akutan Harbor for the "no wind" case. Figures 9 and 10 show the maximum wind-generated velocities for east and west 20-knot winds, respectively. The wind-generated currents are in places an order-of-magnitude greater than the tidal currents alone

3.1.2 Distributions in Harbor

Runs were made to characterize pollutant distribution throughout the harbor for the three wind conditions by examining three distinct layers (1, 10, and 20 meters). Theses are shown in Figures 11, 12, and 13. The model was run for 15 tidal cycles so that a steady state condition had, or nearly had, been attained. The "no wind" case shows that there is a slight cross-harbor transport from the outfall. Transport <u>into</u> the harbor from the discharge point is slightly increased along the southern shore; and <u>out of</u> the harbor it is slightly increased along the northern shore. Concentrations near the head of the bay are less than 0.02 mg/liter.

For the "east wind" case, the distribution appears a little more confusing toward the head of the bay while toward its mouth the major transport seems to be along the southern shore, just opposite of the "no wind" case. Judging by the surface layer, the transport inward appears to be also along the southern shore, but is not apparent at 10 or 20 meters. In the surface layer, there appears to a concentration of 0.06 mg/liter but considerably less than that in the lower layers.

The "west wind" case shows a strong transport both in and out of the harbor along the north shore. Concentrations at the head of the bay can reach 0.04 mg/liter. It would appear that vertical mixing may be much more intense for this case.

3.2 Small Boat Basin Modeling

The boat basin at the head of the harbor is oriented so the short axis (width) is aligned east-west in line with the major wind directions. Since the wind in blowing in either of these two directions nearly continuously, it's probably reasonable to consider its effects in analyzing the basin's mixing efficiency. In an enclosed region such as a boat basin, winds will tend to generate surface flows in the wind direction and subsurface flows in the opposite direction. To describe this process in a model, it must be capable of capturing 3-dimensional effects. We had originally intended to use the 3-dimensional modeling only for the Akutan Harbor motions and to use 2-d modeling in the boat basin. It was obvious early in the analysis that such a description did not reflect the more realistic 3-d effects and would predict a mixing situation untenable to most water-quality standards. Therefore, we changed plans and began the more complex 3-dimensional model in the basin as well. These 3-d flows had a large effect on the vertically averaged concentrations in the basin.

This analysis also produced concentrations that varied in the vertical as well. However, for the method that was selected to analyze the mixing (exchange coefficients) it seemed more reasonable to vertically average these and thereby produce a single concentration for each horizontal grid point in the basin.

After considering several scenarios, three were ultimately selected for inclusion into this report. They included the no-wind situation in which all to the exchange is driven by tidal velocities; a 10-knot east wind superimposed on the tidal flow; and similar situation for a 10-knot west wind. The exchange coefficients for those cases are presented in Table 1. The residence time for a pollutant to remain inside the harbor is also provided.

Table 1. Vertically-averaged Exchange Coefficient in boat basin.

	No Wind	**10-knot Wind**	
		East	**West**
Vertically-Averaged Exchange Coef.	0.08	0.15	0.23
Residence Time (days)	6.25	3.2	1.9

These are typically low values indicating poor exchange within the small boat harbor. The mixing is significantly improved by adding wind. The west wind is even more instrumental for increasing the mixing than the east wind. This imbalance between east and west winds of the same magnitude is probably due to the location and orientation of the outlet

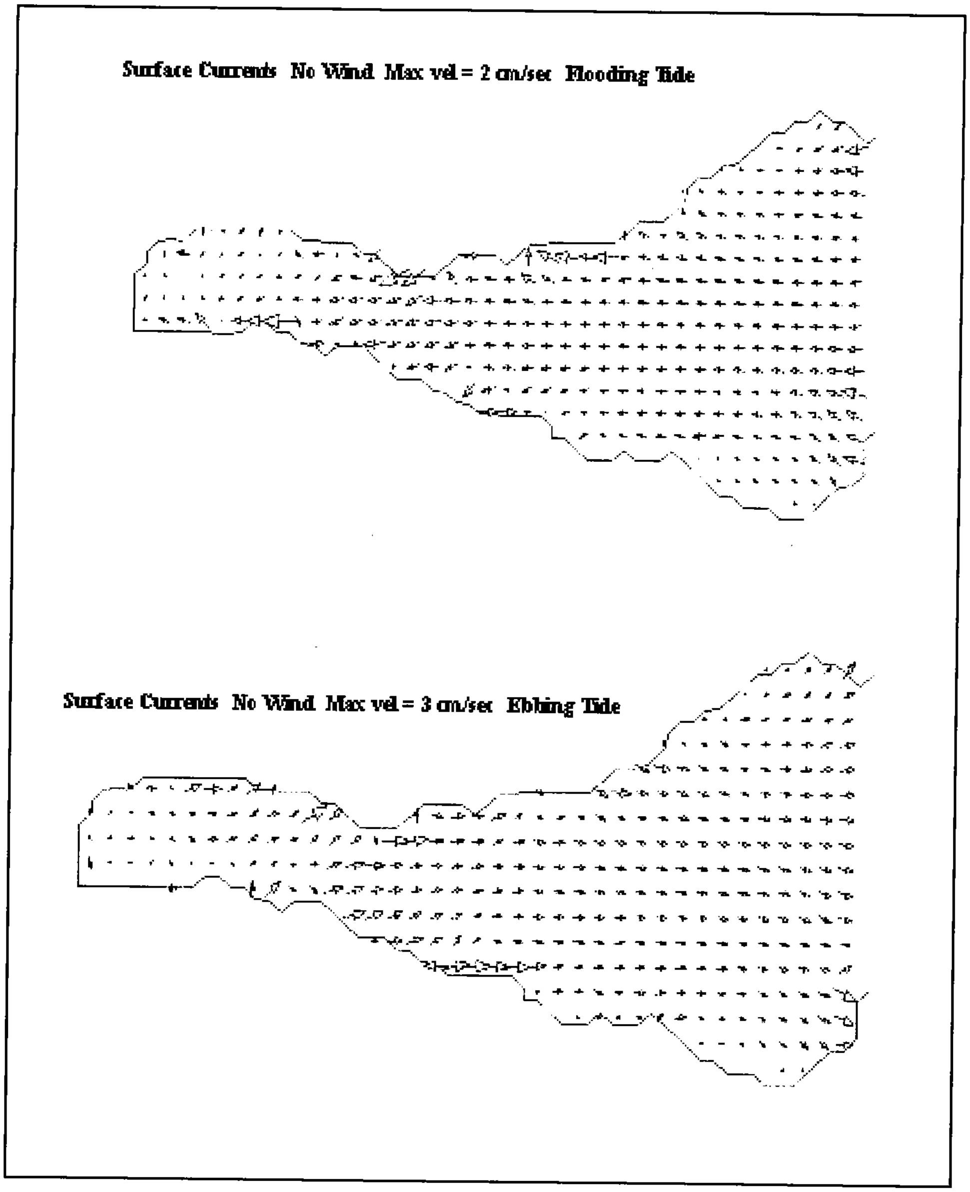


Figure 9. Surface currents in Akutan Harbor for the "no wind" case (tidal currents only)

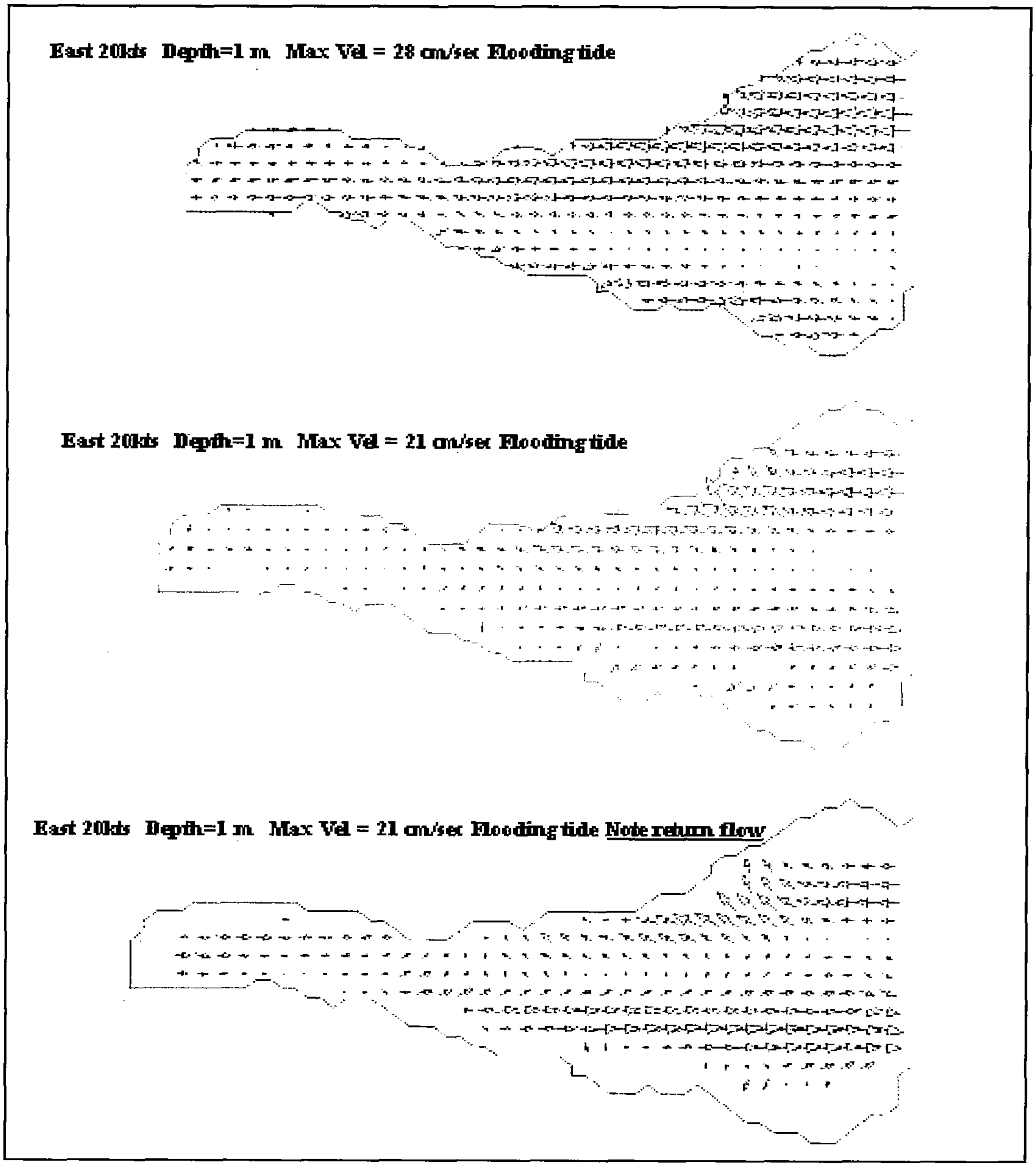


Figure 10. Currents in Akutan Harbor at three depths for case of 20-knot east winds.

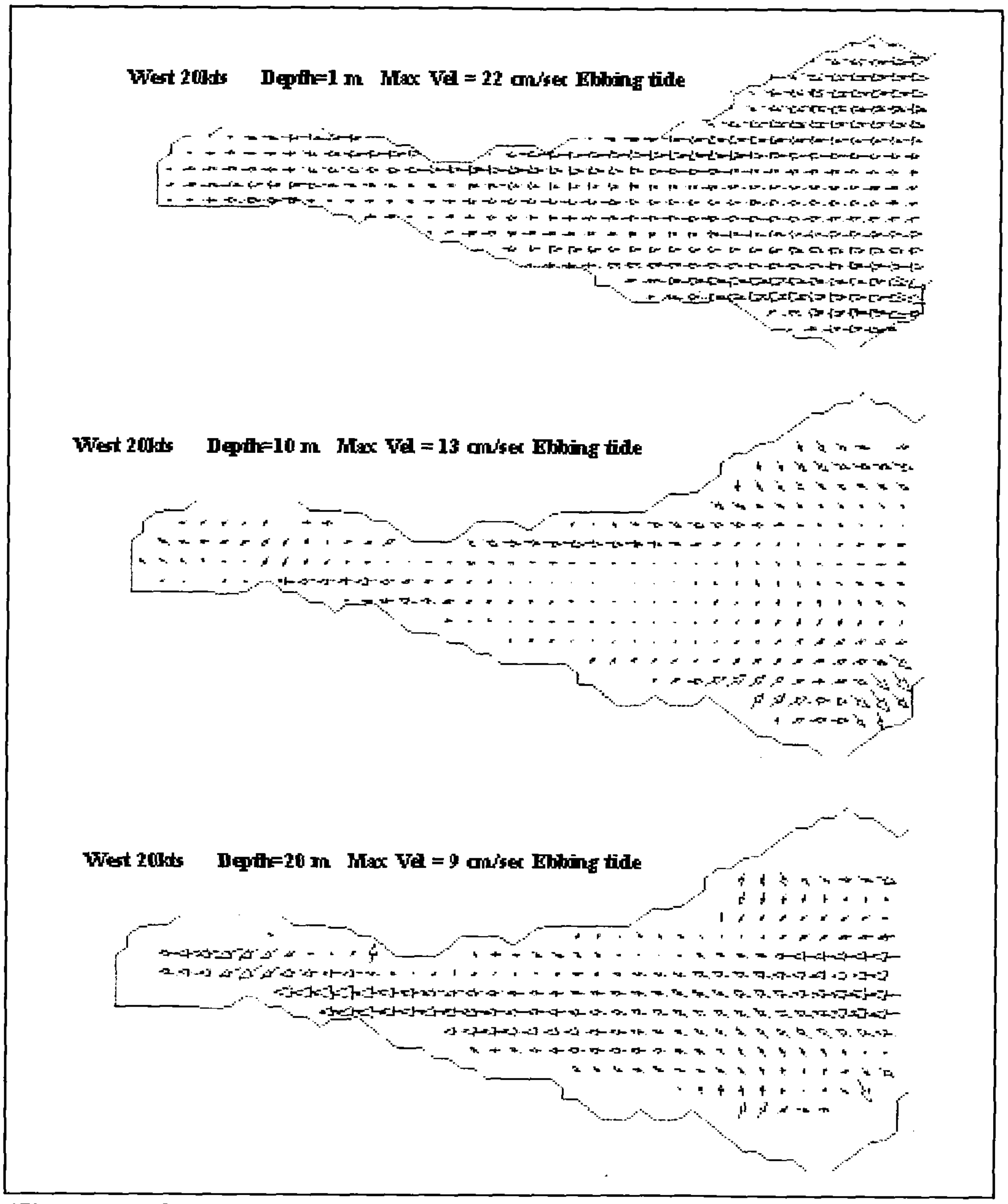


Figure 11. Currents in Akutan Harbor at three depths for case of 20-knot west winds.

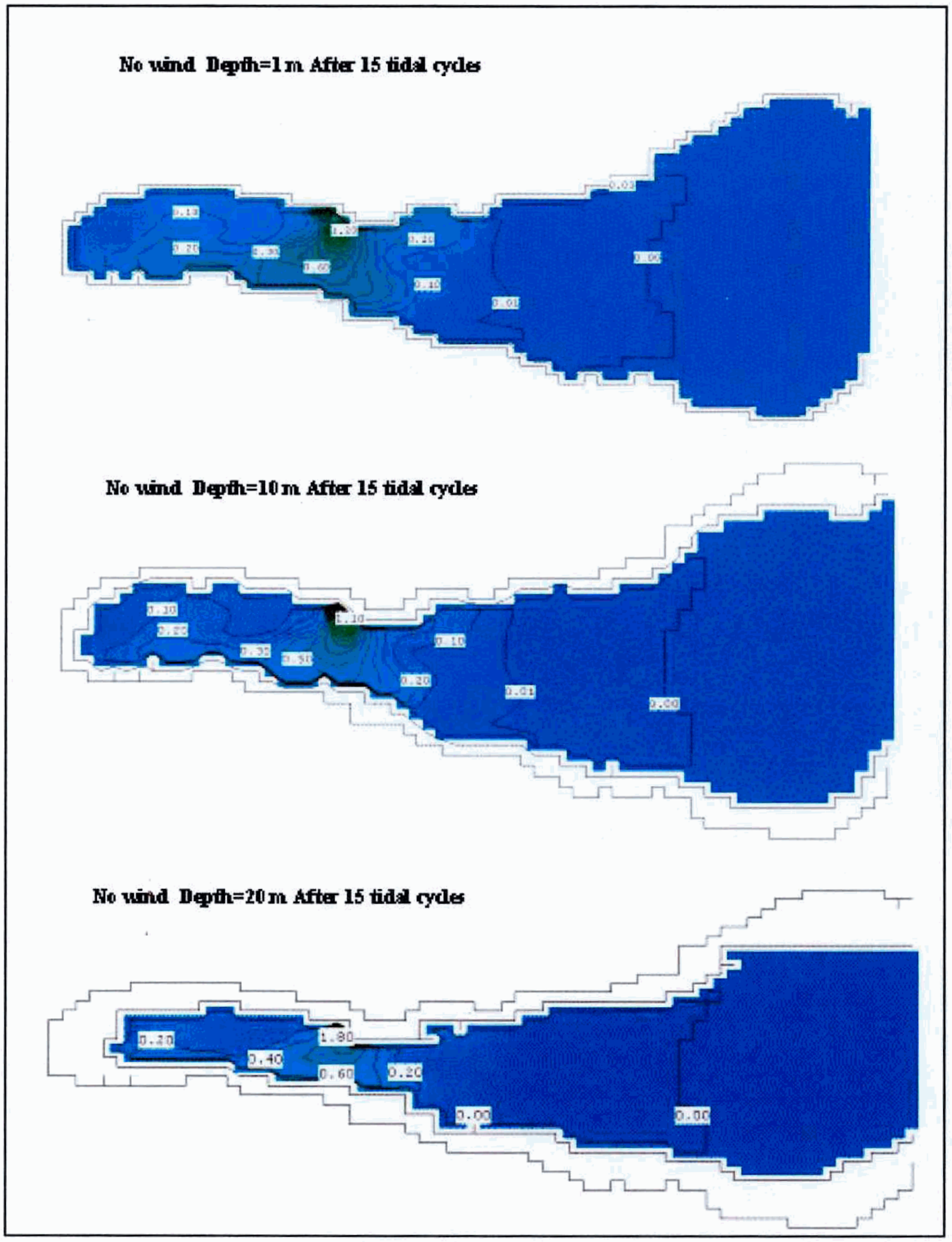


Figure 12. BOD concentrations levels in Akutan Harbor during calm conditions, after 15 tidal cycles

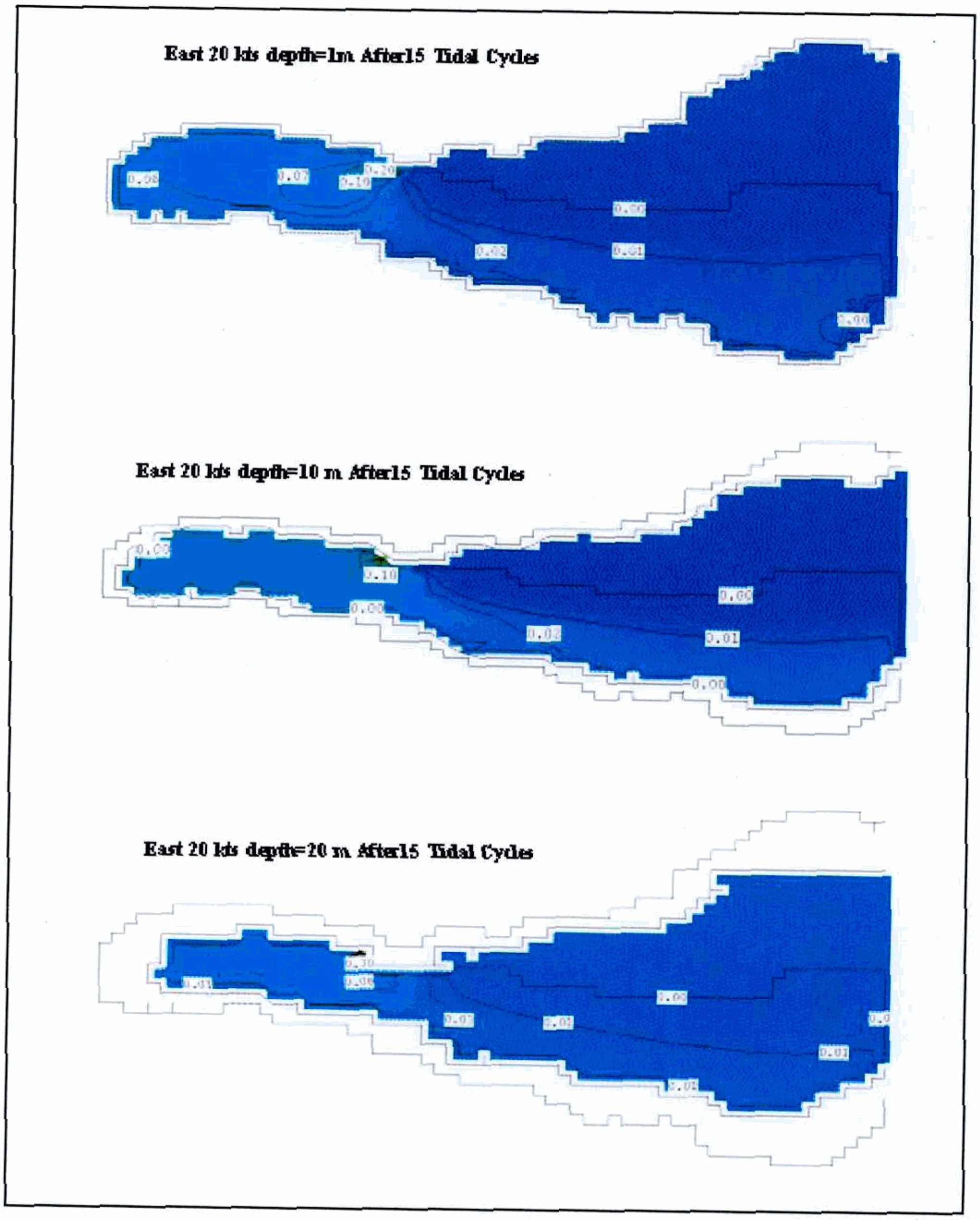


Figure 13. BOD concentrations levels in Akutan Harbor for east winds, after 15 tidal cycles

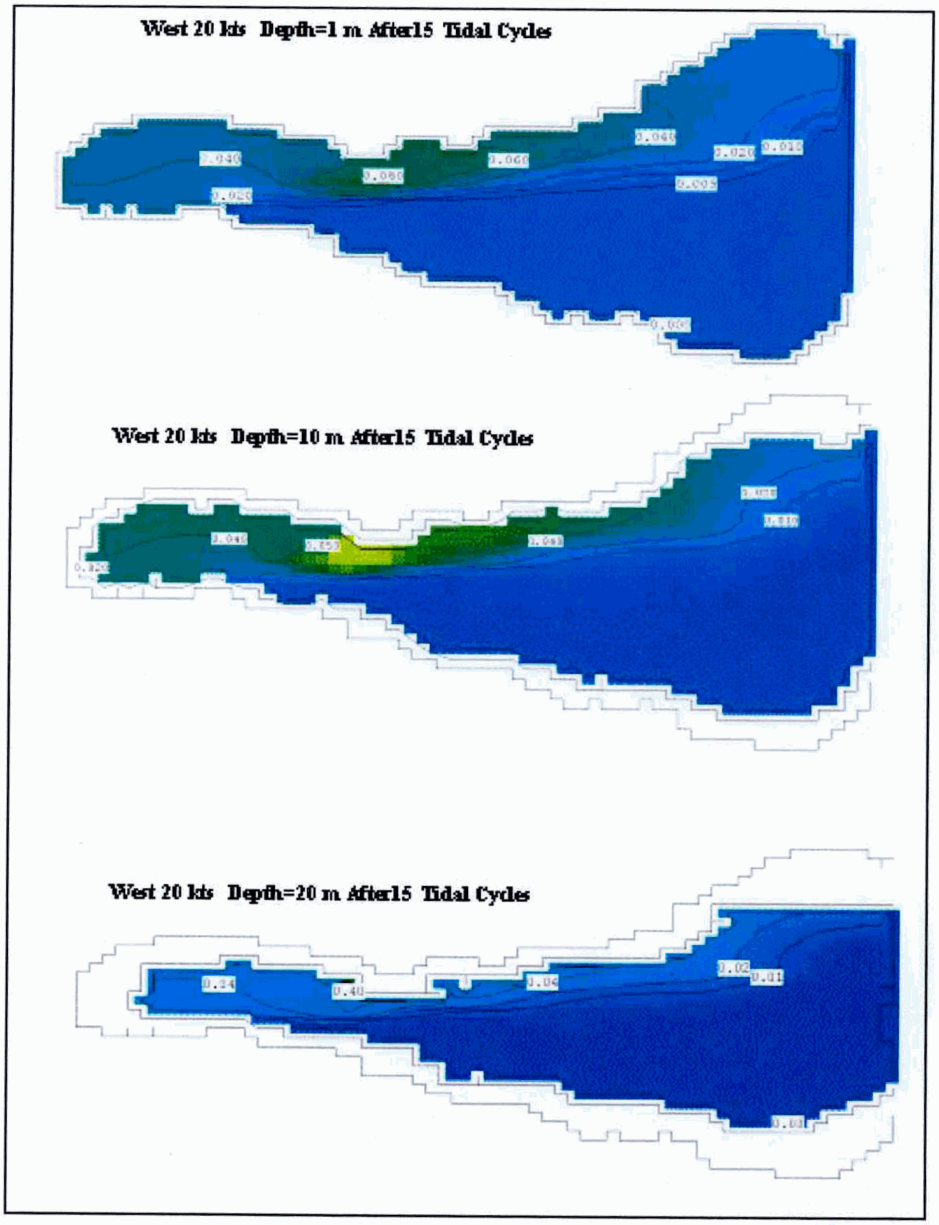


Figure 14. BOD concentrations levels in Akutan Harbor for west winds, after 15 tidal cycles

4. Conclusions

A series of computer runs were undertaken to investigate the fate of discharges from Trident's Seafood plant and the mixing capacity of a small boat harbor under consideration for the head of the harbor. A number of concerns were delineated at the beginning of this report which were to be addressed by these applications. Each will be individually addressed.

1. <u>*The possible build up of fish processing wastes in the boat basin.*</u>
   Three wind conditions have been investigated in which the basin-wide concentrations at three separate layers has been investigated. In no cases did the concentrations near the head of the bay, which would serve as the source of basin water on flood tide, exceed 0.06 mg/liter. Now these concentrations have been treated as conservative materials. Clearly, BOD would not be conservative, but would decrease with time as dissolved oxygen was consumed. It appears that this should not have noticeable impact on DO. It was stated early on that although it was felt that the 10,000 pounds per day of BOD was thought to be a reasonable number, it could be low by a hundred percent. If such were the case, then it appears that mixing would still be more than sufficient to maintain good DO levels in the boat basin. This does not even take into account any increased absorption of DO in the basin due to more active mixing by wind.

2. <u>*The flushing rate/volume exchange that is anticipated in the boat basin due to tides and winds.*</u>
   The exchange coefficients were estimated for the boat basin for three wind conditions. The usual "no wind" was investigated as were cases for 10 knot east and west winds. Recall that for the Akutan Harbor modeling the wind cases were 20-knot winds. In that case, the attempt was being made to bracket the conditions, but lower winds were considered in the boat basin case. This was done because it was soon realized that mixing by tidal activity alone was poor. Therefore, realistic wind values were sought which could assist in the mixing process.

   For those cases the average exchange coefficients varied between 0.08 and 0.23 with the largest being for west winds and the smallest for no winds. The east-wind case was in between at 0.15. According to the Washington State, Department of Fisheries Report authored by Cardwell (op.cit, 1981), adequate boat harbor mixing begins when the average coefficient value reaches 0.3. It appears that the low tidal range coupled with the relatively small, deep basin, and wide entrance all combine to limit mixing.

3. <u>*The direction of flow of the effluent from the boat basin.*</u>
   The same parameters that indicated poor exchange through the basin entrance when considering mixing inside the basin also apply to water exiting the basin. The momentum to carry this water well away from the mouth just doesn't exist.

In addition, tidal currents are extremely low at head of the bay. The water leaving the basin will be moved almost in total response to the winds; east winds will pile the water against the shore and create offshore transport at depth and west winds will cause the basin water to move nearly due west toward the mouth of Akutan Harbor.

4. *The potential for exceeding the State's water-quality standards for certain substances within the basin.*
   Since the exchange of water through the boat basin entrance is limited, it is likely that nearly any substance that is regulated by the State's water-quality program and has the potential to be in the basin at those levels could meet or exceed standards. A good deal of care will probably need to be exercised to keep materials from entering the basin waters.

5. *Under what conditions would there be a BOD/DO problem in the mooring basin.*
   The conditions that might introduce excess amounts of BOD or create a depleted DO content would probably be from the discharges from vessels or non-point sources into the basin itself. It is apparent from the modeling that it is highly unlikely that BOD from Trident's outfall would create a problem in the basin.

6. *If settleable solids have enough residence time in the basin to accumulate in the basin sediments.*
   Assuming that there are no local sources of settleable solids, then it is highly unlikely that they will create a problem in the boat basin. There could be ample wave activity in the northern end of the basin given the location and orientation of the entrance. If sands and finer material were available, they could certainly be transported into this end of the basin. However, this material is extremely limited and the indication for such transport activity is small. The settleable solids that are introduced at Trident's outfall are extremely small. Most is deposited on the seabed shortly after leaving the outfall. It we also include the TSS in this category, their concentrations at the head of the harbor would be about half of that designated for BOD assuming none settled out in transit and that is highly unlikely. Unless there is some local source or a wind-blown source, settleable solids should not create a problem at the boat basin.

7. *The influence of freshwater intrusion into the mooring basin on the possible enhanced buildup or discharge of contaminants.*
   Freshwater could be either a net benefit or detriment to the build up of pollutants in the harbor. If the water was introduced near the bottom, then the freshwater might enhance the vertical exchange of water which, in turn, might have a positive effect on harbor mixing. However, mixing due to wind effects would clearly mask the effects of entrainment by rising freshwater. If the freshwater were introduced higher in the water column, it could actually limit vertical mixing by capping the system. As a general rule, every attempt to exclude freshwater should be considered due to the increased likelihood of ice formation in the basin.

A 3-dimensional computer model has been applied to the circulation in Akutan Harbor and in the proposed small boat basin. The model clearly indicates that Akutan Harbor cannot be thought of as a simple 2-layer flow. Winds can clearly introduce horizontal as well as vertical circulation in the harbor.

The model was also used to examine flows and substance transports in the boat basin. The primary concern that this demonstrated was that mixing in the basin will be quite limited. Mixing enhancements by east and west winds will double or triple the efficiency as measured by exchange coefficients. The residence time for pollutants in the harbor could be as much as 6.25 days for the "no wind" case and 1.9 days for the "west wind" case.

5. References

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Nece, Ronald E., Eugene P. Richey, Joonpyo Rhee, and H. Norman Smith, 1979, Effects of planform geometry on tidal flushing and mixing in marinas, University of Washington, Charles W. Harris Hydraulics Laboratory. Tech. Rept. No. 62, 70 pp.

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ADDITIONAL WAVE AND WATER QUALITY ANALYSES FOR THE POTENTIAL BOAT BASIN AT AKUTAN HARBOR, ALASKA

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OCTOBER 28, 2003

1.0 INTRODUCTION

An earlier report[1] was issued that described the potential water quality in the small boat basin under consideration for the head of Akutan Harbor (Figure 1). Those analyses investigated several wind conditions and used a semidiurnal tide as the driving force for supplying water and momentum to the basin. It came as no great surprise that mixing was quite restricted in the basin. Somewhat earlier than that, a report was delivered that contained a wave analysis using the wave program STWave to calculate the design wave conditions for the head of the harbor. The 50-yr design significant wave height was determined to be 3.1 ft. with a period of 5.0 seconds.

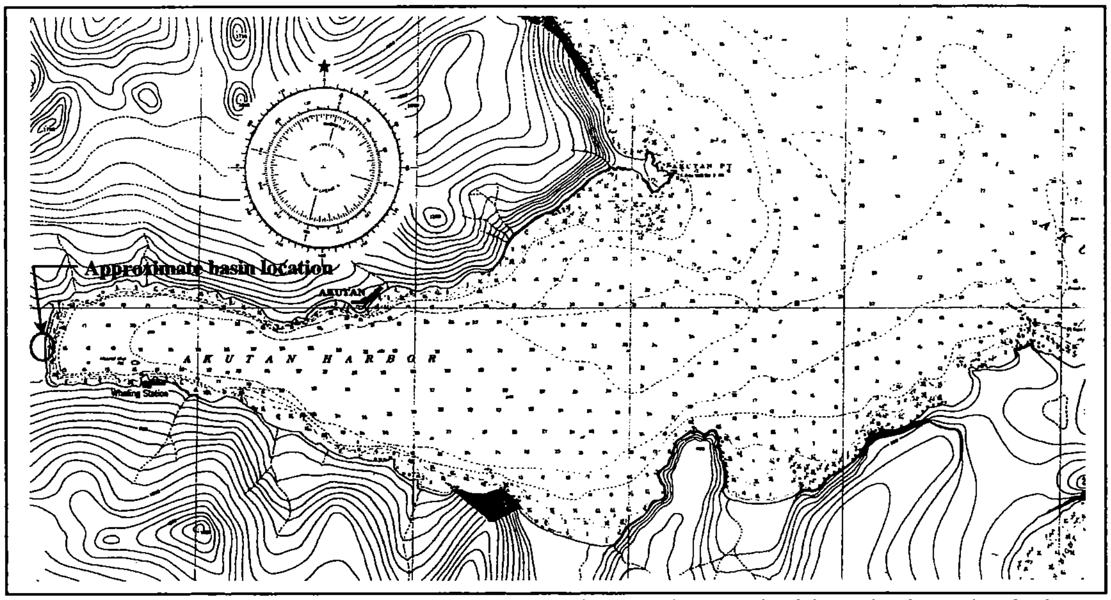

Figure 1. Akutan Harbor with the community on the north side. The boat basin is being designed for the head of the bay.

Since the issuance of those reports, concern has arisen to develop ways to improve the mixing by modifying the shape of the boat basin while keeping most other factors such as basin depths and total volumes the same. In addition, since adding a breakwater to reduce wave heights seems impractical, concern has arisen as to the possibility of relatively high waves entering the boat basin, therefore, most of the wave attenuation will be left to the basin entrance.

An investigation of these two concerns was undertaken and is the subject of this report. The mixing potential for the existing configuration was determined using three tidal conditions. Then the basin entrance was reconfigured to increase entrance velocities and the analysis was redone using the same inner basin geometry as called for in the existing configuration. Then that geometry was modified and the analysis and using the altered entrance configuration the analysis was repeated. In wave conditions for the inner basin were determined using the latest version of REFDIF, a wave program that treats

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[1] [1] Coastline Engineering, Circulation modeling in Akutan Harbor and the potential impacts by and to the proposed small boat harbor, October, 2001.

refraction and diffraction in a unified way. Each of these concerns was treated separately and is reported herein.

The proposed boat basin is to be located on the western head of Akutan Harbor. The harbor is about 3½-long embayment in the east-west direction. For the west 2 miles the width is about on half mile. Tidal currents in the harbor are low and respond to wind by setting up a three-dimensional flow system with the surface currents responding directly to the wind and the deeper currents opposing the surface flows to maintain continuity.

2.0 MIXING IN THE BOAT BASIN

The configuration chosen as the likely preferred plan is as shown in Figure 2. It consists of a 12-acre inner harbor (excluding the entrance acreage) and has a stepped depth. The northern most depth is 18 feet, the middle portion at 16 feet and the southernmost at 14 feet relative to MLLW. The entrance depth is the same as the deepest portion of the basin, 18 feet

The Alaska Department of Environmental Conservation (ADEC) wanted answered was whether there was a design possible that might provide significantly better mixing while not interfering with the navigation. The approach to answering this question consisted of first modeling the existing configuration and to calculate the appropriate mixing parameter: mean and variation of the exchange coefficient. Tides are known to play an important role in facilitating mixing in boat basins. Generally, the highest tides produce the greatest mixing. Akutan has a complex tidal curve, albeit, with a small range. It transforms from a nearly pure diurnal signal to a fairly strong semidiurnal signal during the course of two weeks. During the highest tides the signal is semidiurnal. We have chosen to simulate three tide conditions for this investigation. They are shown in Figure 3.

The analysis uses a computer model to simulate the mixing of a hypothetical substance in the boat basin. The scheme used was initially developed to investigate mixing in St. Paul Island boat harbor and has been used on numerous boat basins and natural bays in Alaska. It was recently used on over 140 theoretical basins for the ADEC. For that project, a procedure to observe the mixing process was implemented to observe the mixing process in colored animation. The actual effectiveness of the mixing process is determined by calculating the mean and standard deviation of a quantity referred to as the Mixing Coefficient[2] (E) after a certain elapsed time. This coefficient is calculated from the concentrations as:

$$E = 1 - \left(\frac{C_t}{C_0}\right)^{T/t}$$

Where *t* and ***T*** refer to time and the length of the tidal period and

[2] Nece,Ronald E., Eugene P. Richey, Thee Joonpry, and H. Norman Smith, 1979, Effects of planform geometry on tidal flushing, in marinas, Tech. Rept. No. 62, Charles W. Harris Hydraulics Lab., Dept. of C.E., U. of WA, 71 pp.

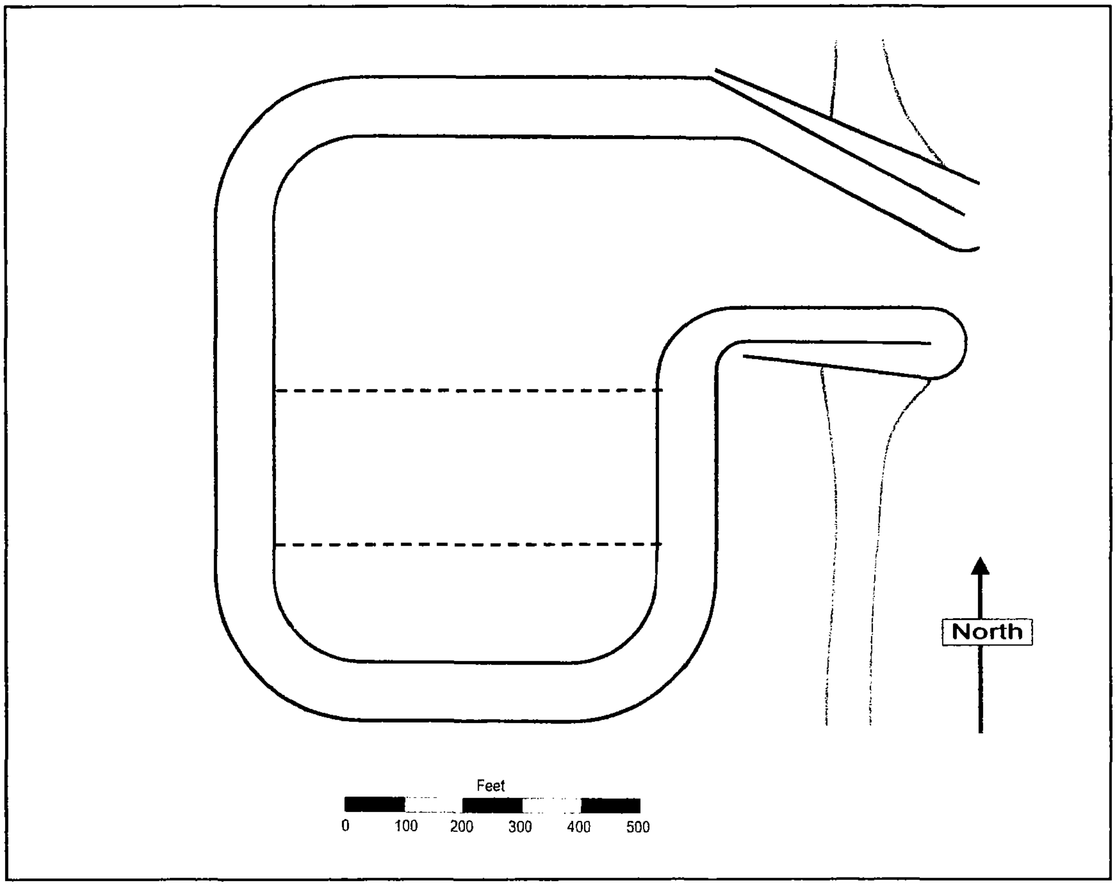

Figure 2. The configuration believed to be the preferred plan. The wide inner entrance was to enhance navigation.

Where *t* and *T* refer to time and the length of the tidal period and the C_t and C_0 are the concentrations at time *t* and the initial concentration. By a simple transformation, this can be shown to be a function of the number of tides. Due to the difference in periods between diurnal and semidiurnal tides, it was decided to calculate the exchange coefficient based on time.

The initial simulation produced the distribution of the exchange coefficients as shown in Figure 4. This images, and those that follow are for the high water slack during the fourth tidal cycle. The results are presented in terms of the mean and standard deviation of E in Table 1. In this figure, the white indicates complete mixing the mixing decreases as the color approaches black. The red color signifies almost no mixing.

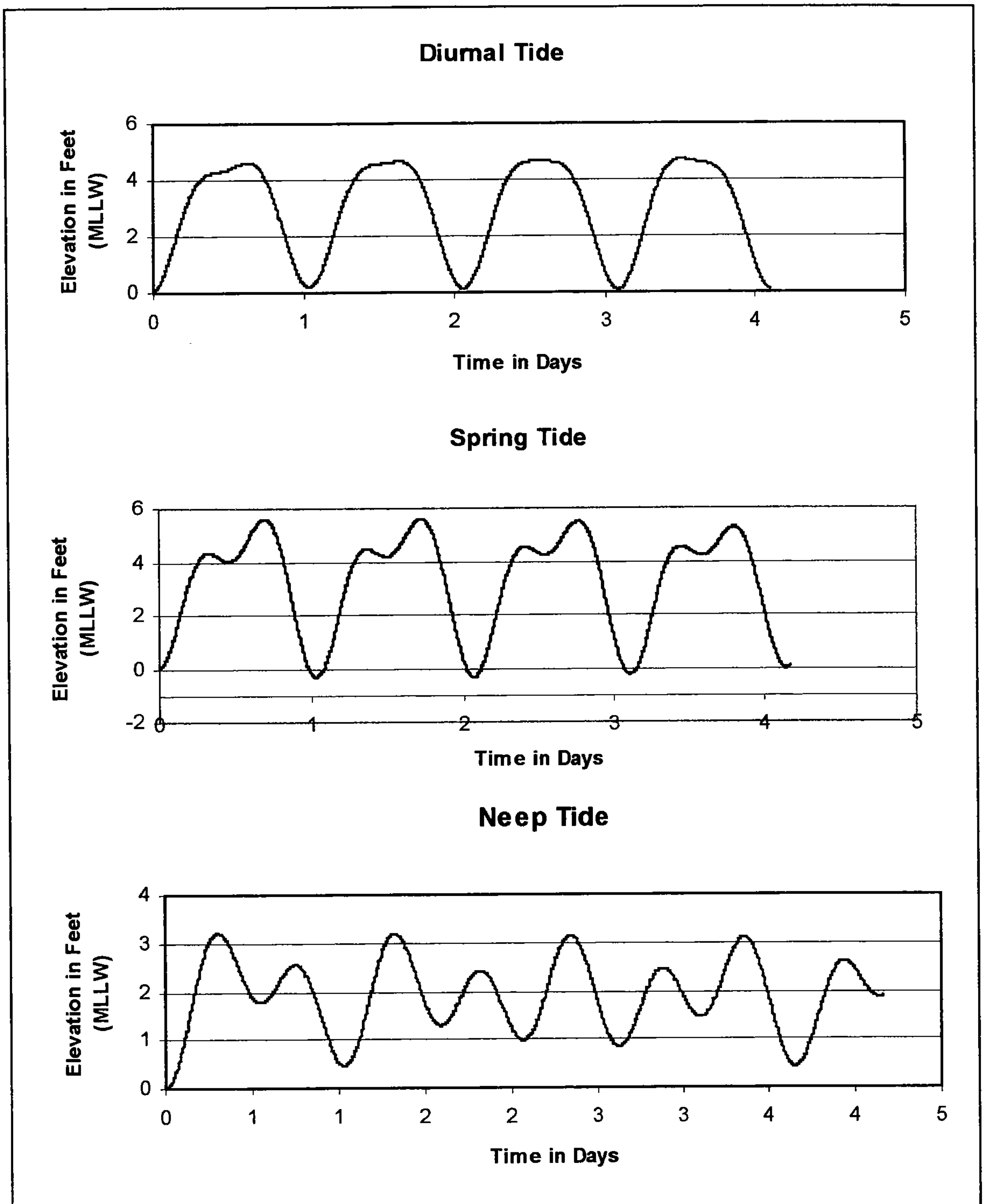

Figure 3. Three tidal conditions used for modeling. These represent actual tides as predicted from tidal constituents.

Table 1. Basin means and standard deviations for the Exchange Coefficients for the given configuration.

CONFIGURATION	EXCHANGE COEFFICIENT	
	Mean	Std. Dev.
Original Rectangular Basin	0.05	0.10
Modifiedctangular Basin	0.17	0.11
Modified Circular Basin	0.17	0.11

The entrance was then altered to maintain the same width over its entire length. This configuration is shown as Figure 5. Figure 6 shows exchange coefficient distribution for this configuration. There is a significant improvement in the circulation and mixing in comparison to the original configuration. This improvement is quantified in Table 1. The third option consisted of the same basin area and water volume as the previous two. It also had the modified entrance—uniform width, but it had a more circular shape than the previous alternatives. This configuration is shown in Figure 7 and its exchange coefficient distribution is shown in Figure 8. It was anticipated from previous studies that this configuration would produce the most well mixed inner basin. While there

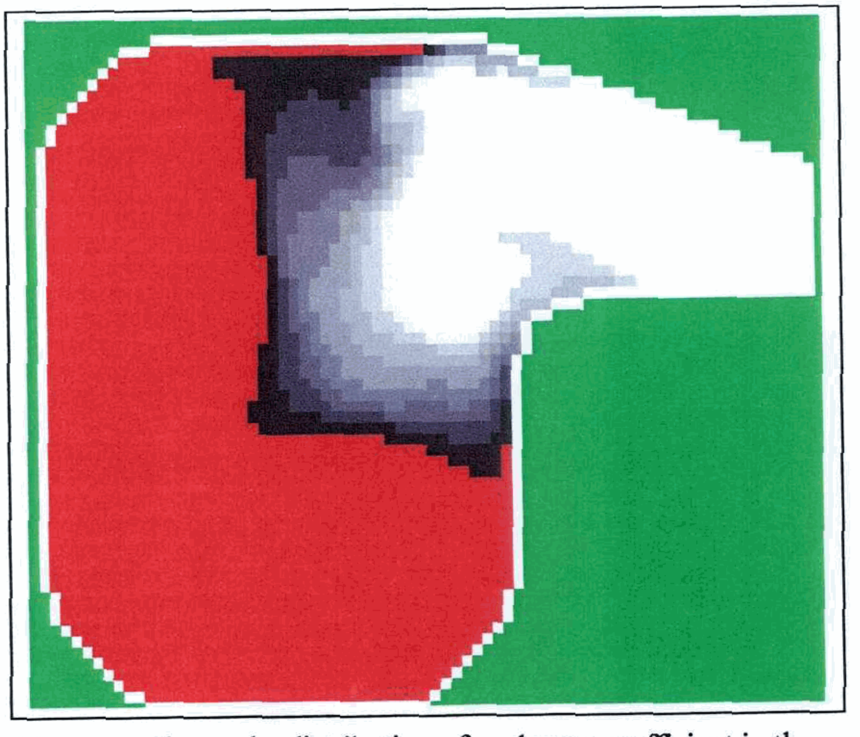

Figure 4. Shows the distribution of exchange coefficient in the rectangular basin with the wide inner entrance (the original preferred alternative). White indicates well-mixed areas while the red signifies poorly mixed areas.

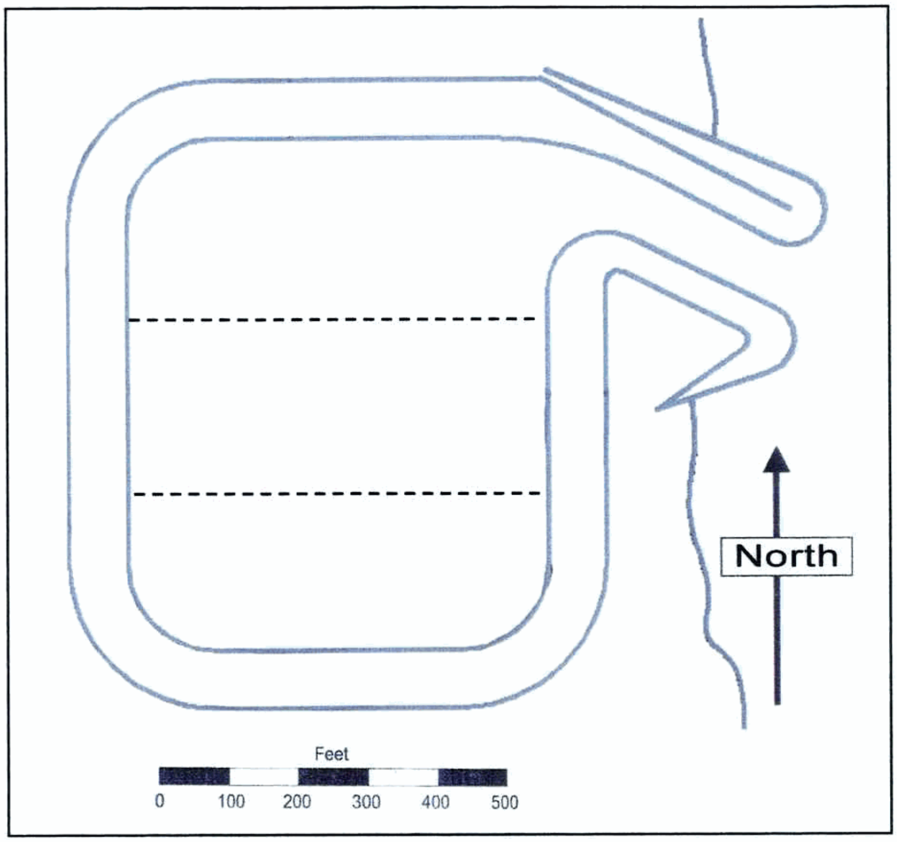

Figure 5. Rectangular configuration with the modified entrance.

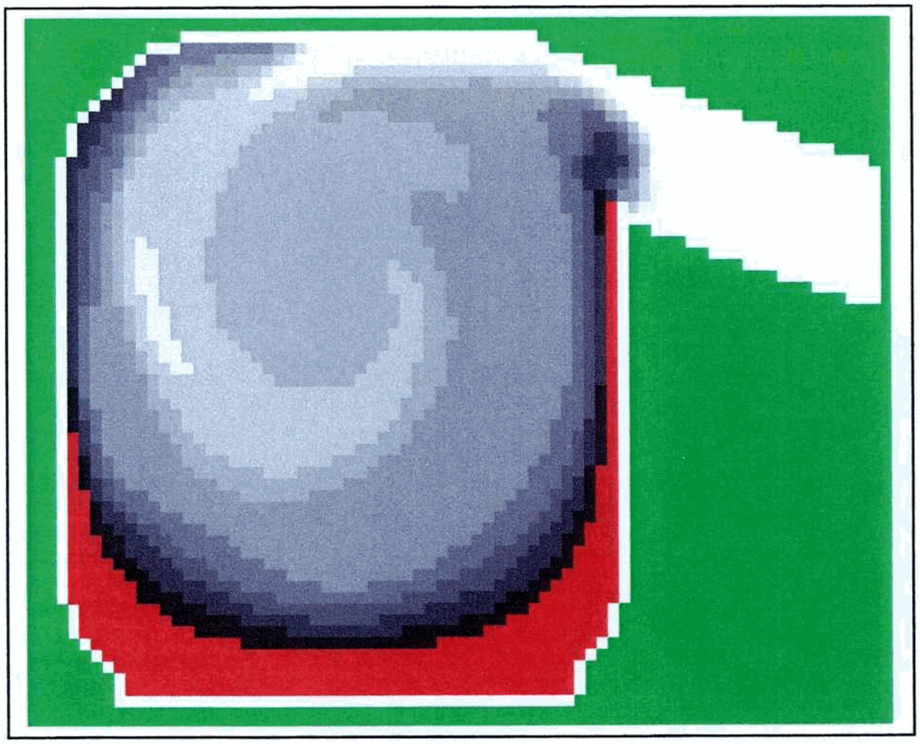

Figure 6. Shows the distribution of exchange coefficient in the rectangular basin with the narrow inner entrance. White indicates well-mixed areas while the red signifies poorly mixed areas.

was a marginal improvement in water quality with this shape, it cannot practically be distinguished from the previous configuration on the bases of improved water quality (Table 1).

It is believed that there are two possible reasons why the circular shape did not show a demonstrable increase in mixing efficiency when compared to the more rectangular shape. The first was that the tidal ranges were just too small to generate any excess momentum to take full advantage of this shape, and the second was that the entrance had such a high volume capacity that most of the incoming flow was retained in the entrance and water was not allowed to exchange between the basin and the water on the outside of the entrance.

To examine this possibility, the entrance was shortened for configurations 2 and 3. This forced greater exchange between waters inside and outside the basin. This did yield a mean exchange coefficient a few percent greater than the comparable basin with a longer

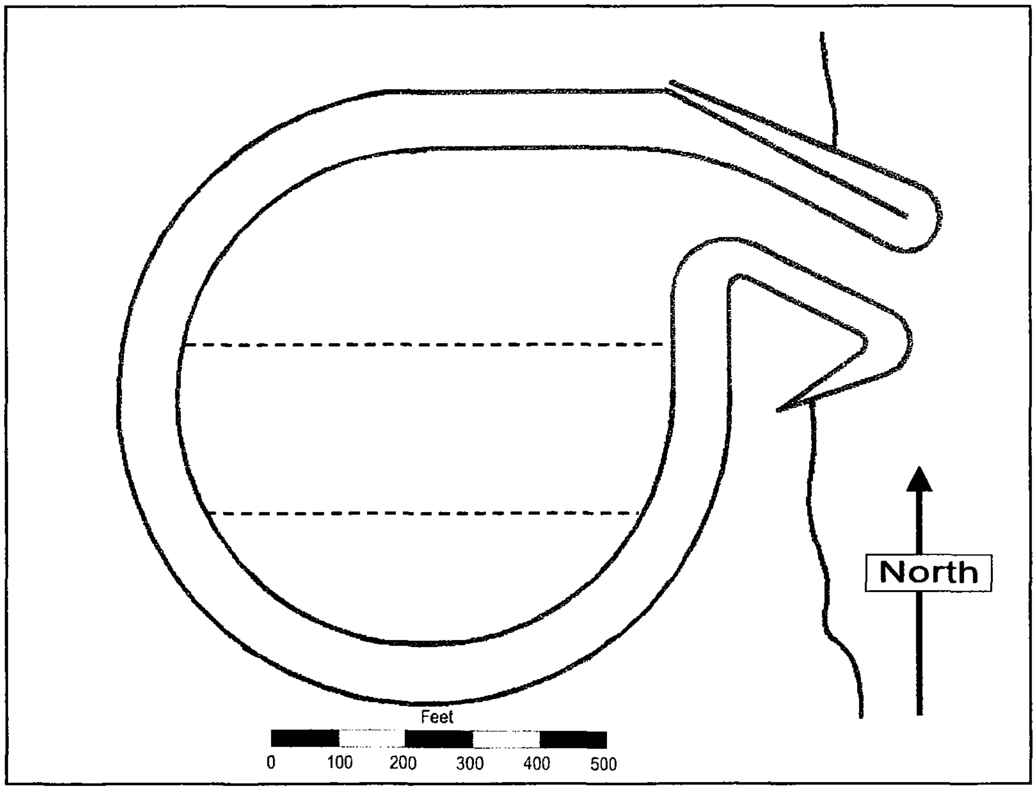

Figure 7. Rectangular configuration with the modified entrance.

entrance; it also showed that the circular basin was somewhat better than the rectangular basin. The difference has not substantial. So the most likely reason the rectangular basin performed nearly as well as the circular shape is due to the lack of sufficient momentum to take full advantage of the circular shape.

Clearly, the initial modification involving changing the width of the inner entrance did generate a marked increase in amount of mixing and exchange within the basin in comparison to the original design. It is also suspected that this alteration will further reduce wave heights in the basin as described in the subsequent section.

While additional designs did generate some efficient mixing, the difference was subtler than between the first two options investigated.

3.0 BASIN WAVE ANALYSIS

Another concern for the designers and the Corps of Engineers was whether the preferred entrance would permit waves higher than allowable for prudent boat basin design. The Corps has often limited these to a significant height of 1 foot or less for the given 50-year design wave. In the present harbor, the anticipated fleet is to be composed of vessels

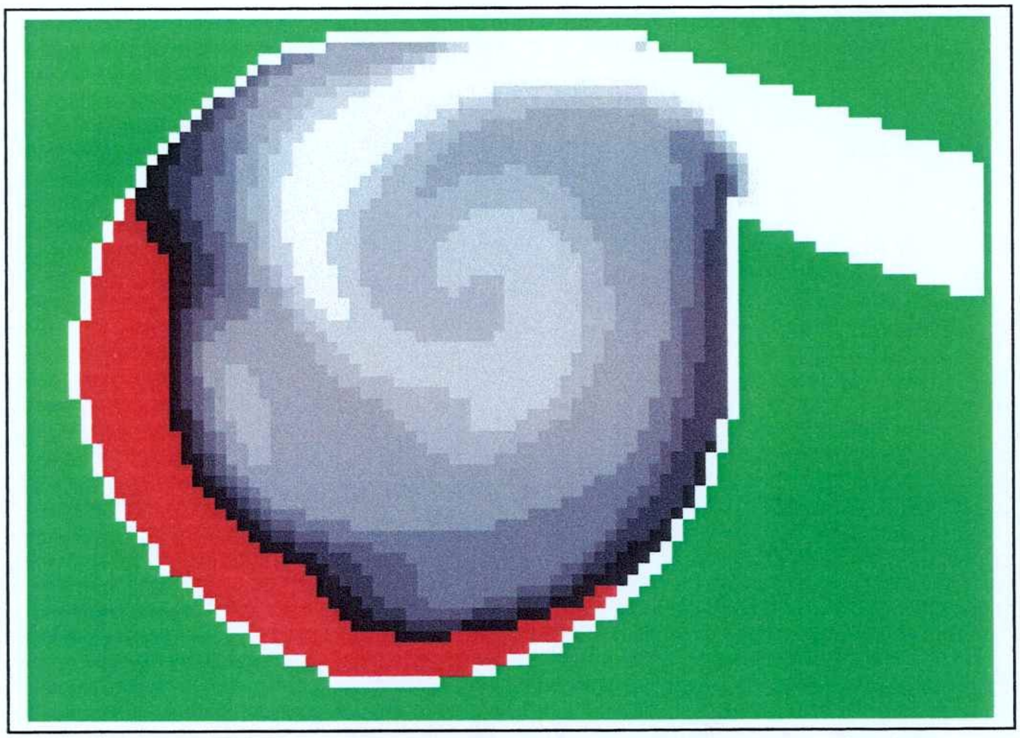

Figure 8. Shows the distribution of exchange coefficient in the circular basin with the narrow inner entrance. White indicates well-mixed areas while the red signifies poorly mixed areas.

whose length will be longer than 100 feet. Therefore this height restriction seems somewhat severe. The design significant wave height at the entrance to the basin has been determined to be 3.1 feet.

The wave program REFDIF (version 2.5) was used to investigate the transformation of the design wave as it enters the basin. REFDIF solves the refraction and the nonlinear diffraction processes in a unified way. Figure 9 presents the general contours of the wave height in the entrance and inside the basin for the given design wave.

The program indicates that wave heights are well attenuated in the basin entrance and only a small region of the basin will see waves over 0.4 feet high. No waves exceeding 1.0-foot high propagate into the basin.

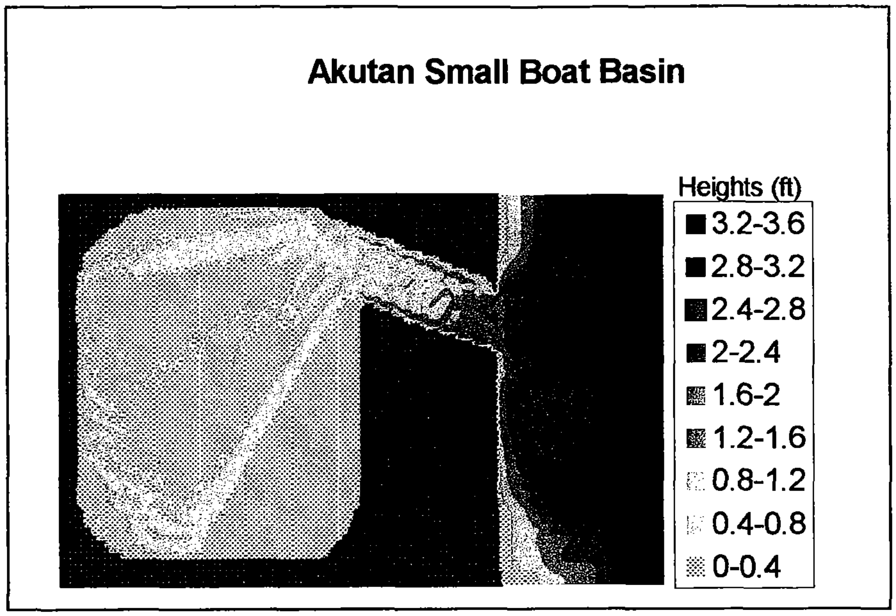

Figure 9. Wave heights in small boat basin. Most of the heights in the are less than 0.4 feet high. Waves a foot high only exist in the entrance channel.

A note on fluid velocities

The equations used to obtain the fluid velocities are referred to by different names, but they are forms of the Navier-Stokes momentum equations. These describe, by way of Newton's second law of motion, the process whereby external (surface and body) forces alter the fluid's momentum (mass * velocity). Besides the forces provided by the more obvious head differences, they are also applied as surface forces such as drag (friction) along the bottom and sides and on the top of the fluid as wind stress. Other forces that are integral parts of the N-S equations include the differences in density between adjacent water particles, the coupling (or friction) between adjacent particles moving past one another and Coriolis forces. These are treated mathematically several different ways. While these forces are probably the most important for describing nearshore circulation, there are more and this is merely a simplified description.

The velocities obtained by solving these equations are then used in another set of equations (the convection-diffusion equations) to predict the distribution of substances in the water. This is where the mixing or the changes in concentration as functions of time and space are determined. Then these results can in turn be used to obtain the exchange coefficients or other mixing efficiency measures.

The convection-diffusion equation equations (just as the actual process) operates with whatever velocities are provided to them. It doesn't matter whether they are the result of tides, winds, or density differences. Often only tides (plus some type of friction) are used to drive the flow because it is either the most dominant force or the only one that is continuous, or both. But when winds are reasonably constant and of sufficient magnitude, then a case can definitely be made that they should be used in the mixing process. That's all we did for the Akutan boat basin mixing situation.

APPENDIX E
REAL ESTATE PLAN
NAVIGATION IMPROVEMENTS
AKUTAN, ALASKA

REAL ESTATE PLAN
AKUTAN HARBOR PROJECT
AKUTAN, ALASKA
28 January 2004

Purpose of Report: The final Feasibility Report for this project is scheduled for completion in late 2004. A Feasibility Study, Phase I Preliminary Site Assessment Report was completed in July 1998, and the Reconnaissance Report was completed in August 1997. The proposed Akutan Harbor project will be located approximately 1.5 miles west of the City of Akutan, within Township 70 South, Range 112 West, Seward Meridian, Alaska. This report identifies and describes the Lands, Easements and Rights of Way (LER) required for construction, and operation and maintenance of the Reconfigured 12-Acre Alternative Harbor Project for 58 vessels. Federal General Navigation Features (GNF) include the following: an entrance channel; two (2) rubblemound breakwaters; a turning basin; an excavated and dredge material disposal, construction and staging area; and a mitigation area for creek rerouting and removal of a fish barrier. The local sponsor is the Aleutians East Borough, and their Local Service Facilities (LSF) include: a mooring basin; an excavated material and dredge disposal area; one (1) acre within the Federal GNF material disposal area that will be designated for a Harbormaster Building and essential port facilities; and an additional mitigation area only.

Project Summary: The project site is located mid way along the Aleutian chain, on the western end of Akutan Harbor off the Bering Sea. The harbor will be constructed on an old glacier bed adjacent to the shore, which is flanked by mountains, and is considered to be the only suitable site within the Harbor. Project excavation and dredging will begin at the mooring and turning basins and move outward, with the excavated and dredged material deposited in designated disposal areas to the south and southwest side of the harbor. An existing creek that runs in an eastwardly direction from the northwest into the proposed harbor will be rerouted to the north of the harbor and reconnected with the original creek above the harbor. Additionally, a project access road will be constructed from the north side of the harbor around the western side to tie in with the dredge disposal, construction and staging area. Mitigation required for the loss of habitat due to project construction includes a 100± foot buffer area with several streamlets on both sides of North and Rust Creeks. For planning and costs estimating purposes, fee simple acquisition of mitigation lands has been assumed in this Real Estate Plan and Feasibility Report, although the final decisions on the nature and extent of the required real estate interest may change after project authorization. Total mitigation costs for the Federal GNF and LSF lands for the Feasibility Report are shown below the Real Estate Cost Estimate Table, with a proportional split of 35 percent of the costs attributed to the GNF, and the remaining 65 percent to the LSF.

Current Land Ownership: The Akutan and Aleut Native Corporations, own the surface and subsurface estates respectively, which is a majority of the uplands required for the harbor project. Lands within U.S. Survey 766 are owned by the City of Akutan. The Government's dominant rights of Navigation Servitude will be exercised for tidelands below the Mean High Water (MHW) Line. A map depicting the real estate required for the Akutan Harbor Project is shown as Exhibit A, and the legend is described in Exhibit A-1.

Summary of Required Real Estate Interests:

	ACRES	OWNERS	INTEREST
FEDERAL GENERAL NAVIGATION FEATURES			
Entrance Channel and Breakwaters BMHW*	**3.48**	State of Alaska	Navigation Servitude
Entrance Channel AMHW**	**0.48**	City of Akutan	Fee
Breakwaters AMHW	**1.44**	City of Akutan	Perpetual Easement
Turning Basin AMHW	**8.20**	Akutan and Aleut Corporations	Fee
Excavated & Dredge Material Disposal, Construction & Staging Area AMHW ***	**7.00**	Akutan and Aleut Corporations	Three (3) Year Temporary Easement
Rust Creek Rerouting Mitigation Area AMHW	**9.98**	Akutan and Aleut Corporations	Fee
LOCAL SERVICE FACILITIES			
Mooring Basin AMHW	**12.72**	Akutan and Aleut Corporations	Fee
Excavated & Dredge Material Disposal Area AMHW ***	**20.50**	Akutan and Aleut Corporations	Three (3) Year Temporary Easement
Access Road AMHW	**1.02** **0.07**	Akutan and Aleut Corporations and City of Akutan	Perpetual Easement
Harbormaster Building Area within the GNF Excavated & Dredge Material Disposal, Construction & Staging Area AMHW	**1.00**	Akutan and Aleut Corporations	Fee
Mitigation Area Only AMHW	**28.71** **2.00**	Akutan and Aleut Corporations and City of Akutan	Fee
Project Boundary	**98.57**	N/A	N/A

* Below Mean High Water ** Above Mean High Water

*** The Local Sponsor plans to acquire additional easements for the use of these areas for storage of excavated and dredged material from the project that will be used throughout the Aleutians East Borough.

Non-Standard Estates: It has been recommended by State and Federal Fish and Wildlife Agencies, but not yet determined, that the local sponsor obtain a Conservation Easement in perpetuity from the Akutan and Aleut Corporations and the City of Akutan for the mitigation lands. The intent of the Conservation Easement would be to protect the natural integrity of the creeks and their contiguous wetlands for fish and wildlife habitat; personal or subsistence harvests of fish, wildlife, and plant resources could continue, but no development or commercial use of any kind would be allowed.

Federally Owned Lands Within the Project Boundary: There are no identified federally owned lands within the project area that have been discovered.

Potential Flooding Induced by Construction, Operation or Maintenance of the Project: No flooding is predicted due to construction, operation or maintenance of the project.

Baseline Cost Estimate for Real Estate: The real estate costs are based on a gross appraisal performed by the staff appraiser on 14 January 2002, and a supplemental update completed on 27 January 2004. Should another gross appraisal be prepared, the values provided herein could substantially change. Administrative costs are for mapping, title work, surveying, appraisal and the final crediting process. A 20 percent contingency for value changes over time has been included in the land costs.

Federal General Navigation Features (GNF)				
Item	**Federal**	**Local**	**Subtotal**	
Administration	20,000	$15,000	$35,000	
Real Estate Land Costs		$78,500	$78,500	
Relocation		$0	$0	
Local Service Facilities (LSF)				
Item	**Federal**	**Local**	**Subtotal**	
Administration	$10,000	$20,000	$30,000	
Real Estate Land Costs		$171,500	$171,500	
Removals		$0	$0	
Total Cost				**$315,000**

The total mitigation land costs for the Feasibility Report are $83,000.00, with 35 percent/$29,050.00 attributed to the Federal GNF, and the remaining 65 percent/$53,950.00 attributed to the LSF.

Relocation Assistance Benefits: No persons or businesses will be displaced by this project. Therefore, no relocation assistance benefits under Public Law 91-646 will be required.

Mineral Activity: No known mineral activity has occurred within the project area, nor is any anticipated.

Non-Federal Sponsor's Legal and Professional Capability and Experience To Acquire and Provide LER: The Aleutians East Borough has full eminent domain authority for public purposes. An Assessment of the sponsor's Real Estate Acquisition Capability is shown as Exhibit B.

Application or Enactment of Zoning Ordinances: No enactments or applications for zoning have been located that affect the project area.

Schedule of All Land Acquisitions:

	Corps of Engineers		Local Sponsor	
Activity	**Initiate**	**Complete**	**Initiate**	**Complete**
Receipt of final Drawings from Engineering/Project Manager		May-07		
Execution of PCA		Feb-07		
Formal Transmittal of final Real Estate maps to LS with notification to acquire LER	Feb-07	Mar-07		
Mapping, legal descriptions, title evidence			Feb-07	Mar-07
Conduct appraisals, negotiations & closing			Mar-07	May-07
Certify that all necessary LER is available for project construction	May-07	May-07		
Submit credit requests			May-07	Sep-07
Review & approve or deny credit requests	Jun-07	Oct-07		

Relocations of Facilities, Roads, and Utilities: There are no utilities, roads, or facilities that will need to be relocated due to this project.

Impact on Real Estate Acquisition Due to Suspected or Known Contaminants: No contaminants have been found that will adversely effect real estate acquisition.

Known or Anticipated Support of Opposition to the Project: The City of Akutan, and the Borough support construction of the harbor, and no known opposition has been expressed by area residents, or is anticipated.

Non-Federal Sponsor's Notification of Acquisition Risks Prior to Signing of the Project Cooperation Agreement (PCA): The schedule above may be shortened if the sponsor begins acquisition (at its own risk) prior to signing of the PCA. The sponsor was notified of the risk of early acquisition in January 2002.

The original Real Estate Plan was prepared by Ann P. Hardinge, Real Estate Appraiser in August 2002, and revised by Karen L. Pontius, Realty Specialist, in January 2004.

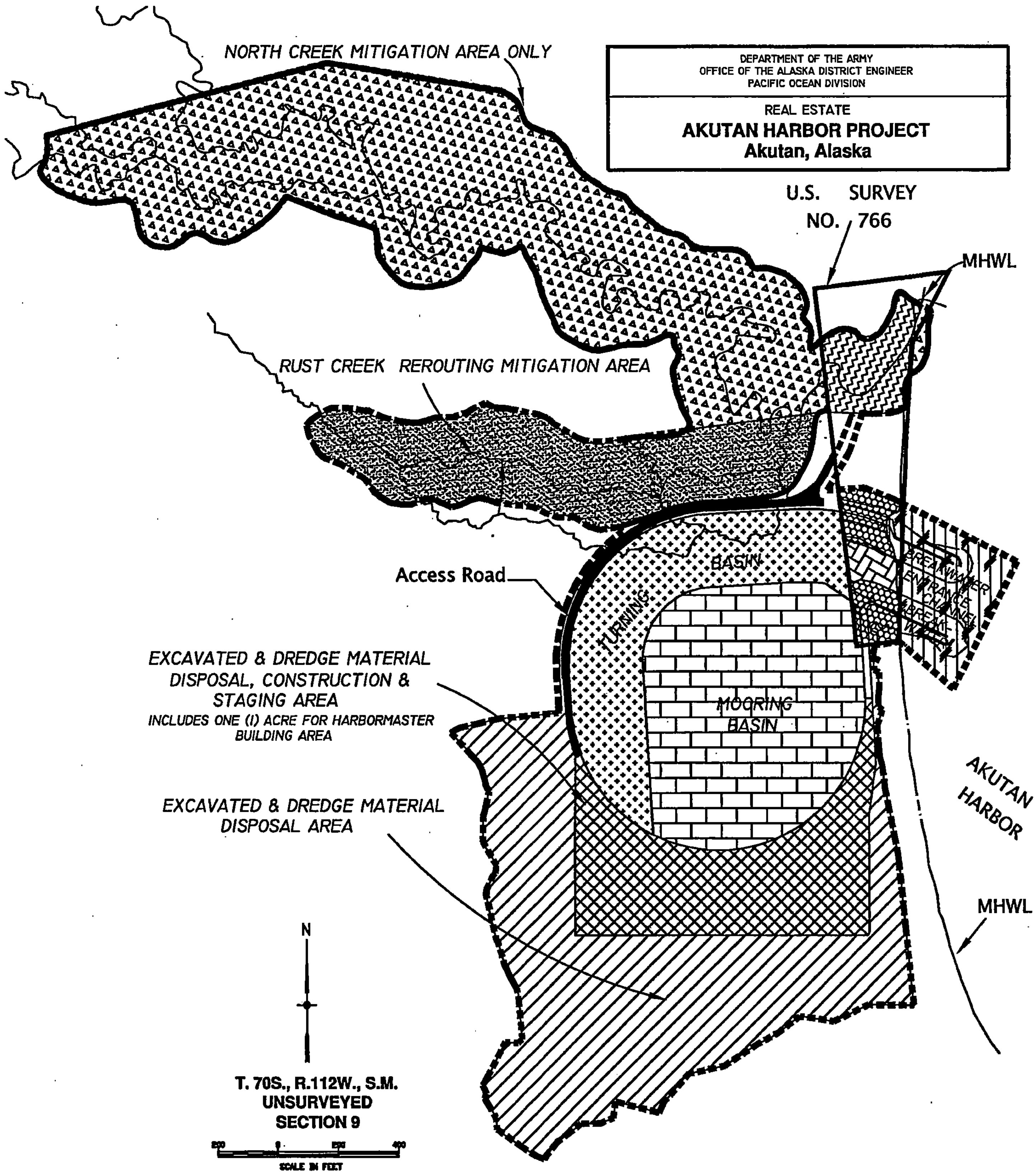
DEPARTMENT OF THE ARMY
OFFICE OF THE ALASKA DISTRICT ENGINEER
PACIFIC OCEAN DIVISION
REAL ESTATE
AKUTAN HARBOR PROJECT
Akutan, Alaska
NORTH CREEK MITIGATION AREA ONLY
U.S. SURVEY NO. 766
MHWL
RUST CREEK REROUTING MITIGATION AREA
Access Road
TURNING BASIN
MOORING BASIN
EXCAVATED & DREDGE MATERIAL DISPOSAL, CONSTRUCTION & STAGING AREA
INCLUDES ONE (I) ACRE FOR HARBORMASTER BUILDING AREA
EXCAVATED & DREDGE MATERIAL DISPOSAL AREA
AKUTAN HARBOR
MHWL
N
T. 70S., R.112W., S.M.
UNSURVEYED
SECTION 9
SCALE IN FEET

EXHIBIT A

AKUTAN HARBOR PROJECT

GENERAL NAVIGATION FEATURES (GNF)

- Entrance Channel = 0.48 ± Acre
- Breakwaters = 1.44 ± Acres
- Turning Basin = 8.20 ± Acres
- Excavated & Dredge Disposal, Construction & Staging Area = 8.00 ± Acres Includes one (1) Acre Area, to be determined for Harbormaster Building Area
- Mitigation Area for Creek Rerouting = 9.98 ± Acres
- Navigation Servitude = 3.48 ± Acres
- Project Boundary = 98.57 ± Acres

LOCAL SERVICE FACILITIES (LSF)

- Mooring Basin = 12.72 ± Acres
- Excavated & Dredge Disposal Area = 20.5 ± Acres
- Access Road = 1.02 ± Acres
- Access Road = 0.07 ± Acres
- Mitigation Area Only = 28.71 ± Acres
- Mitigation Area Only = 2.00 ± Acres

EXHIBIT A - 1

ASSESMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

**AKUTAN HARBOR:
AKUTAN**

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? Yes,

b. Does the sponsor have the power of eminent domain for this project? Yes~~, with voter approval~~

c. Does the sponsor have a "quick-take" authority for this project? ~~N/A~~ Yes

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? No

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? No

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? No

b. If the answer to II a is yes, has a reasonable plan been developed to provide such training? N/A_

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load if any, and the project schedule? Yes

e. Can the sponsor obtain contractor support, if required, in a timely fashion? Yes

f. Will the sponsor likely request USACE assistance in acquiring real estate? No

EXHIBIT B

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? Yes

b. Has the sponsor approved the project/real estate schedule/milestones? Yes_

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? Yes

b. With regard to this project, the sponsor is anticipated to be: highly capable/ **Fullycapable**

V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes

b. Does the sponsor concur with this assessment? Yes

SOURCE:

Bob Juettner
Borough Administrator
Aleutians East Borough
907/274-7555
Date: 1/16/02

Prepared By:

Name: Ann P. Hardinge
Title: RE Appraiser
Date: 17 Jun 2002

Reviewed and approved by:

Harold D, Hopson
Acting Chief, Real Estate Division

APPENDIX F
CORRESPONDENCE
NAVIGATION IMPROVEMENTS
AKUTAN, ALASKA

ALEUTIANS EAST BOROUGH

SERVING THE COMMUNITIES OF
KING COVE ■ SAND POINT ■ AKUTAN ■ COLD BAY ■ FALSE PASS ■ NELSON LAGOON

May 2, 2002

Colonel Steven Perrenot
District Engineer
Alaska District
Army Corps of Engineers
PO Box 6898
Anchorage, AK 99506-6898

Dear Col. Perrenot,

The Aleutians East Borough is the local sponsor of the Akutan Boat Harbor Project. As such, it is responsible for the non-federal portion of any project authorized and constructed by US Army Corps of Engineers as a result of Congressional action. The Aleutians East Borough recognizes that it responsible for the payment of 20% of the General Navigation Features and 100% of the Local Service Facilities.

The financial components of the project can be summarized as follows:

	Total Project	Federal Share	Local Share
GNF	$ 10,567,000	$ 9,510,000	$ 1,057,000
LERR, GNF	$ 226,000		$ 226,000
Addition Funding		$ (831,000)	$ 831,000
Subtotal GNF	$ 10,793,000	$ 8,679,000	$ 2,114,000
Aids to Navigation	$ 15,000	$ 15,000	$ -
Local Service Fac.	$ 5,095,000	$ -	$ 5,095,000
Lands	$ 968,000	$ -	$ 968,000
Subtotal LSF	$ 6,063,000	$ -	$ 6,063,000
Final Cost	$ 16,871,000	$ 8,694,000	$ 8,177,000

The Aleutians East Borough will meet its financial commitment of $8,177,000 by utilizing both GO Bonds and revenue bonds, a cash donation and in kind contributions of land as follows:

❑ CLERK/PLANNER
P.O. BOX 349
SAND POINT, AK 99661
(907) 383-2699
(907) 383-3496 FAX
e-mail: AEBCLERK@aol.com

❑ BOROUGH ADMINISTRATOR
1600 "A" STREET, SUITE 103
ANCHORAGE, AK 99501-5146
(907) 274-7555
(907) 276-7569 FAX
e-mail: aeboro@gci.net

❑ FINANCE DIRECTOR
P.O. BOX 49
KING COVE, ALASKA 99612
(907) 497-2588
(907) 497-2386 FAX

❑ RESOURCE DEPARTMENT
211 4TH STREET, SUITE 314
JUNEAU, AK 99801
(907) 586-6655
(907) 586-6644 FAX
e-mail: beth@ptialaska.net

Contributor		GO Bonds	Revenue Bonds	Lands for LSF	Cash Grant
Aleutians East Borough		$ 5,000,000	$1,123,000		
City of Akutan				$1,204,000	
APICDA					$850,000
TOTAL	$8,177,000	$ 5,000,000	$1,123,000	$1,204,000	$850,000

GO Bonds: The Aleutians East Borough has issued GO Bonds for a number of capital improvement projects including school construction, docks, airports and boat harbors. It issues the bonds through the Alaska Municipal Bond Bank Authority. The financial strength of the Aleutians East Borough and the Alaska Municipal Bond Bank Authority results in the issuance of bonds at a very favorable interest rate. The Aleutians East Borough's ability is further enhanced by the fact that it has retired several bonds issued in the late 1980s and early 1990s. The Aleutians East Borough currently holds $1M in GO Bond authorization for this project. The State of Alaska is on the verge of approving a bond debt reimbursement program that will contain $4M of reimbursable bond debt authority for the Akutan Boat Harbor Project. While it is a departure from the dollar for dollar match that the State of Alaska provided on the King Cove Boat Harbor and the Sand Point Boat Harbor, this program is consistent with other shared debt programs administered by the State of Alaska.

Revenue Bonds: Unlike GO Bonds that are tied to tax receipts, revenue bonds must be paid from the receipt of fees. Given the size of the vessels and the number of vessels to be moored in Akutan, the harbor will generate sufficient fees to retire this debt.

Lands for LSF: The City of Akutan and the Akutan Village Corporation are engaged in discussion on this issue. Under section 14C3 of the Alaska Native Claims Settlement Act, the municipality within a native village may claim and receive up to 1,280 acres of land for community related projects. The Akutan Village Corporation supports this project for the economic development benefits it will bring to the community and its shareholders. Therefore, it has agreed to make the land available to the City of Akutan for this project. In turn, the City of Akutan has agreed to give the necessary rights to the land to the Aleutians East Borough for the project.

Cash Grant: The Aleutian Pribolof Islands Community Development Association has agreed to contribute $850,000 in cash on the behalf of its members in the village of Akutan. The Aleutian Pribolof Islands Community Development Association is a federally created economic development organization that receives a percentage of the allowable harvest of fish and crab in the Bering Sea. It uses the profits from its allocation to support economic development activities for its six member communities. The

Aleutians East Borough and the Aleutian Pribolof Islands Community Development Association have cooperated to jointly fund projects in Akutan, False Pass and Nelson Lagoon.

If you have any question or require further documentation, please contact me.

Sincerely,

Robert S. Juettner
Administrator

APPENDIX G
COST ESTIMATES
NAVIGATION IMPROVEMENTS
AKUTAN, ALASKA

Akutan Alternatives For use in Table 3 of FR
Unit prices are from the reconfigured 12 acre basin MCACES estimate

				12 acre basin		15 acre basin		20 acre basin		reconfig 12 acre basin	
item	Units	unit price	Contin	amount	total	units	total	units	total	units	total
Mob & Demob	LS	1,122,652	20%	1	1,347,000	1	1,347,000	1	1,347,000	1	1,347,000
Breakwater & Seawall											
Armor rock	CY	61.36	20%	15,000	1,104,000	15,000	1,104,000	15,000	1,104,000	15,000	1,104,000
B-rock	CY	49.06	20%	8,000	471,000	8,000	471,000	8,000	471,000	8,000	471,000
Core rock	CY	41.72	20%	45,000	2,253,000	45,000	2,253,000	45,000	2,253,000	45,000	2,253,000
Navigation Foundations	LS	24,281	20%	1	29,000	1	29,000	1	29,000	1	29,000
Total BW&SW					**3,857,000**		**3,857,000**		**3,857,000**		**3,857,000**
Dredging											
Entrance/Maneuv Chan											
Slope protection	CY	79.01	20%	9,700	920,000	9,700	920,000	10,700	1,014,000	9,700	920,000
Entrance Channel Dredge	CY	6.43	10%	180,000	1,273,000	180,000	1,273,000	180,000	1,273,000	82,000	580,000
Maneuvering Channel Dredge	CY	6.43	10%	300,000	2,122,000	337,000	2,384,000	366,000	2,589,000	280,000	1,980,000
Temporary Dewater basin	LS	76,842	10%	1	85,000	1	85,000	1	85,000	1	85,000
Hydrographic Survey	EA	14,568	20%	2	35,000	2	35,000	2	35,000	2	35,000
Silt Barrier	LS	145,683	20%	1	175,000	1	175,000	1	175,000	1	175,000
Water Analysis	LS	40,000	20%	1	48,000	1	48,000	1	48,000	1	48,000
subtotal E/M chan					**4,658,000**		**4,920,000**		**5,219,000**		**3,823,000**
Mooring Basin											
Slope protection	CY	83.93	20%	7,500	755,000	8,800	886,000	11,300	1,138,000	10,000	1,007,000
Mooring basin	CY	6.49	10%	370,000	2,641,000	473,000	3,377,000	629,000	4,490,000	481,000	3,434,000
subtotal Mooring Basin					**3,396,000**		**4,263,000**		**5,628,000**		**4,441,000**
Total Dredging	CY				**8,054,000**		**9,183,000**		**10,847,000**		**8,264,000**
Dock Facilities	LS	2,063,848	20%	1	2,477,000	1.26	3,121,000	1.58	3,913,000	1	2,477,000
Uplands Requirements											
Access Spur Road	LS	82,352	20%	1	99,000	1	99,000	1	99,000	1	99,000
Uplands Gravel Surface	LS	254,450	20%	1	305,000	1.26	385,000	1.58	482,000	1	305,000
Total Uplands Requirements					**404,000**		**484,000**		**581,000**		**404,000**
Rust Creek Relocation	LS	267,086	20%	1	321,000	1	321,000	1	321,000	1	321,000
Construction total					16,460,000		18,313,000		20,866,000		16,670,000

Boat Harbor - Akutan, AK
Reconfigures(12) Acre Inland
Basin

Designed By: Tryck Nyman Hayes, Inc.
Estimated By: Tryck Nyman Hayes, Inc.& USACE

Prepared By: Mike Field (TNH) and Clarke
Hemphill (USACE)

Preparation Date: 04/01/04
Effective Date of Pricing: 10/01/03

Sales Tax: 0.0%

This estimate is based on quantities provided by Tryck Nyman Hayes, Inc. engineers for the reconfigured (12) size basin.

This is an estimate of probable construction cost only and actual bids will vary from this estimate. The estimate excludes bid preparation documents, administrative costs, fittings and equipment, except that specifically stated in the estimate.

Prices are based on current Davis Bacon labor rates and current prices for materials, freight and equipment. The estimate is based on the assumption that the project will receive competitive bids from general contractors who will also get subcontractors and suppliers competitive bid.

Schedule Assumptions: Construction will start March 2006, and work completed December 2007.

This estimate assumes normal escalation based on the current economic climate in Alaska. It is assumed that materials for filling and rock will be brought in by barge from Dutch Harbor.

	QUANTITY	UOM	CONTRACT	ESCALATN	DGN&ENG	CONTINGN	S&A	TOTAL COST	UNIT COST
01 BASE BID									
01.01 Breakwater									
01.01.01 Material and Placement									
01.01.01.01 Armor Rock	15000.00	CY	920,471	0	0	0	0	920,471	61.36
01.01.01.02 B-Rock	8000.00	CY	392,512	0	0	0	0	392,512	49.06
01.01.01.07 Core Rock	45000.00	CY	1,877,513	0	0	0	0	1,877,513	41.72
TOTAL Material and Placement	1.00	EA	3,190,495	0	0	0	0	3,190,495	3190495
01.01.03 Navigation Foundations	1.00	EA	24,281	0	0	0	0	24,281	24280.57
TOTAL Breakwater			3,214,776	0	0	0	0	3,214,776	
01.02 Entrance & Maneuvering Channel									
01.02.01 Slope Protection	9700.00	CY	766,412	0	0	0	0	766,412	79.01
TOTAL Slope Protection	9700.00	CY	766,412	0	0	0	0	766,412	79.01
01.02.02 Dredging									
01.02.02.01 Entrance Channel	82000.00	CY	527,019	0	0	0	0	527,019	6.43
01.02.02.02 Maneuvering Channel	280000.00	CY	1,799,579	0	0	0	0	1,799,579	6.43
01.02.02.03 Temporary Dewatering Basin	1.00	EA	76,842	0	0	0	0	76,842	76841.93
01.02.02.04 Hydrographic Survey	2.00	EA	29,137	0	0	0	0	29,137	14568.34
01.02.02.05 Silt Barrier	1.00	EA	145,683	0	0	0	0	145,683	145683.42
01.02.02.06 Water Analysis	1.00	EA	40,000	0	0	0	0	40,000	40000.00
TOTAL Dredging	362000.00	CY	2,618,260	0	0	0	0	2,618,260	7.23
TOTAL Entrance & Maneuvering Channel			3,384,672	0	0	0	0	3,384,672	
01.03 Mooring Basin									
01.03.01 Slope Protection	10000.00	CY	839,263	0	0	0	0	839,263	83.93
01.03.02 Dredging	481000.00	CY	3,120,560	0	0	0	0	3,120,560	6.49
TOTAL Mooring Basin			3,959,822	0	0	0	0	3,959,822	
01.04 Local Harbor Facilities									
01.04.01 Float System	1.00	EA	2,063,848	0	0	0	0	2,063,848	2063848
01.04.02 Access Spur Road	1.00	EA	82,352	0	0	0	0	82,352	82351.62

	QUANTITY	UOM	CONTRACT	ESCALATN	DGN&ENG	CONTINGN	S&A	TOTAL COST	UNIT COST
01.04.03 Uplands Gravel Surface	1.00	EA	254,450	0	0	0	0	254,450	254450.01
TOTAL Local Harbor Facilities			2,400,650	0	0	0	0	2,400,650	
01.05 Mob and Demob									
01.05.01 Mobilization	1.00	EA	837,073	0	0	0	0	837,073	837072.65
01.05.02 Demobilization	1.00	EA	285,709	0	0	0	0	285,709	285709.47
TOTAL Mob and Demob			1,122,782	0	0	0	0	1,122,782	
01.06 Rust Creek Relocation									
01.06.07 Redirect Existing Drainage	1.00	EA	267,086	0	0	0	0	267,086	267086.27
TOTAL Rust Creek Relocation			267,086	0	0	0	0	267,086	
TOTAL BASE BID	1.00	EA	14,349,788	0	0	0	0	14,349,788	14349788
TOTAL Boat Harbor - Akutan, AK	1.00	EA	14,349,788	0	0	0	0	14,349,788	14349788