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NOATAK RIVER BANK EROSION STUDIES

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FINAL SUBMITTAL

NOATAK RIVER BANK EROSION STUDY AT NOATAK, ALASKA

ANTHC Project No. AN01-Q55

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NOATAK RIVER BANK EROSION STUDY AT NOATAK, ALASKA

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NOATAK RIVER BANK EROSION STUDY AT NOATAK, ALASKA

EXECUTIVE SUMMARY

The Noatak IRA Council and the Alaska Native Tribal Health Consortium (ANTHC) are currently in the process of updating water and sewer plans for the Village of Noatak, Alaska. The bank of the Noatak River adjacent to the village has undergone significant erosion over the past 50 years. Short-term erosion threatens to destroy the three existing water wells in the village. Long-term erosion may threaten the water treatment facilities building. As part of this water and sewer plan update, R&M Consultants, Inc. has performed an erosion study for PDC, Inc., who is under contract to ANTHC. The purpose of this study is to estimate the extent of future erosion at five locations, estimate how long the existing water wells may survive, and evaluate a location for new water wells.

The methods of investigation and analysis for this study consisted of collecting existing data, interpretation of aerial photos, and field reconnaissance. Existing reports and other pertinent data are summarized in this report. As part of the study, 12 sets of aerial photos taken between 1952 and 2000 were analyzed. Past erosion rates were determined and used to predict future erosion limits. A field trip was conducted in August, 2002 to observe existing conditions.

Noatak lies on the west bank of the Noatak River, approximately 55 miles northwest of Kotzebue. There is no road access and year-round access is by air. The village lies within the Mission Lowland, a broad tundra flat crossed by a forested floodplain. The river is interpreted to be a split-channel river, and the part of the river flowing by the village is split into a west and east channel.

Discharge in the Noatak River channels has shifted between the east and west channels several times over the past 50 years. A small, apparently gradual shift in one channel about a mile upriver of the village occurred during the 1960s and 1970s and appeared to have lead to a major shift in the pattern and an increase in the rate of erosion along the bank in the village. Several erosion control projects have been constructed and ultimately failed over the years, including a 1,900-foot long wood retaining wall constructed in the 1960s. A large 1,500-foot long concrete structure built in the 1980s and is still in place today. A large erosion control project was planned in the 1990s, but was never funded. At present, the East Channel has the maximum discharge rate and the West Channel has become a high-water channel. The West Channel split upriver from the village into two channels referred to as Channel A and Channel B. Changes in the direction and relative discharge in these two channels are interpreted to be one of the causes of the changing pattern of bank erosion at the village.

Location A (Drawing A-03) consists of the section of river bank lying downriver of the concrete erosion control structure. The increase in erosion rates along this stretch of the river bank appears to be due to gravel mining and the shifting of flow from Channel A to Channel B. The recent diversion of flow from the West Channel to the East Channel may reduce short-term erosion rates. However, much of the erosion at Noatak appears to occur during floods when there is still significant flow through the West Channel.

Location B (Drawing A-04) consists of the section of river bank protected by a concrete erosion control structure. The banks behind the structure are vegetated and appear to have been relatively stable since it was constructed in the early 1980s. Channel A flowed along the bank, which showed evidence of active erosion prior to construction. Parts of the downriver structure have failed and other parts may fail in the near future. This study indicates the structure will fail completely sometime after 2020.

Location C (Drawing A-05) consisted of the island (gravel bar) adjacent to the north side of the village. Photos showed that the vegetation had increased, thus indicating a period of increasing stability. This appeared to be primarily due to the shifting of the flow of the river from Channel A to Channel B. Water Wells 1 and 2 were located on the island. Water Well 1 was lost in 1990 and Well 2 is now threatened. Channel A appeared to be deflecting Channel B away from the island, at least during periods of low water. As long as this deflection continues, it appears that the island will remain stable.

Location D (Drawing A-06) consists of the section of river bank upriver of the concrete erosion control structure. The banks along the southern part were observed to be vegetated during the field reconnaissance and appeared to be stable with only minor erosion occurring. The northern part consisted of banks along two islands and the river at the upriver end of Location D. Prior to flow shifting from Channel A to Channel B, significant erosion was occurring at this location.

Location E (Drawing A-0-7) consists of a vegetated island upriver from the village. Photo analysis showed that the island has been eroding since 1986, as a meander bend in Channel B moved downriver.

Between 1952 and 1978 it appeared that a series of small overflow channels coalesced into Channel B and began flowing into the West Channel of the River. After 1978, the flow increased in Channel B and it became the main channel.

Water Wells 3 and 4 (Figure 15) were located immediately behind a part of the concrete mat that is failing and may fail completely in less than 5 years. The remaining water well (2), on the gravel bar at Location C was located on the edge of the island, with only a few feet separating it from the active channel (Figure 11). The river has reportedly overtopped it more than once and it is likely to be destroyed during the next period of high water. The proposed new water wells at Location C have a design life of 20 years and lie on a portion of the island estimated to last at least that long.

The reliability of the projections made during this study depend upon the river regime remaining basically the same for the next 50 years. Major changes to the channel configuration may change the projected erosion limits. Due to the uncertainties in these types of studies we recommend that erosion monitoring be performed. Monitoring would provide information for evaluating the rates of erosion projected in this report.

NOATAK RIVER BANK EROSION STUDY AT NOATAK, ALASKA

1.0 INTRODUCTION

1.1 Background

The Noatak IRA council is currently completing an update to their March, 1992 Water and Sewer Facilities Plan. The Facilities Plan update is being completed as a cooperative effort between the Noatak IRA and the Alaska Native Tribal Health Consortium (ANTHC). The project is funded by the State of Alaska Village Safe Water Program (VSW). As part of the update, this erosion study has been performed by R&M Consultants, Inc. (R&M) for PDC, Inc. who is under contract to ANTHC. The purpose of the study is to determine if the location of proposed new facilities may fall within areas subject to erosion during their design life. A project location map is provided as Figure 1. For comparisòn purposes, both 1952 and 1978 aerial photographs are presented as Drawing A-01 of Appendix A.

The bank of the Noatak River adjacent to the village of Noatak has undergone significant erosion over the past 50 years. Various structures, including the school and AVEC tank farm are planned to be relocated north of the landfill near the recently constructed Kuutchauraq Subdivision. The same area is also identified for future housing and community expansion. The airport apron is planned to be relocated to the west of the runway due to on-going bank erosion. The airstrip may also need to be relocated at some future time. Erosion threatens to destroy the remaining water well on the island (Location C) at the north end of the village in addition to two on-shore wells located behind a concrete erosion control structure.

The site description, interpretation of aerial photos, conclusions and recommendations presented herein are based on our current understanding of the study and locations as outlined herein and illustrated on the drawings included in the appendices of this report.

1.2 Contract Authorization

This study has been conducted under the terms of Agreement No. ANTHC-00-C-0205, between the Alaska Native Tribal Health Consortium, and PDC, Inc. This report is in specific fulfillment of Notice to Proceed No. 0161 of the contract. R&M's study has been conducted for PDC under their Notice to Proceed from ANTHC dated June 25, 2002.

1.3 Purpose and Scope-of-Work

The intent of this study was to estimate the projected 10, 20 and 50-year extent of erosion along the west bank of the Noatak River floodplain at Noatak. The study also considered the impact of upriver and downriver changes in river channel morphology. The study area was separated into six locations as shown on Drawing A-02 of Appendix A.

1. Location A - The river banks between the village borrow sources and the downriver end of the existing concrete erosion control structure.
2. Location B - The section presently protected by the concrete erosion control structure.
3. Location C - The island off the upriver end of the village.
4. Location D - The west banks of the river floodplain upriver of the concrete erosion control structure.
5. Location E - The west banks of a large island upriver of the village.
6. Upriver changes in the channel morphology that may affect erosion at the village.

The project has been divided into the following tasks:

1. Review and summarize available previous river erosion or floodplain studies for Noatak.
2. Analyze the past rate of erosion using aerial photos, and based on that rate, estimate the future rate and limits of erosion.
3. A field reconnaissance to Noatak to inspect the river bank, inspect the island, and solicit local knowledge from the IRA Council.
4. Prepare a report including:

    a. An evaluation of the existing concrete erosion control structure and an estimate of the amount of time until the on-shore wells will be destroyed.
    b. An evaluation of the log chevron protection structure used to protect the remaining island well and an estimate of the amount of time until the well will be destroyed.
    c. Review of the proposed design for the installation of two additional water wells on the island.
    d. A description of the analytic methods, estimated rates of erosion, and limitations of the study.
    e. Annotated color photography to illustrate site conditions.

2.0 METHODS

The methods of investigation and analysis used for this study can be divided into the following categories.

- Collection of Existing Data
- Aerial Photo Analysis
- Field Reconnaissance

Following is a brief description of each of these categories.

2.1 Collection of Existing Data

Much of the information concerning past events and conditions utilized in this report were derived from aerial photos, data from previous reports, and on personal recollections. Many of the documents from previous projects could not be located. There was notable disagreement about past events and information between the various information sources. For this report, we relied primarily on historical aerial photos, and secondarily on documents and oral communications.

Information was solicited from the following sources.

1. U.S. Army Corps of Engineers - Alaska District (USACE-AD), including:
   a. Civil Works Project Management Branch
   b. Regulatory Branch
   c. Floodplain Management Services
2. United States Geological Survey (USGS)
3. U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS)
4. Federal Aviation Administration (FAA)
5. State of Alaska Department of Transportation and Public Facilities (DOT&PF)
6. State of Alaska Department of Community & Economic Development (DCED)
7. Interagency Hydrology Committee for Alaska
8. Alaska Native Tribal Health Consortium (ANTHC)
9. Noatak IRA Council

2.2 Aerial Photo Analysis

Historical erosion along the west bank of the Noatak River, adjacent to and upriver of the village of Noatak, was analyzed by scanning aerial photos taken over a 48-year period, scaling them using a community map with an orthophoto base, and then digitizing the top of the river bank. The following aerial photos were utilized during this project:

TABLE 1

AERIAL PHOTOS UTILIZED FOR THIS PROJECT

DATE PHOTO TAKEN	B&W/ COLOR	APPROX. SCALE	FLIGHT NO.	FRAME NO(S).	SOURCE
Aug. 15, 1952	B&W	1:42,000	15	0080 to 82	US Geol. Survey
Aug. 18, 1962	B&W	1:3,000	ALT 1500	1 to 8	BLM
Sept. 15, 1966	B&W	1:4,800	AMT 2100	3 & 4	ANTHC (COE ?)
June 12, 1972	B&W	1:4,800	Noatak 1	1 to 5	ANTHC/Aeromap
Aug. 11, 1975	B&W	1:3,600	Roll 16	7 to 13	BLM
July, 1978	Color Infra red	1:63,360	—	5903	NASA/Aeromap
Sept. 22, 1984	Color	1:4,800	Noatak 207	5 to 11	ANTHC/Aeromap
June 15, 1986	B&W	1:6,000	NOA. 1	1 to 5 & 7	Aeromap
June 15, 1986	B&W	1:12,000	NOATAK 1	1 to 3	ANTHC
July 23, 1990	B&W	1:6,000	Noatak 15	2	ANTHC
July 23, 1990	B&W	1:6,000	90-12	CF07-63/64	Aeromap
Aug. 26, 2000	Color	1:12,000	Noatak 1	1 to 3	Aeromap

The community map was prepared by McClintock Land Associates, Inc. in 1999(?) and was based on a digital orthophoto prepared by National Map Accuracy Standards from August 17, 1999 photography. The orthophoto was corrected, by rectification to ground control stations, to remove distortion and warpage due to ground topography and aircraft tilt and trim (McClintock, 1999). Starting with the 2000 aerial photos, the features on the photos were registered in AutoCAD to the structures and topographic features on the map. Then photos taken in 1990 were registered to the 2000 photos and 1984 photos to the 1990 photos and so on going back to the 1952 photos. For each year the top of the river bank was then digitized and placed into AutoCAD. Graphs showing past erosion rates and projected future erosion rates were then prepared. Aerial photos showing the river upstream of Noatak in both 1952 and 1978 are shown on Drawing A-01. An overall view of the estimated extent of future erosion is included as Drawing A-02. Maps of the digitized top of bank for each year and estimated erosion limits at each location are shown on Drawings A-03 through A-07. Plots of time versus erosion are included in Appendix B as Drawings B-01 through B-06.

Location C, which consists of an island (gravel bar) along the north side of the village does not have a readily definable top of bank or other feature that can be tracked over time. Additionally, water levels vary too much in the photos to use as a defining feature. The primary items of interest on the island are the changes to the island's size and the growth of vegetation which may indicate increasing stability. To illustrate these changes, photographs of the island for each year are shown on Drawing A-05. Location E, which consists of an island upriver of Location C has only limited or partial photo coverage. Thus, the results may not be as reliable as those from areas where more coverage is available.

Methods used for this type of study assume a relatively uniform environment, both in the past and the future. The soils that will be eroded in the future are assumed to be similar to those eroded in the past. The channel morphology is assumed to be the same with minor changes both before and after the study. It should be noted that the changes in channel morphology observed during this study complicate the possible estimate of future erosion rates and may reduce the accuracy of these projections. To the extent possible, we have adjusted the estimated rate and direction of erosion to reflect the conditions expected to occur. Discussions of some possible alternative scenarios are included in the description for each location.

The presence of an erosion control structure within the study area that will apparently fail within the time line of this study creates an additional complication for the analysis. This creates a situation where no erosion will occur at this location until the structure fails. The failure will be dependant upon the height and frequency of floods and construction projects impacting the bank, among other things. Thus, a projection of future limits of erosion will be dependent upon when the structure fails and wether the structure fails in stages or in one event. Additionally, the rate of projected erosion after failure will depend upon the channel configuration at the time it fails.

Due to these changes in the channel configuration and the presence of an erosion control structure, there appears to be only limited areas along the bank of the floodplain where a simple 50-year projection can be made. Elsewhere, the 50-year projection will involve factoring in the failure of this structure and shifts in channel configurations that are occurring. Due to these complications, the 50-year projection may be less reliable than would be the case with a simpler scenario. We don't expect all of the structure to fail within the next 20 years and the 10 and 20-year projections can be made with a greater expectation of reliability, barring unexpected shifts in river channel configurations.

The plots of time versus erosion, shown in the graphics in Appendix B, are average rates. Actual rates will vary from year to year and detailed measurements taken over time may produce a more "jagged" line than shown. Erosion may even cease temporarily in some locations.

2.3 Field Reconnaissance

Mr. Robert M. Pintner, P.E., of R&M Consultants, Inc., accompanied Mr. Andy Meltzer, P.E. of ANTHC on a field trip to Noatak on August 13 and 14, 2002. The purpose of the trip was to inspect the river bank and island (Location C) and solicit historical local knowledge from the Noatak IRA Council members.

The river bank inspection was performed by ATV, and on foot. The water level was low enough that all of the areas of concern could be accessed without using a boat, including the area approximately 2 miles upriver where the main channel had recently diverted to the east. The existing concrete erosion control structure was viewed from a gravel bar in the river, as well as up close. The river bank erosion in Location A was viewed by ATV from a gravel bar in the river, and the island (Location C) was inspected on foot.

Interviews of village elders and Noatak IRA Council members were limited because many of the intended contacts were attending a funeral in Kivalina on August 14. The people that were available for interviews included Mr. Herbert Walton, IRA Administrator, and Mr. Ivan Booth a village Elder, and lifetime resident of Noatak. Conversations were also held with the water plant operator, and assistant operator as well as a few additional people who were encountered during the river bank inspection.

2.4 Public Meeting

Mr. Peter K. Hardcastle, R&M Consultants, Inc. accompanied Mr. Andy Meltzer, P.E., of ANTHC, to a public meeting in Noatak on January 22, 2003. The purpose of the trip was to present the study to the village and answer questions.

3.0 REGIONAL SETTING AND GENERAL PROJECT CONDITIONS

3.1 Regional Setting

3.1.1 Location

Noatak is located on the west bank of the Noatak River, approximately 55 miles northwest of Kotzebue, Alaska and 70 miles north of the Arctic Circle (Figure 1). It is the only village on the Noatak River, and lies between Cape Krusenstern National Monument and Noatak National Preserve. Noatak was originally established as a fishing and hunting camp in the 1800s, and subsequently developed into a permanent settlement. Subsistence activities are the primary focus of the village and fisheries are an important part of the harvest.

There is no road access to Noatak and year-round access is by air, typically via Kotzebue. There is a 4,000-foot lighted gravel runway. Small boats are used during summer months and winter travel is by ATV or snowmachine. All forms of travel are dependent on weather conditions.

The Noatak River originates in the Endicott Mountains and flows west between the Baird and De Long Mountains, then turns south and empties into Kotzebue Sound, just north of the City of Kotzebue. The river has a length of 396 miles, a drainage basin of 12,597 square miles and an estimated annual flow of 10,000 cubic feet per second (AIDEA, 1976).

3.1.2 General Geology

Noatak lies within the Mission Lowland, which is the lower part of the Noatak Lowland (Wahrhaftig, 1965). The Mission Lowland consists of broad tundra flats containing thaw lakes and pingos, crossed by a forested floodplain, and surrounded by rolling hills. The area is considered to be underlain by thick permafrost (Ferrains, 1965). Glaciers probably covered the Mission Lowland during the early Pleistocene but not during later glaciations. Outburst floods from proglacial lakes in the upper part of the Noatak Valley reportedly occurred during the late Pleistocene (Hamilton and Van Etten, 1984). Soils in the lowlands typically consist of fine-grained soils overlying alluvial gravels. There is no evidence of shallow bedrock near the village of Noatak.

Regional geology of northern Alaska is discussed in Moore et al. (1993). Although quite dated, Smith and Mertie (1930) present information on the geology and mineral resources of northwest Alaska.

3.1.3 General Hydrology

Noatak is located on a flat lying segment of the river floodplain at about an elevation of 55 feet. It has a gradient of less than one foot per mile at the village and the floodplain ranges from one to one and a half miles in width (USACE-AD, 2002).

The Noatak River at Noatak is interpreted to be a split-channel river. A split-channel river is defined as "a river having numerous islands dividing the flow into two channels. The islands and banks are usually heavily vegetated and stable. The channels tend to be narrower and deeper and the floodplain narrower than a braided system" (USFWS, 1980). It can be thought of as a river transitional between a braided river and a meandering river. The channels are generally more stable than would be expected on a braided river. For instance, one can find many of the channels on the aerial photos in 1952 in the same location as the present. However, shifting flow in a split-channel river is more typical of that found in a braided river. Ten to 15 miles downriver of Noatak the river becomes a meandering river, generally confined to a single sinuous channel.

The aerial photos indicate that the segment of the river flowing past the village is split into an eastern and western channel. Between about 1970 and 1990 the photos indicate that the west channel was split into two channels upriver of the village. The relative amount of flow through these channels has apparently varied over time. The flow appeared to switch back and forth between the east and west channels, depending on naturally occurring diversions upriver of the village. These diversions can be caused by ice jams or erosion of gravel bars.

The aerial photos indicate that the aerial extent of vegetation has been increasing on the floodplain since 1952. This may indicate a more stable channel morphology in the river since 1952, or it may be caused by lower flow in the river due to climatic changes, or it may be part of the natural evolution of the river.

3.1.4 Flooding

The U. S. Army Corps of Engineers Flood Plain Management Service notes that the Noatak River floods seasonally with a 15-foot rise recorded at five to 20-year frequencies. With this flood level, 10 percent of the village would be flooded. The 20 to 100-year frequency ranges will flood up to 25 feet above the normal river level. There is low to no flood hazard above the 25-foot level. The most probable causes of flooding are ice jamming downriver during breakup, or heavy rains during the late summer. According to IRA Council members, one of the largest floods occurred during 1987, which brought flood waters to the top of the remaining island water well casing.

3.1.5 Climate

The Noatak area has a transitional climate typical of the coastal regions of the Chukchi Sea. Weather generally fluctuates between maritime and continental and a combination of both. Long, cold winters and cool summers characterize the climate. The Alaska Department of Community and Economic Development, Alaska Community Database (www.dced.state.ak.us/cbd/commdb/CF_BLOCK.cfm) reported that winter temperatures averaged about -21° to 15° F and summer temperatures about 40° to 60° F. Extreme temperatures were recorded from -59° to 75°. The mean annual precipitation was about 10 to 13 inches (including equivalent snow fall), with about 48 inches of snow.

A summary of climatological data obtained from Kotzebue, approximately 55 miles to the south, is presented in Table 2. Kotzebue is the closest weather station with a significant weather record.

TABLE 2

CLIMATOLOGICAL DATA
for KOTZEBUE, ALASKA

LOCATION (STATION)	KOTZEBUE WSO*
Period of Record (yrs.)	1949-2001
Elevation (ft.)	10
Mean Annual Temperature (°F)	21.6
Mean Max. Daily Temperature (°F)	27.9
Mean Min. Daily Temperature (°F)	15.3
Record High Temperature (°F)	85
Record Low Temperature (°F)	-52
Mean Annual Precipitation (in)	9.5
Maximum Daily Precipitation (in)	1.6 (Sept. '78)
Mean Annual Snowfall (in)	50.2
Maximum Recorded Depth (in)	53.0 (Apr. '73)

* From the Western Regional Climate Center Web Page on 8/12/2002, at www.wrcc.dri.edu/summary/climsmak.html.

3.2 Summary of Past Erosion and Erosion Control Efforts

The following is a historical summary of the erosion that has occurred at Noatak and the efforts to control it. The items are a synopsis of information gathered during this study. Inconsistences were found between information provided from various sources. In areas of disagreement, the aerial photos were considered to be the most reliable source of information.

1. The 1952 aerial photos show the Noatak River splitting into an eastern and western channel about a mile upriver of the village. The West Channel flowed adjacent to the village. In 1952, the West Channel was a single channel flowing in what we have referred to in this report as Channel A (see Drawing A-01). Portions of the East Channel above the village later become part of West Channel that we refer to as Channel B.

2. The airport was constructed in the early 1960s. The 1962 aerial photos show large gravel pits on a vegetated island adjacent to the north end of the airport with access roads leading to the airport (see Figure 4). It is not known how much material was taken out of the floodplain. Within a few years of mining, significant erosion began to occur along the island and adjacent bank.

3. Prior to 1978, most of the erosion appeared to be occurring along the upriver edge of the village. It was apparently caused by Channel A (at that time the main part of the West Channel) flowing along that edge of the village.

4. A wooden crib retaining wall was built sometime between 1962 and 1966. It consisted of wooden piles with logs laid horizontally behind them. The wall was about 1,900 feet long and stretched from above the village downriver to about where the existing concrete erosion control structure ends (see Figure 2). Most of this wall appeared to have been swept away by the river by 1972.

5. The 1962 through 1975 aerial photos show what appeared to be the coalescing of small overflow channels to form the present Channel B. The 1978 aerial photo showed Channel B to be connected to the West Channel and it appeared to be the main channel on the western side of the floodplain. There appeared to be more flow in the West Channel at this time than the East Channel.

6. 1970's - The Scope-of-Work (ANTHC, 2002) mentions a 160-foot long, 10-foot high retaining wall built near the original water treatment plant and the AVEC power plant. The wall was reportedly built in the early 1970's and was destroyed by a flood in 1974.

7. After 1978, Channel B became the main channel on the west side of the floodplain and Channel A became a high water channel. During the late 1970s through the present day extensive, rapidly occurring erosion was noted along the river bank adjacent to the airport. This was apparently caused by Channel B flowing directly into the bank. As flow decreased in Channel A, erosion decreased along the northern part of the village.

8. A concrete erosion control structure was built in the early 1980s. It is still in place today. However, some parts of the structure have failed and other parts are beginning to fail. The project was reportedly designed by the Physical Facilities Division of the Alaska Department of Transportation & Public Facilities and funded by the Alaska Department of Community and Economic Development

(USACE-AD, 2002). The State of Alaska Legislature made appropriations of about 3.4 million dollars for erosion control at Noatak in 1980 and 1981 (personal communication, Christy Miller (DCED), July 29, 2002).

9. Barge traffic to Noatak ended in 1992 when a Crowley Marine tug and barge grounded about one-half mile down river of the village. It was reported that the gravel bar was in the same location in 2001. Prior to that date, fuel transported by barge to the village ended in 1989 or 1990 because of inadequate channel depth (USACE-AD, 2002).

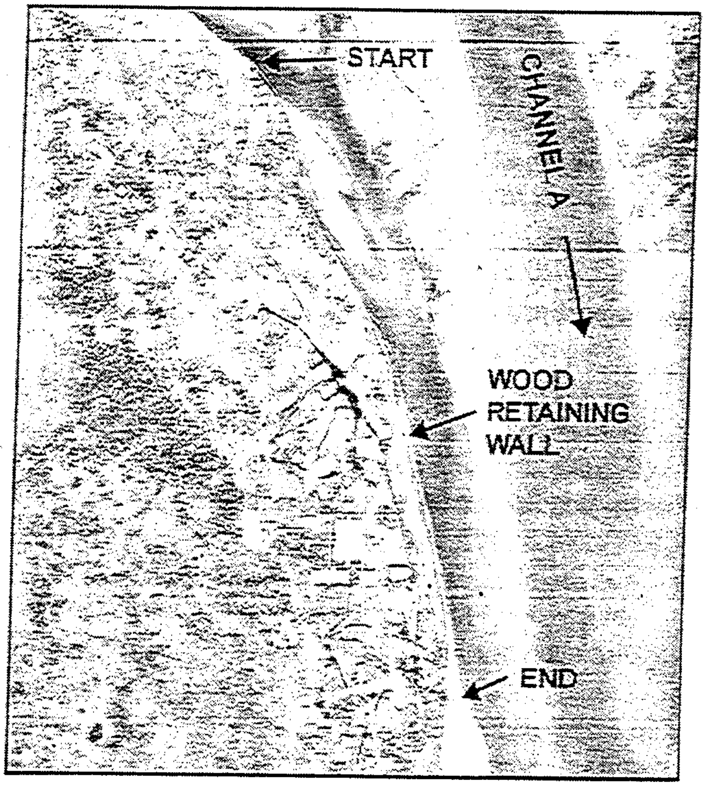
10. The National Resources Conservation Service constructed a small erosion control wall near Noatak in the fall of 1993, reportedly to protect the cemetery and the road to the landfill. It was swept away the next spring (personnel communication, Laurie Richter (NRCS), August 20, 2002).

11. A large erosion control project was planned during 1994 and 1995. The project would have dredged 600,000 cubic yards of material from gravel bars and river channels upriver of the village and placed the material along the river bank at Location A. Diversion structures consisting of gravel-filled geotextile bags were planned in front of the village. All the necessary permits were approved, however, the project was not funded (USACE-AD).

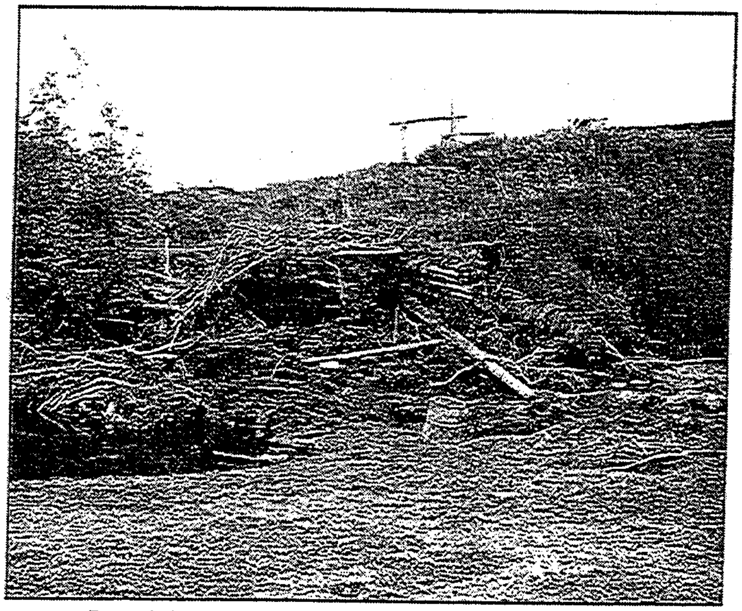
12. 2002 - A field reconnaissance conducted as part of this study found that a channel diversion had occurred upriver of the village that diverted most of the river flow into the East Channel (see Drawing A-01). Residents of Noatak indicated that this diversion had occurred withing the previous two or three years.

FIGURE 2

WOOD RETAINING WALL



1966



Remaining section of a ruined wall at the north end of the Village - August, 2002.

3.3 Existing Information

A small number of related technical projects have been performed in this area. Detailed information from these prior investigations has not been repeated herein. The reader is referred to the previous reports for specific data (see References).

3.3.1 DOT&PF - Noatak/Kobuk Area Erosion Control Study - 1978

An extensive search has been made for this document but at the time of publication of this report we have been unable to find a copy. It is reportedly the study used in the design of the existing concrete erosion control structure built in the early 1980's.

3.3.2 USGS - Water Resources of the Noatak River Basin - 1979

Two hydrological surveys were made during April and August, 1978 to collect data along the Noatak River. The April trip was made to provide data during late winter, a period of low water and maximum ice accumulation. Many springs and open leads were noted along the main course of the river and a large open lead was noted at Noatak Village. As much as 2.5 meters of ice was observed on the river and it was frozen to the bottom in places. The discharge increased from about $4m^3$/sec. in April to about $280m^3$/sec. in August. Pools from 300 to 1500 meters long with gravel and cobble beds, separated by gravel riffles as much as 100 meters long were noted. Most maximum evident flood marks were found near the base of mature willows. The Noatak River channel was noted as being quite stable except for some bank erosion through the Mission Lowlands. Other data collected, but not reported, included spot depth and estimates of maximum evident flood peak and bankfull channel discharges at selected stream sites (Childers, 1979).

3.3.3 USACE - Permits for Noatak Bank Stabilization - 1995

A large erosion control project was planned during 1994 and 1995 but was never constructed. The project would have dredged up to 600,000 cubic yards of material from exposed gravel bars (up to 146 acres) and approximately 500,000 cubic yards from river channels (up to 30 acres) below the ordinary high water mark of the river. The mining would have taken place along the east side of Channel B, immediately upriver and alongside the village. Most of the material would have been placed along the river bank at the downriver end of the village to stabilize the bank in this area, protect gravel bag diversion structures, and to fill approximately 30 acres of the eroding channel of the river adjacent to the townsite. Some of the material would have been used for 2-ton gravel filled, geotextile bags and placed in river channels to create 1,500 feet of diversion structures. A permit was approved, although the project funding was canceled. We were unable to find any hydrologic or erosion studies for this project.

3.3.4 USACE - Navigation Improvements Initial Evaluation Study - 2002

Tetra Tech, Inc. prepared a study for the USACE-Alaska District looking at navigational improvements for the village of Noatak. The purpose of the study was to identify navigation and other water related problems and needs in the study area and conduct preliminary assessments of the engineering and economic feasibility of various alternatives. The report contains a summary of conditions at Noatak and along the river. It reports that the problem started when the river became too shallow for barge traffic. The study considered alternatives including dredging, road construction, and river forecasting (the barge companies would be notified when there was sufficient water to reach the village). The study came to the conclusion that none of the alternatives appeared to be economically feasible.

3.3.5 State of Alaska Administrative Order No. 175 - 1998

The order signed by Governor Knowles orders all state agencies, to the extent possible, to encourage an effort to reduce the risk of flood and erosion losses on state projects. State agencies will consider the potential of flood and erosion hazards on construction projects administered or funded by the State. The complete text of this order can be found at www.gov.state.ak.us/admin-orders/175.html.

3.3.6 State of Alaska Erosion Management Policy

This policy concerns state-funded and state pass-through funded construction. The policy outlines recommended guidelines for considering erosion control during design and construction of a project. It recommends that new structures be located where no erosion control is necessary, the cause of the erosion problem should be identified, and erosion control projects should be sited and designed using appropriate engineering principles. Consideration should be given to the design life of the project, performing an analysis to determine rate of erosion and providing erosion protection as part of the project. The complete text of this policy can be found at www.dced.state.ak.us/ cbd/nfip/pub/NFIP_Policy.pdf.

4.0 EROSION CONDITIONS

4.1 General

There is limited aerial photographic coverage of the river floodplain both up and downriver of the village. Therefore, only general conclusions can be drawn about how major changes in the floodplain, channel morphology and discharge in these areas may have affected the river bank at Noatak. Inspection of aerial photographs taken over the last 50 years indicated that the major characteristics of the Noatak River were unchanged and stable during this time period. The river was interpreted to be a split-channel river, in which the river is sometimes split into two channels. One channel typically is the main channel and the other is a highwater channel. Near the village, the main flow appeared to have switched from one side to the other and then back again. In the early 1950s, the East Channel appeared to be the main channel, but by 1978 the maximum discharge had apparently shifted into the West Channel (see Drawing A-01). During our field reconnaissance in August, 2002, it was observed that much of the flow had diverted into the East Channel again. The East Channel does not directly impact the village.

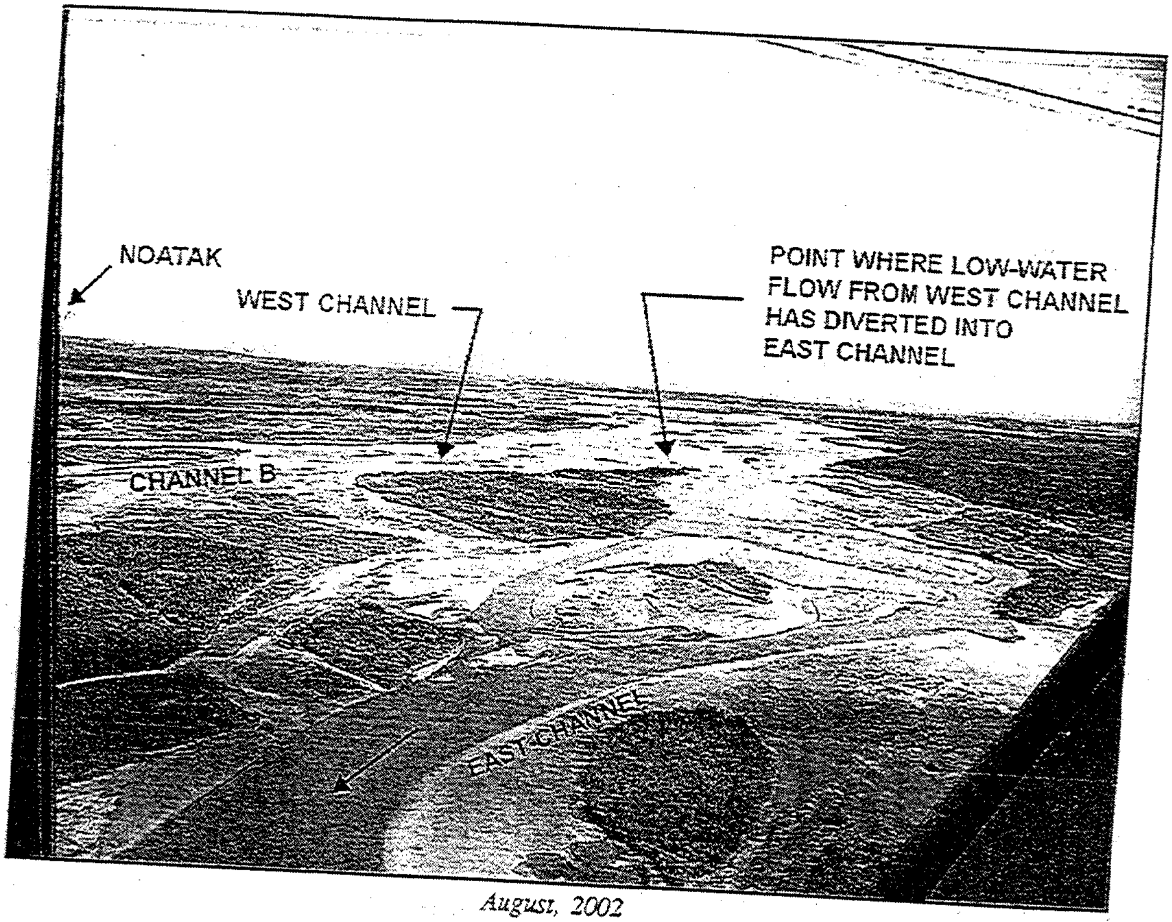
The aerial photographs indicated an increasing aerial extent of vegetation on the floodplain with more and larger areas of vegetation being observed in recent photos. This may indicate a more stable channel configuration at present. This apparent increase in stability may continue for the next 50 years, or the factors that created it may change and the configuration may become more unstable. A less stable channel configuration would make the erosion projections included in this report less reliable.

Since 1952, the discharge in the West Channel has shifted channels up river from the village. In 1952, it flowed by the north side of the village after deflecting away from the bank in a channel referred to as Channel A in this report. Between 1962 and 1978, the discharge in the West Channel appeared to shift gradually into a new channel formed by the coalescing of small over flow channels, referred to here as Channel B. This shift caused the flow from the West Channel to flow more directly toward the village than before. Since 1978, Channel B became the principal channel of the West Channel and Channel A essentially became a high water channel into which several small tributaries of the Noatak River flowed. Changes in the direction and relative discharge in these two channels are interpreted to be the cause of the changing pattern of bank erosion at the village.

The length of the West Channel shortened significantly as the discharge shifted to Channel B and will likely adjust its course to regain the length in the future, by either becoming more sinuous (meandering) or by cutting into the river bank and lengthening the channel downriver near the airport. If it begins to form a more sinuous channel, then rates of erosion may increase in some places and decrease in others.

FIGURE 3

PHOTO OF RIVER FLOODPLAIN



August, 2002

4.2 Location A

Location A consists of the section of river bank lying downriver of the concrete erosion control structure and is shown on Drawing A-03. It parallels the airport and cuts through the old cemetery and sewage lagoon. The soils in the bank consist of ice-rich silt overlying frozen gravel. Much of the recent erosion at Noatak has occurred along this part of the river bank.

Following is a brief summary of the history for Location A, as shown on the aerial photos, along this section of the river bank:

- 1952 - The West Channel of the river was being deflected away from the bank by a large vegetated island.

- 1962 - Gravel had been mined from the vegetated island for airport construction.

- 1972 - A significant portion of the island had eroded away. The river had begun to erode the bank near the old sewage lagoon.

- 1984 - Only the downriver tip of the island remained. The river bank had breached the edge of the old sewage lagoon, which had apparently been partitioned to allow continued use of the western part.

- 1990 - A significant increase in the rate of erosion was noted. The bank had eroded approximately 200 feet since 1984 at the old sewage lagoon and the partition had been breached. The island was completely gone.

- 2000 - The rate of erosion appeared to be similar to that observed on the 1990 photos. However, the point of maximum erosion had moved downriver and erosion had slowed at the old sewage lagoon.

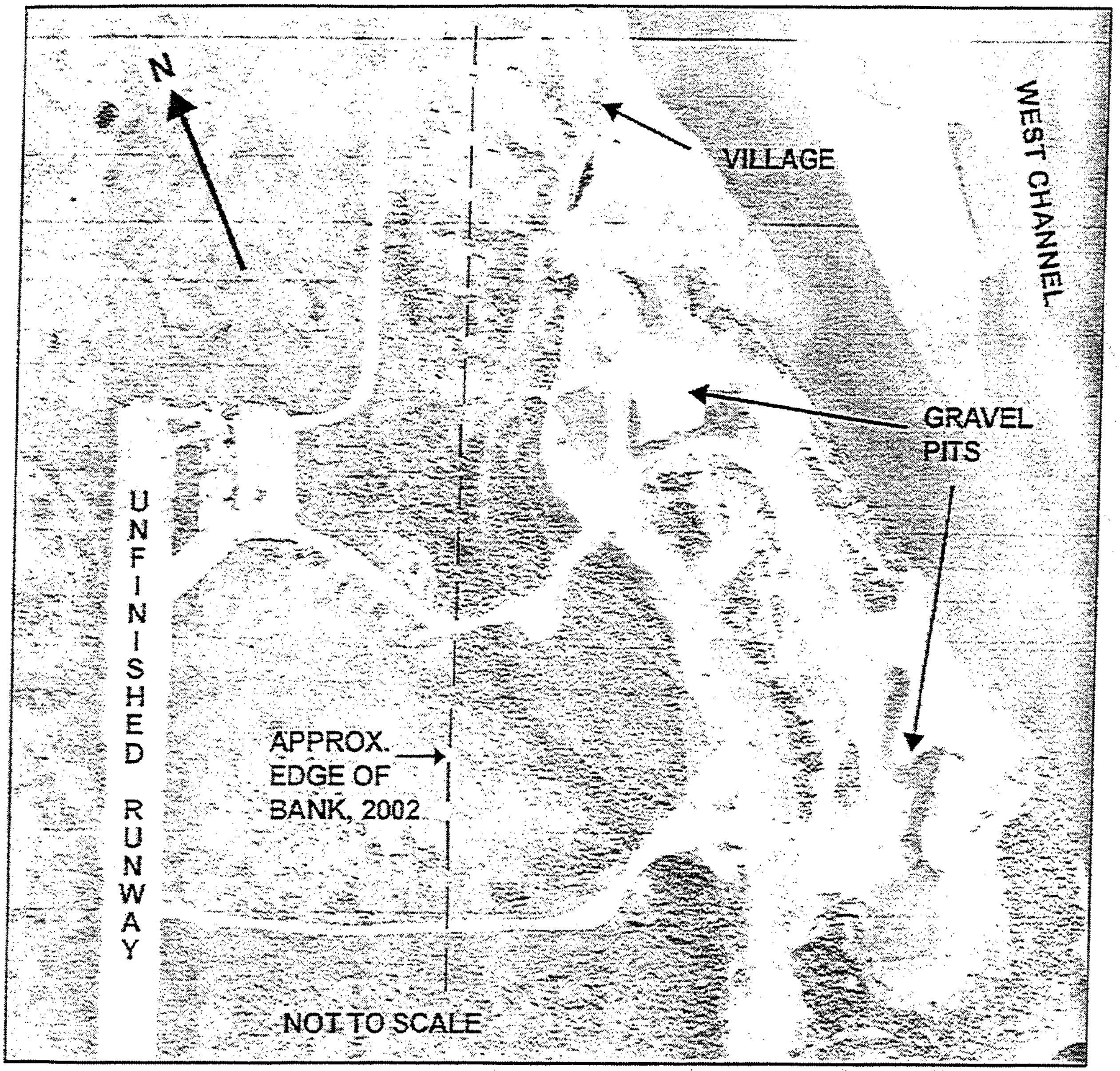
- 2002 - During our field reconnaissance, approximately 75 to 100 feet of erosion was noted at the old sewage lagoon since the 2000 photos were taken.

The mechanism for erosion along Location A appears to consist of thawing of exposed perennially frozen soils which slide down the slope onto the river floodplain. The water then washes the material away exposing more material to erode down the slope. In places where the river is not removing material from the bottom of the slope (such as behind the concrete mat at Location B), the slopes appeared to have stabilized and are vegetated.

The increase in erosion rates along this stretch of the river bank appears to be due to the shifting of flow from Channel A to Channel B. This shift brought the flow in the West Channel more directly to bear against the bank. In 1952, a vegetated island protected this part of the bank. After gravel mining in the early 1960s the island eroded rapidly. The gravel removal may not have caused the erosion, but it likely increased the rate of erosion. Evidence gathered during the field reconnaissance indicates the river may be starting to form a meander bend at Location A. The projected 10 and 20-year erosion limits have been adjusted to show this on Drawing A-03. The recent diversion of flow from the West Channel to the East Channel may reduce short-term erosion rates. However, much of the erosion at Noatak appears to occur during floods when there is still significant flow through the West Channel. The time and sequence of the erosion control structure failure will also have a significant effect on the projected erosion limits. If the structure lasts longer than the approximately 20 to 25 years we have anticipated, then it may slow the rate of erosion toward the airport runway. Its early failure may increase erosion rates if the West Channel can flow more directly into the bank. The failure may also cause a channel shift that will direct the flow away from or into the bank, decreasing or increasing flow accordingly.

FIGURE 4

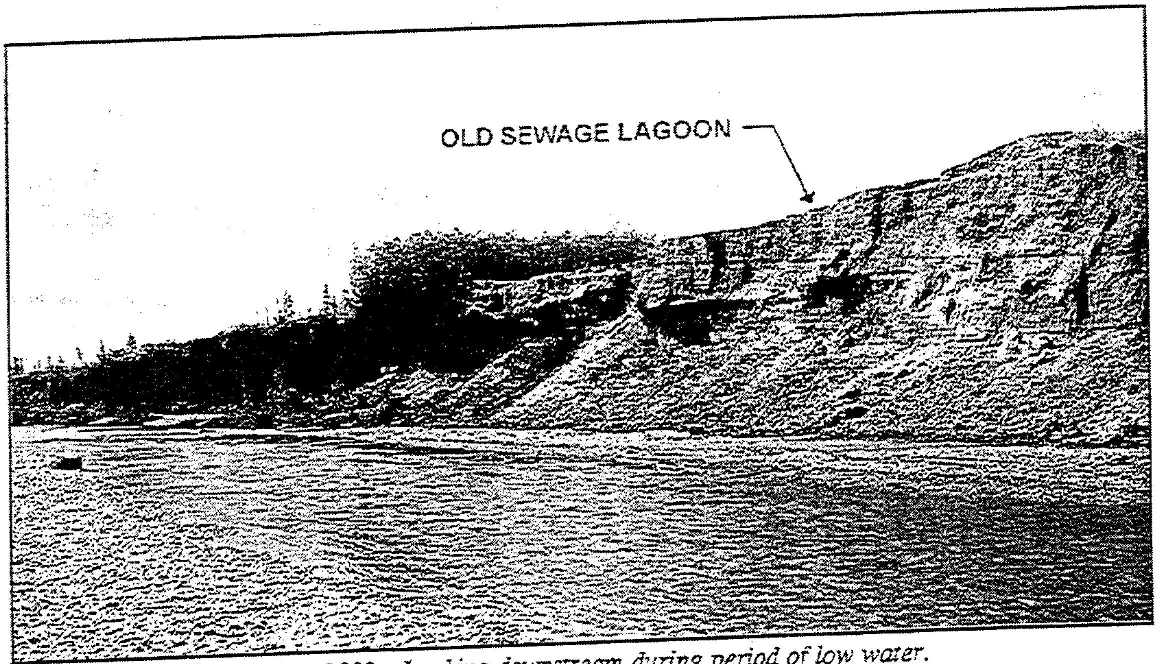
GRAVEL PITS USED TO CONSTRUCT AIRPORT



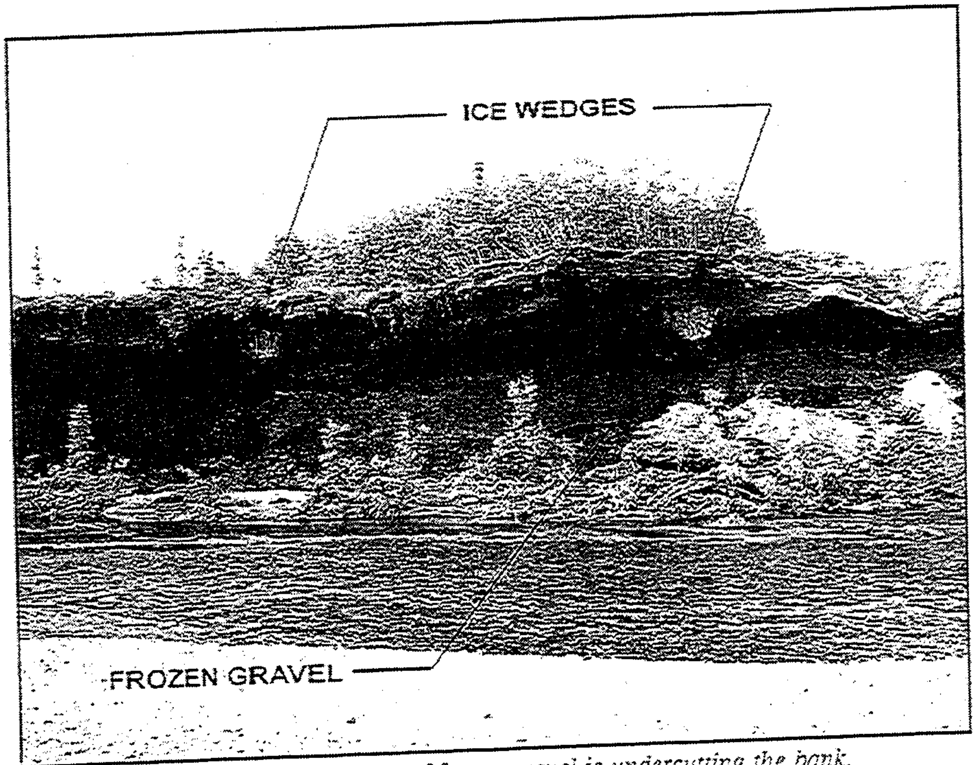
1962.

FIGURE 5

PHOTOS OF RIVER BANK AT LOCATION A



August, 2002 - Looking downstream during period of low water.



August, 2002 - Thawing of frozen gravel is undercutting the bank.

4.3 Location B

Location B consists of the section of river bank protected by a concrete erosion control structure and is shown on Drawing A-04. An oblique aerial photo of Location B is shown in Figure 6. It starts at the north end of the airport and continues upriver to the AVEC tank farm at the upriver end of the village. The banks behind the structure are vegetated and appear to have been relatively stable since it was constructed in the early 1980s.

The following is a brief summary of the erosion history for Location B along this section of the river bank, as shown on the aerial photos and observed during the field reconnaissance:

- 1952 to 1972 - Channel A flowed along the bank, which showed evidence of active erosion (exposed soil in bank). Erosion was occurring at a rate of about 10 feet per year along the bank by the school. Upriver between the school and the present day location of the AVEC tanks there was little noticeable erosion occurring. However, significant erosion had occurred in the 1950s upriver of the AVEC tanks. A wooden crib retaining wall had been built along this location during the 1960s but it had failed soon thereafter.

- 1984 and 1986 - A 1,500-foot long erosion control structure, consisting of bags of concrete wired together and anchored on the shore by piles or by helical anchors had been built. These photos were taken soon after the structure was reportedly built and they show no evidence of failures in the concrete matting.

- 1990 - The photos show evidence of failure along the southern 300 feet of the structure.

- 2000 and 2002 - Photos show that the structure in a concave area along the bank near the school has been covered by gravel.

Prior to construction of the concrete structure, approximately 100 feet of erosion (approximately 5 feet per year) had occurred along the downriver half of the bank protected by the structure. Prior to 1962, there had also been approximately 100 feet of erosion (approximately 10 feet per year) at the upriver end of the structure. Since the structure was built there has been no notable erosion.

The concrete structure was apparently built on a gravel berm placed against the river bank. Bags of concrete were cabled together and anchored to the bank using piles and helical anchors. The upriver half of the structure is apparently still in good shape, with minor areas showing evidence of concrete degradation. The river appeared to have undercut the downriver end of the mat and it was falling apart (see Figure 7). The area of the structure near Water Wells 3 and 4 appears to have started to be undercut by the river and the matting is starting to break apart. Figures 7 through 9 show the condition of the concrete erosion control structure as observed during our August, 2002 site visit.

Information collected and analyzed for this study indicate that the concrete structure will fail completely sometime after 2020. Parts of the downriver section of the structure have already failed and other parts may well fail prior to 2020. It appeared to be designed primarily to prevent erosion caused by flow in Channel A. Failure appears to be likely if and when Channel B cuts through the upriver island at Location E and flows directly into the structure. The resultant scour may rapidly undermine the structure. Once the complete failure of the structure occurs erosion of the bank behind the structure is likely to be rapid. The 50-year erosion limit assumes that a complete failure will occur.

FIGURE 6

PHOTO OF RIVER BANK AT LOCATION B

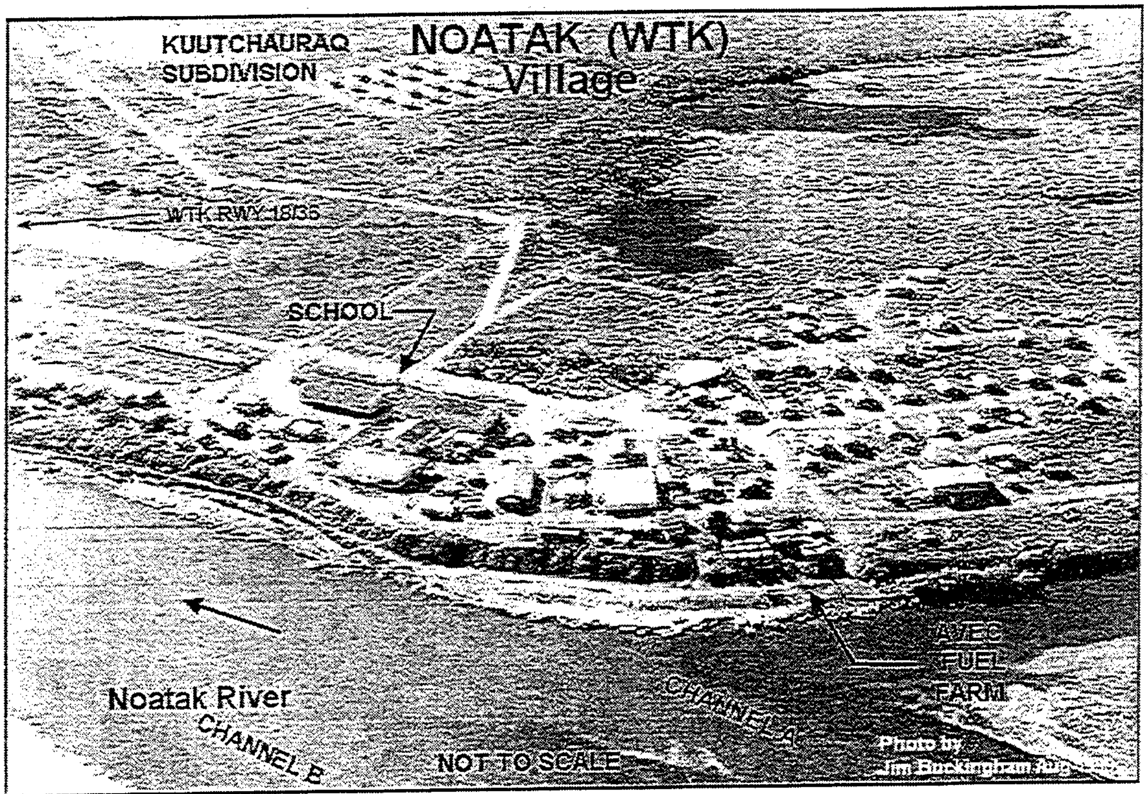
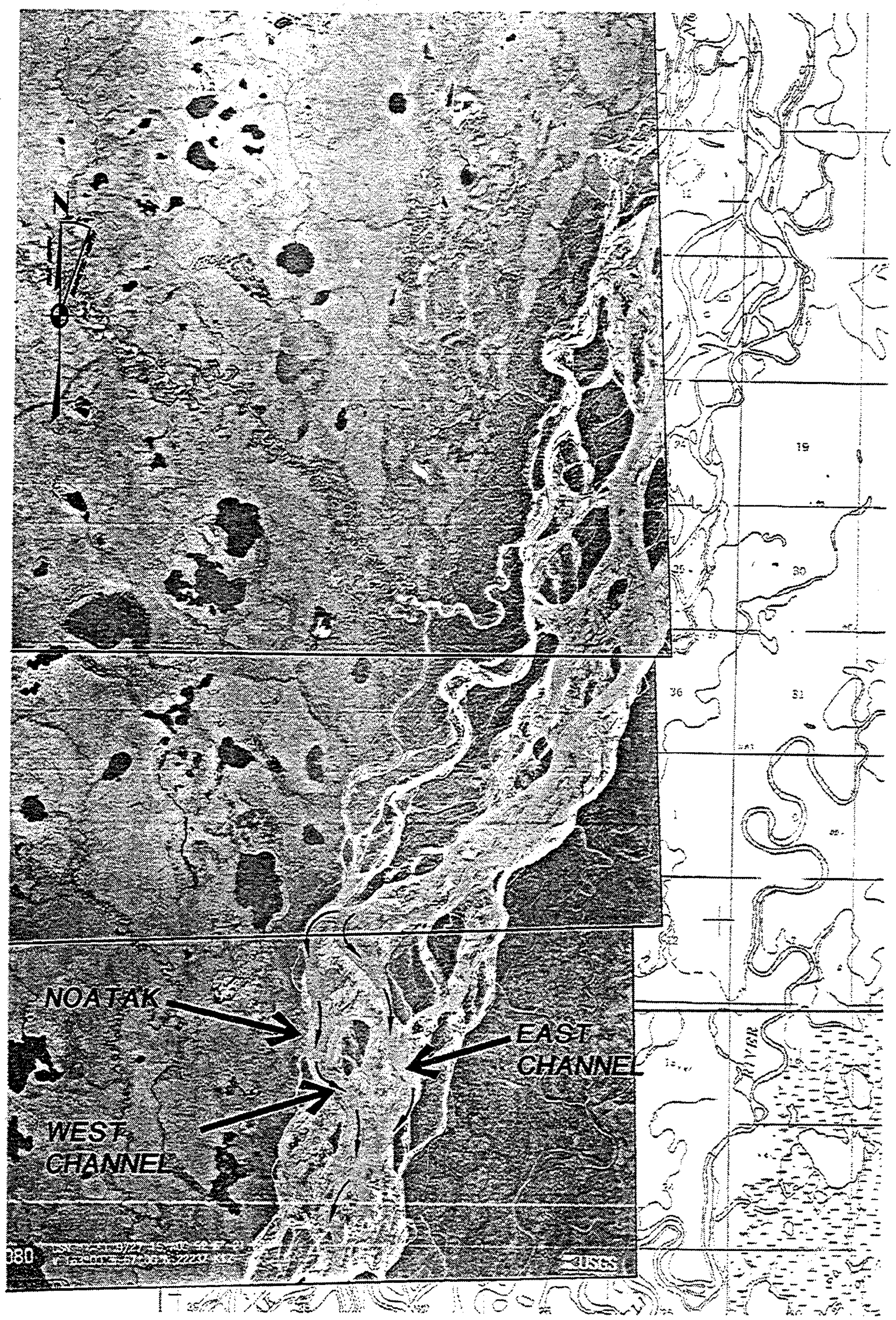
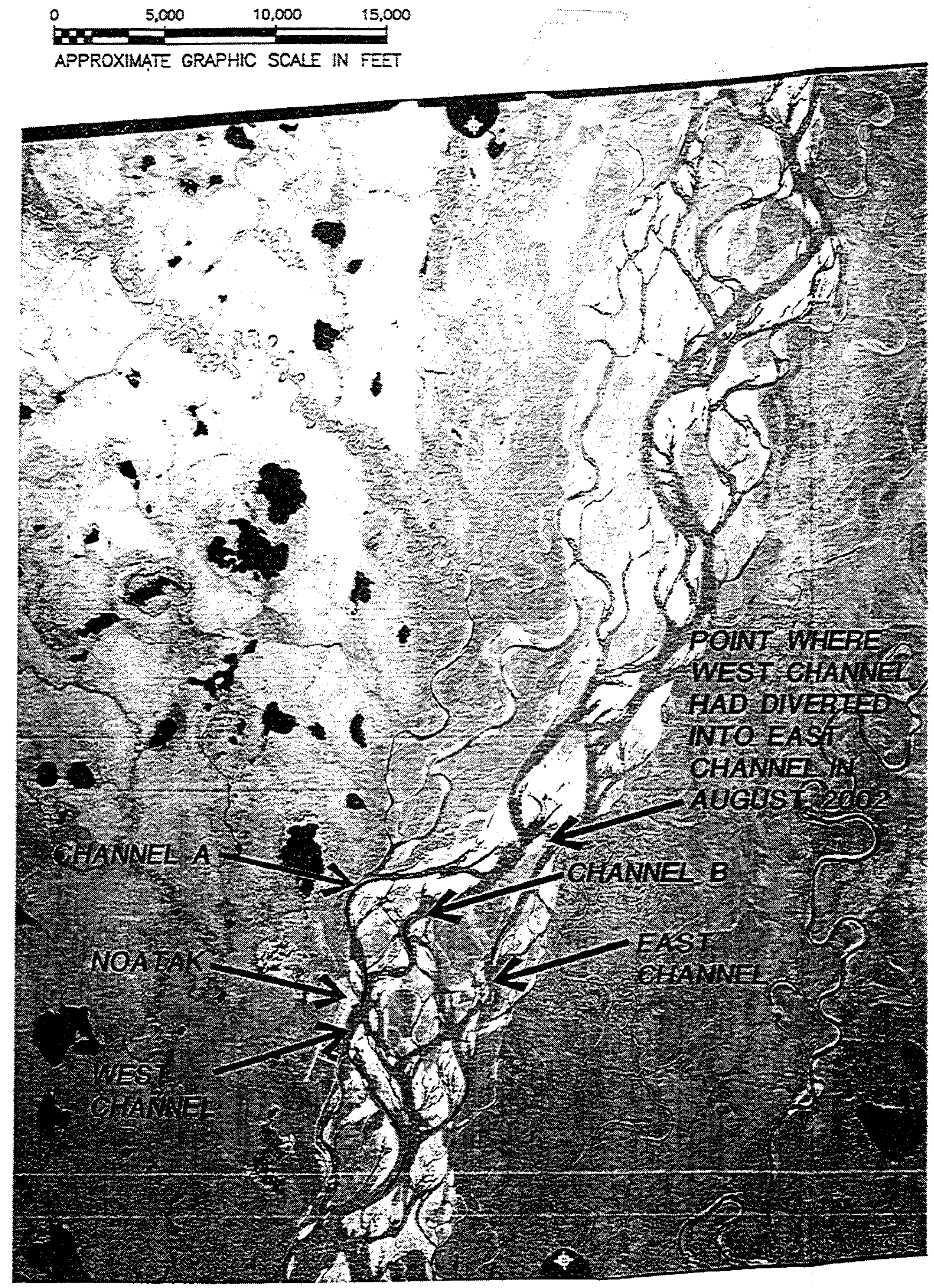


Photo from FAA website www.alaska.faa.gov/fai/afss/index.html.



1952



1978

ALASKA NATIVE HEALTH CONSORTIUM
MULTI-DISCIPLINE A&E SERVICES
ANTHC Project No. AN01-Q55
NOATAK RIVER BANK EROSION STUDY
NOATAK, ALASKA

GREATER NOATAK AREA

R&M CONSULTANTS, INC.
9101 Vanguard Drive, Anchorage, Alaska 99507


RECOMMENDED LOCATIONS FOR EROSION MONITORING LINES.
PROJECTED EROSION LIMITS
2050
2020
2010
NOTES:
THE PROJECTED EROSION LIMITS OUTLINE AREAS THAT MAY BE IMPACTED BY EROSION, DEPENDING ON FUTURE CHANGES TO CHANNEL CONFIGURATION AND DISCHARGE. ALL OR PART OF THESE AREAS MAY BE ERODED INTO THE RIVER. THE PURPOSE OF THESE LIMITS IS TO PROVIDE INFORMATION FOR PLANNING FUTURE CONSTRUCTION PROJECTS.
LANDFILL
SEWAGE LAGOON
KUUTCHAURAQ SUBDIVISION
OLD CEMETARY
OLD SEWAGE LAGOON
NOATAK RIVER
LOCATION A
WEST CHANNEL
LOCATION B
LOCATION C
CHANNEL B
CHANNEL
APPROX. LOCATIONS OF WATER WELLS 3 AND 4
APPROX. LOCATIONS OF WATER WELLS 1 AND 2
APPROX. AREA FOR NEW WATER WELLS
2050
2020
2010
2020 AND 2010
APPROXIMATE GRAPHIC SCALE IN FEET
0
200
400
800
1200
1
2
3
5
6

USKH
SHARED VISION. UNIFIED APPROACH.

Technical Memorandum

Date:	February 1, 2013	**W.O.#:**	879301
To:	Bill Cole, DOT&PF (NR)	**cc:**	Raymond Plummer Sara Lindberg
From:	Mel Langdon		
Project:	Noatak Airport		
Subject:	Noatak Riverbank Erosion Assessment		

1 INTRODUCTION

Cumulative riverbank erosion in the vicinity of the Noatak Airport and apron over the past 60 years has caused the loss of approximately 430 horizontal feet, leaving only approximately 160 horizontal feet between the top of bank and the southeast edge of the apron. An erosion study conducted in 2003 by R&M Consultants, Inc. ("R&M study"), prepared for the Alaska Native Health Consortium (ANTHC) (R&M, 2003), projected maximum erosion extent that would impact the apron by 2010, and by 2020, extend into the runway. Active erosion has been observed since 2003, but the full extent of the R&M study projection has not been realized.

The Alaska Department of Transportation and Public Facilities (DOT&PF) is evaluating the need to relocate the Noatak Airport. This Noatak Riverbank Erosion Assessment Technical Memorandum is meant to supplement DOT&PF's evaluation by summarizing erosion issues using previous reports in the vicinity of the runway, evaluating the environmental factors that are still valid today, and highlighting erosion factors for consideration in the future. This memorandum also discusses road settling issues on Pit Road, the access road parallel to the runway, and how it may be related to riverbank erosion.

2 BACKGROUND

2.1 Overview

The airport and Village of Noatak are located on the west bank of the Noatak River (Figure 1), about 25 miles east of the Chukchi Sea coast, 55 miles north of Kotzebue and 70 miles north of the Arctic Circle. The Noatak River rises in the Brooks Range, and flows west for about 80 miles before turning south and entering the Mission Lowlands, a broad forested floodplain where the Village of Noatak is located.

In the vicinity of the Noatak Airport, the Noatak River is a split channel river, with two channels referred to as the East and West channels. The West Channel separates from the East Channel about 1 mile upstream of the airport (Figure 2). Local knowledge indicates that the main river channel migrated from the west to the east side of the river within the past three decades (Mobley, 2006). An appendix to the 1992 Environmental Assessment for runway extension and apron expansion includes a 1992 letter stating that water levels drop rapidly during the spring in the channel of the Noatak adjacent to the village, no longer allowing barge traffic. This may be reflective of the change in the dominant flow channel. The R&M study indicated that the change in the dominant flow channel, from the West Channel to the East Channel, occurred sometime between 1998 and 2002. The 2006 aerial imagery (Figure 2) indicates that the upstream bifurcation point between the East and West channels continues to exist and the East Channel is the dominant flow channel.

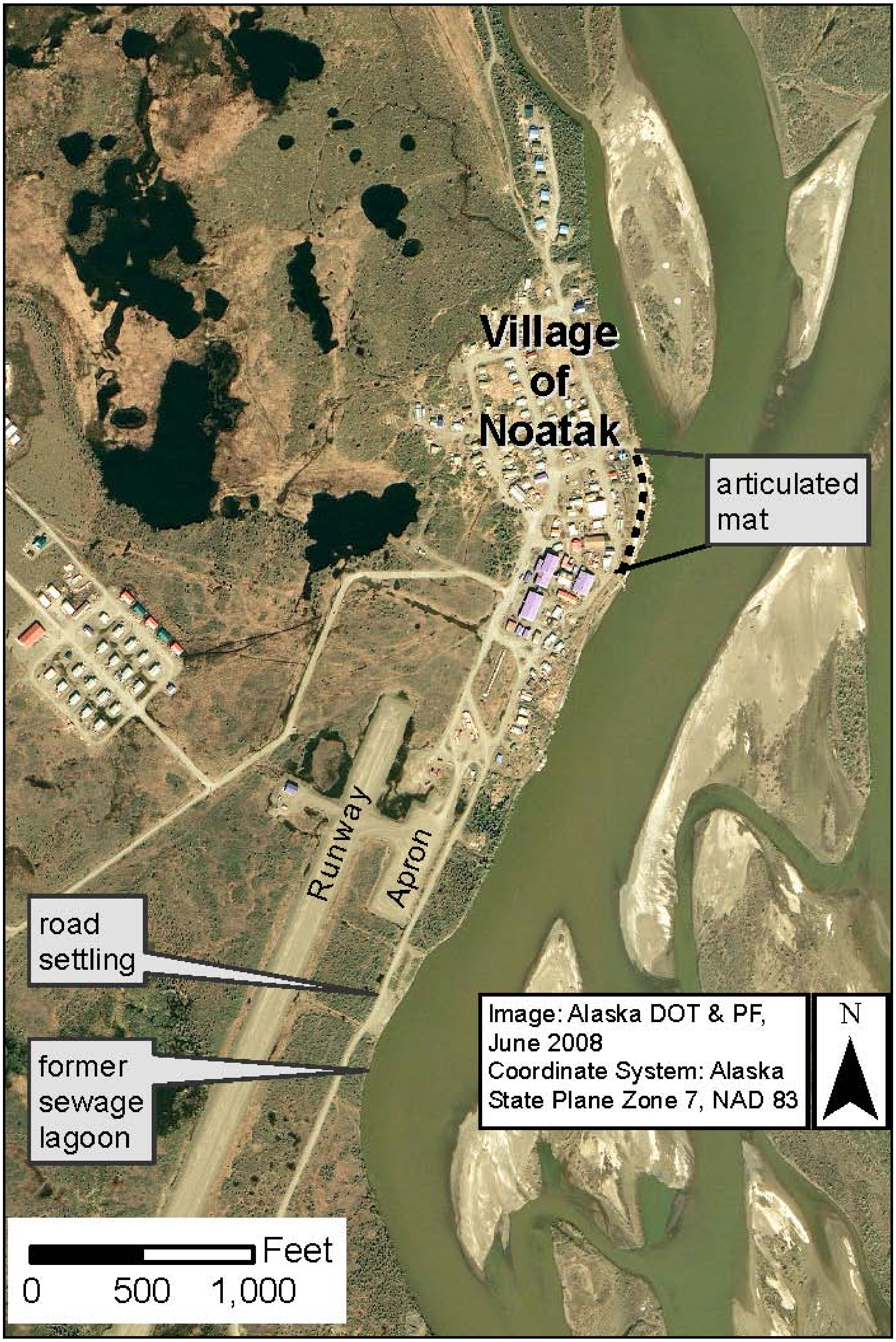


Figure 1: Study Area Features

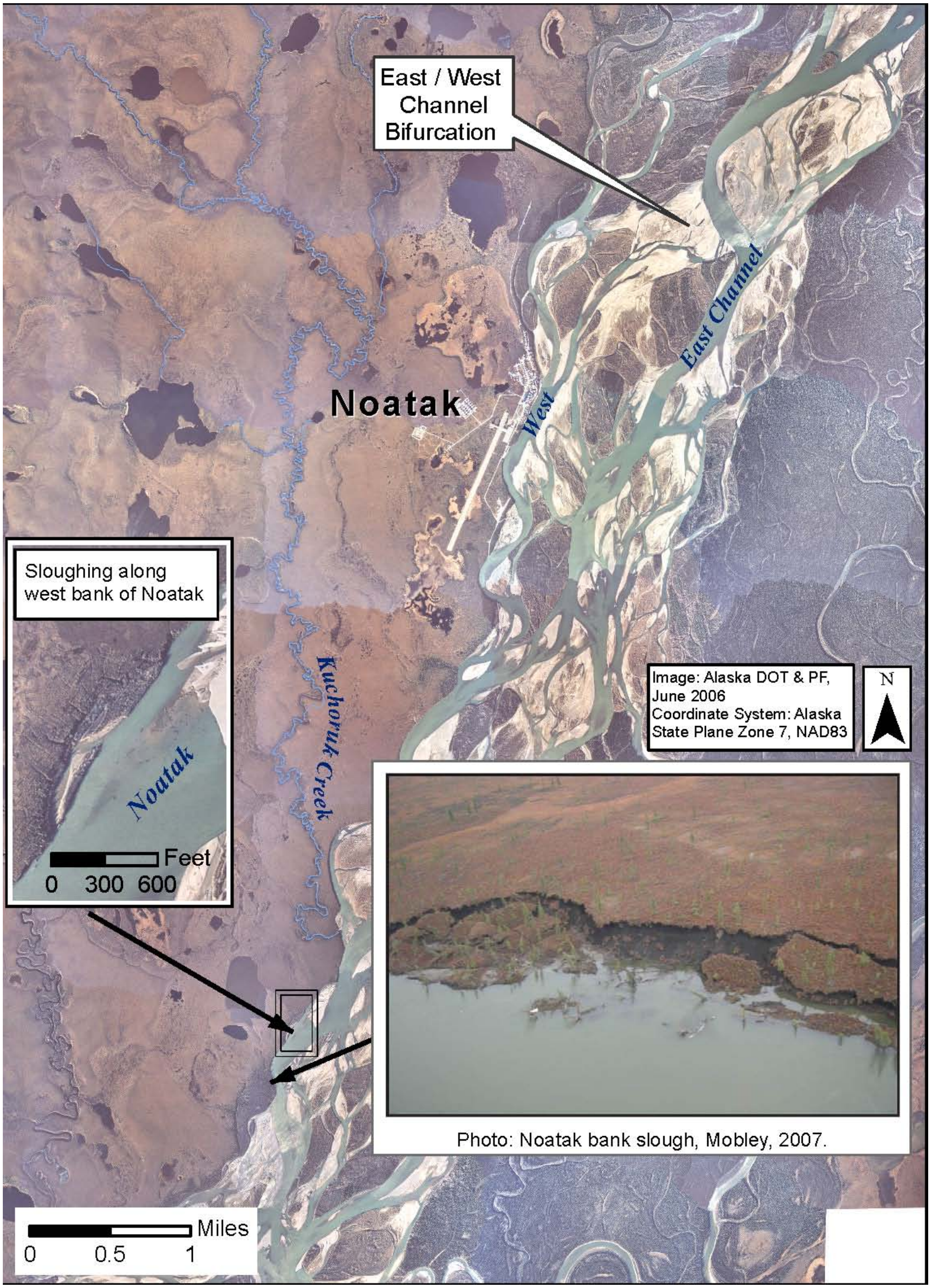


Figure 2: River Setting

Bank erosion has occurred along upstream and downstream portions of the Noatak River. Numerous incidents of erosion have been documented in the mountainous upper main stem of the Noatak River (Swanson, 2012). In the more lowland setting, within 15 miles upstream of the Village of Noatak, erosion has been observed on the west bank over the past 10 years (Kirk, 2013). In addition, approximately 75 to 100 horizontal feet of bank erosion on the west bank has been observed approximately 4 miles downriver from the airport (inset, Figure 2). The incidents of erosion on the west bank, even with the dominant flow not in this channel, are indicative of the westward migration of the river in general and may also reflect other erosion processes described in a following section.

2.2 Previous Studies

1. Erosion in the Vicinity of the Village. As early as 1976, *the "Environmental Considerations for Community Development"* prepared by the Alaska Department of Community and Economic Development Division of Community and Regional Affairs (DCRA) delineated active bank erosion starting about 400 feet upriver from the north end of the runway and extending approximately 800 lineal feet further up river. In 1981, 1,500 lineal feet of articulated concrete mat was installed in this area. This mat has been successful in stemming erosion of the bank above it, but portions of the mat have been undercut by the river and the mat is degrading in other areas.

2. Erosion in the Vicinity of the Airport. Based on aerial photo overlays for 1972 and 2000 in the R&M study, as much as 430 horizontal feet of erosion occurred along a 2,500-foot stretch of the west bank near the airport and former sewage lagoon. A DOT&PF Northern Region trip report dated September 21, 1978, included a photo that showed the sewage lagoon was intact. The R&M study indicated that the sewage lagoon was breached in 1984. The 1992 Environmental Assessment (EA) for runway extension and apron expansion describes westward migration of the river, facilitated by the presence of ice-rich silt that is eroded away more easily than gravel. An appendix to this EA includes a September 1991 memo indicating that the sewage lagoon had been washed out since a previous visit. These observations indicate progressive erosive activity over the 1978 to 2000 time period, averaging 20 feet per year.

3. Quantitative Documentation of Flow Regime. A 2002 U.S. Army Corps of Engineers (USACE) study (USACE, 2002) reported that the East Channel is the dominant low-flow channel (estimating that it carried about two-thirds of the river flow in September 2001, a relatively low-flow period) and probably is also the dominant high flow channel. This study indicates that the East Channel appears to be increasing in depth and capturing an increasing share of the flow and that the current planform favors this trend, because flow into the West Channel takes a perpendicular bend, increasing the potential that the West Channel will fill and have reduced capacity over time. The report observed that the West Channel does convey flow, particularly during high water events. This study estimated maximum bank erosion rates of up to 20 feet per year in some locations.

4. Erosion Rates Defined and Erosion Extents Projected. The R&M study discussed the relative flows in the East and West channels, as above. The study also evaluated potential erosion effects from further flow bifurcation just upstream of the village around an island that has experienced erosion. The R&M study identified historic bank locations from a series of aerial photos from 1952 through 2000 and for six discrete cross-sections, including two across the runway and apron areas of the airport. The study delineated potential maximum extents of erosion to occur by 2010, 2020, and 2050. By 2010, the projected maximum erosion would

extend into the apron and, by 2020, into the runway. For two cross sections in the airport area, the study estimated a maximum rate of erosion of 60 feet per year.

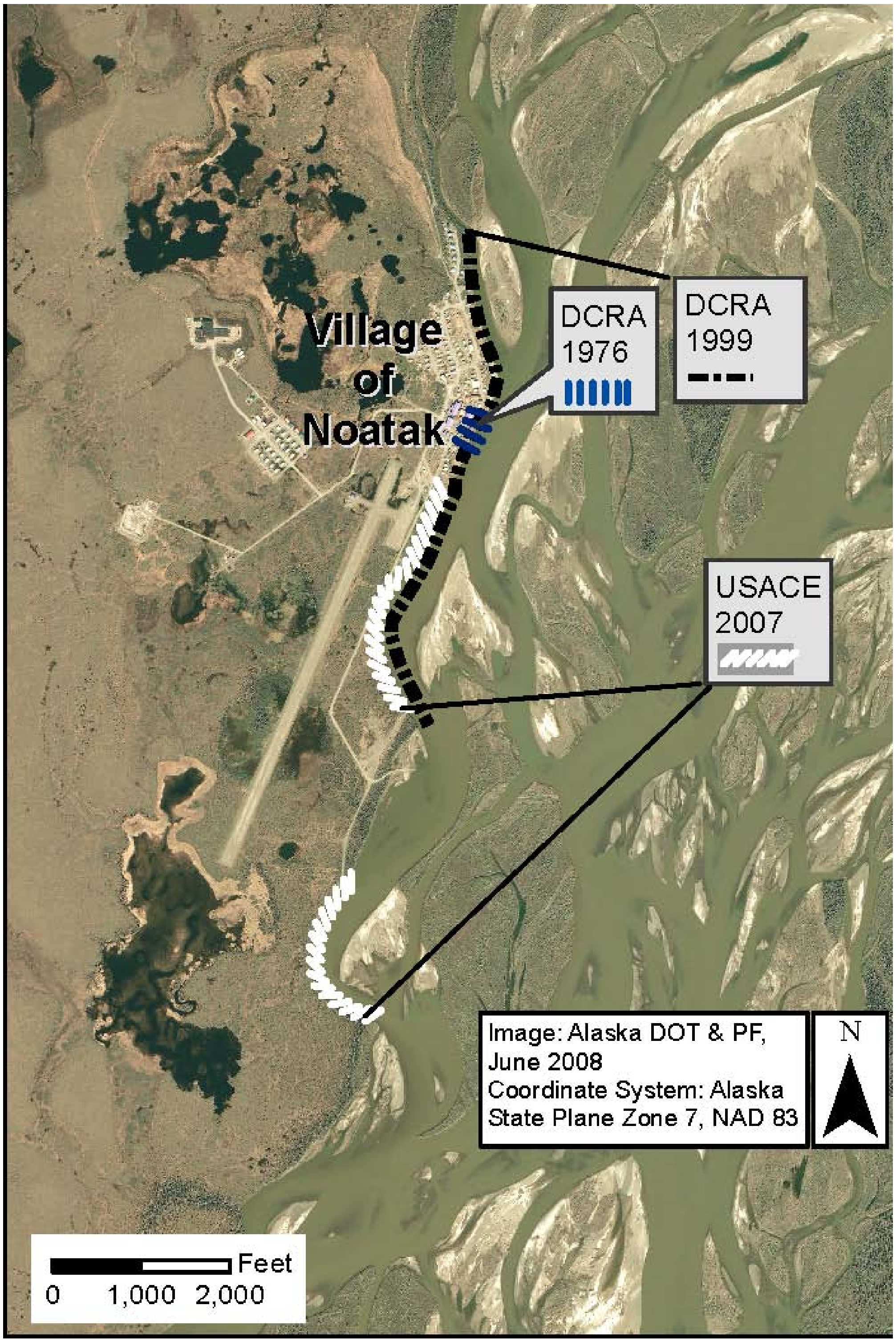


Figure 3: Areas of Erosion

5. Current Areas Subject to Erosion. Areas depicted on maps prepared by two agencies (DCRA, 1999 and USACE, 2007) in the past 13 years are shown on Figure 3. Erosion is more apparent in areas of high, steep banks, than along the area adjacent to the airport apron. The *Alaska Baseline Erosion Assessment* (USACE, 2009) rated Noatak as a "Monitor Conditions Community," having significant impacts related to erosion, in which taking action to prevent a problem from becoming worse would be prudent.

3 EROSION OBSERVATIONS AT NOATAK 2003 - 2012

1. Aerial photographs were obtained by DOT&PF for 2000, 2005, 2006, 2007, 2008, and 2011 and are shown in Figure 4. Because of varying water levels at the time of the photos, the absolute extent of erosion is not measurable at the level of detail in the aerial photos. However, between 2000 and 2005, it appears that about 80 horizontal feet have been lost, corresponding with erosion observed in May-June, 2004.

2. May-June 2004. Erosion was observed southeast of the airport apron during spring break-up. The environmental coordinator for the Village of Noatak notified DOT&PF that there was high water and active erosion on May 28, 2004. DOT&PF staff made a field visit on June 11th and estimated that the edge of Pit Road at the southeast corner of the apron was 125 feet from the riverbank.

3. August 2006. During a reconnaissance visit to assess gravel sources for a new runway (HDL, 2006), the hydrologist observed that significant permafrost was evident on the west mainland bank of the Noatak River, with active erosion present. The study *stated "The exposure of the massive ice at the cut bank and resulting erosion will likely continue whether or not the river geometry continues to direct energy toward the cut bank."*

Figure 4: Aerial Photography 2000 to 2011

4. August 2012. Significant erosion occurred southeast of the airport apron during a very rainy late summer period.

   - A DOT&PF sketch based on GPS coordinates collected on August 1, 2012, site visit and aerial imagery (Figure 6), indicates the distance from the southeast corner of the apron to the riverbank is now about 125 feet. Photos from that site visit (Figure 5) illustrate the bank height and the extent of erosion along the bank. DOT&PF personnel note that active erosion was occurring at Point C shown in Figure 6 and that erosion had occurred both up and downriver from Point C, as illustrated by the red line ("2012 anticipated shoreline") in Figure 6. The actual location of Point C may be somewhat closer to the river than shown on this figure, due to cloud cover interfering with the GPS satellite signal (Dianoski, 2013). Assuming Point C is only half the distance from the river edge than shown on Figure 3 and comparing this with the 2006 edge of bank, it appears that 20 to 30 horizontal feet had been lost.
   - DOT&PF's contract airport maintenance staff in Noatak described the erosion as occurring over several weeks, losing about a foot a day (Kirk, 2013). He described high water all summer and an eddy effect against the bank during the active erosion. The maintenance staff also observed sinkholes next to Pit Road, between the road and the runway. During the summer rain, runoff from the road entered the sinkholes but didn't fill them, apparently because water was seeping out. Seepage from the riverbank face on the other side of the Pit Road from the sinkholes was observed. This may indicate that there is direct seepage from the subsurface to the face of the riverbank.

Figure 5: Bank Erosion August 2012 Orange cones set along east side of Pit Road. (Left) looking upriver from Point C (Right) looking downriver from Point B

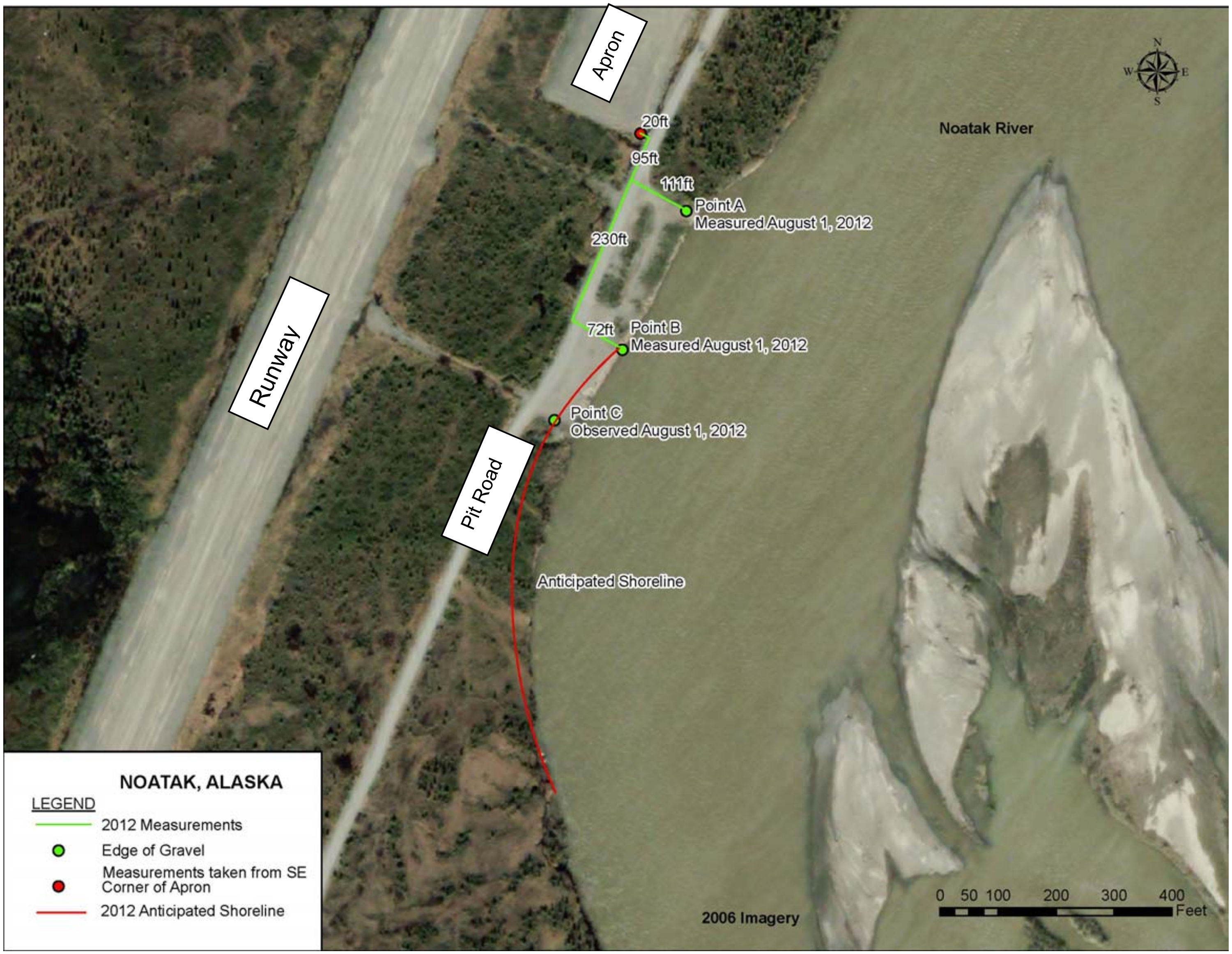


Figure 6: Measured Extents of Erosion August 2012

4 EROSION DRIVERS AND PROCESSES

Climate and river characteristics can influence the types and rates of riverbank erosion.

4.1 Types of Erosion

Thermal Erosion. Thermal erosion occurs when formerly frozen soil media thaws and slumps, particularly along rivers in permafrost settings (Scott, 1978; Lawson, 1989; Gatto, 1995). The Noatak watershed is underlain by continuous permafrost except in some localized areas; such as thaw bulbs associated with rivers, springs, or groundwater. Riverbank erosion processes in permafrost are primarily driven by this detachment of soil in the active (seasonally thawed) layer from the underlying permafrost layer. Deeper depths of thaw may be caused by exposure of the soil profile to ambient temperatures either after sloughing or due to site disturbance, which removes the insulating effects of vegetation (e.g., construction of the airport).

In non-cohesive (gravelly and sandy soils), thawing causes the loss of frozen water holding the soil matrix together at steep angles, and the exposed bank slumps to its angle of repose. In cohesive soils (silts and clays) deeper depths of thaw causes melt water to exert pore pressure as it drains. This seepage force and the saturation of bluff faces and cut banks causes slumping.

Sediment Transport. As the soil slumps, it may temporarily buttress the intact bank by providing slope toe protection and it may also provide thermal protection to the slope face as well. When this material is carried away by river flow, which may not necessarily require high flows, further slumping can occur. This starts the cycle over by exposing a new face to surface interaction, including warming and water seepage.

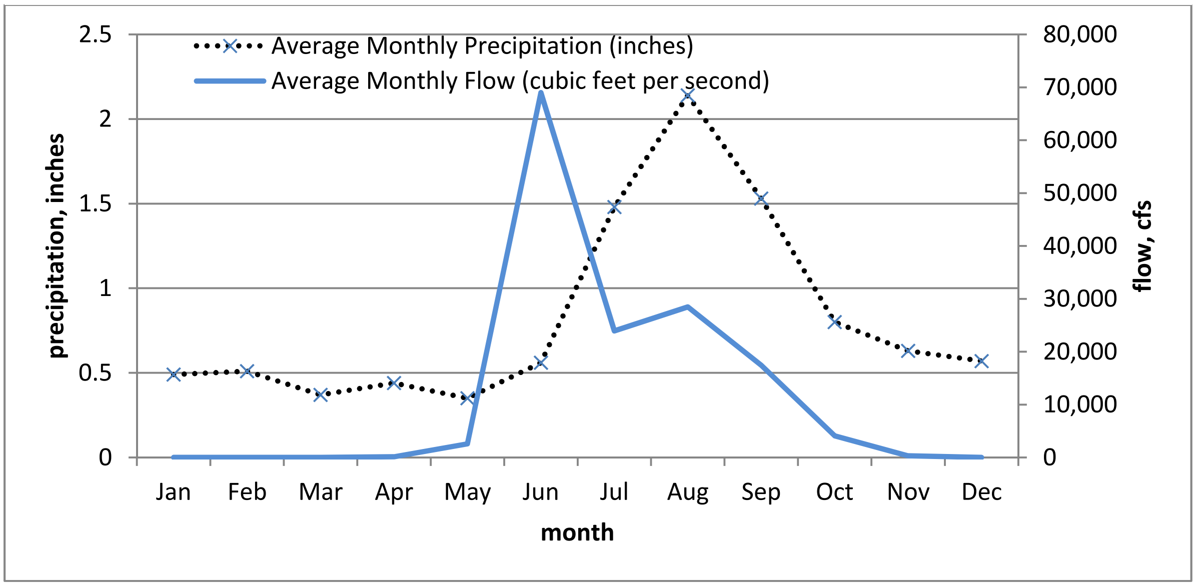
Particle Erosion. In addition to thermal erosion, due to changes in thaw depth and permafrost, aided by sediment transport, it has been observed (Kirk, 2013) that particle erosion due to shear stress and turbulence exerted by water flow occurs at higher flows. When higher flows occur at times when the bank material is not frozen, such as during late summer rains, the river flow will remove bank material as well as material at the toe.

4.2 Climate Influences

Historic Climate Setting. The precipitation pattern in the Noatak watershed follows a strong seasonal trend, with about 50 percent of the precipitation occurring in July, August, and September. Precipitation as snow accumulated from October through April melts during the May and June breakup period. Seasonal flows in the Noatak River respond to these climatic factors: spring high flows are linked to rapid snow melt while late summer and fall high flows are related to rainfall precipitation.

Figure 7 shows average monthly precipitation at Kotzebue and total flow in the Noatak River, as gauged by the U. S. Geologic Survey downstream from the split channel section. The Kotzebue Airport is the closest climate station to the Noatak Airport with a long record. Although these precipitation values were not measured at Noatak or in the Noatak watershed, they provide a representation of the seasonal precipitation variability. Flow was only measured for seven years (1965 to 1971) so does not reflect a robust or contemporary period of record, but does show seasonal flow variation.

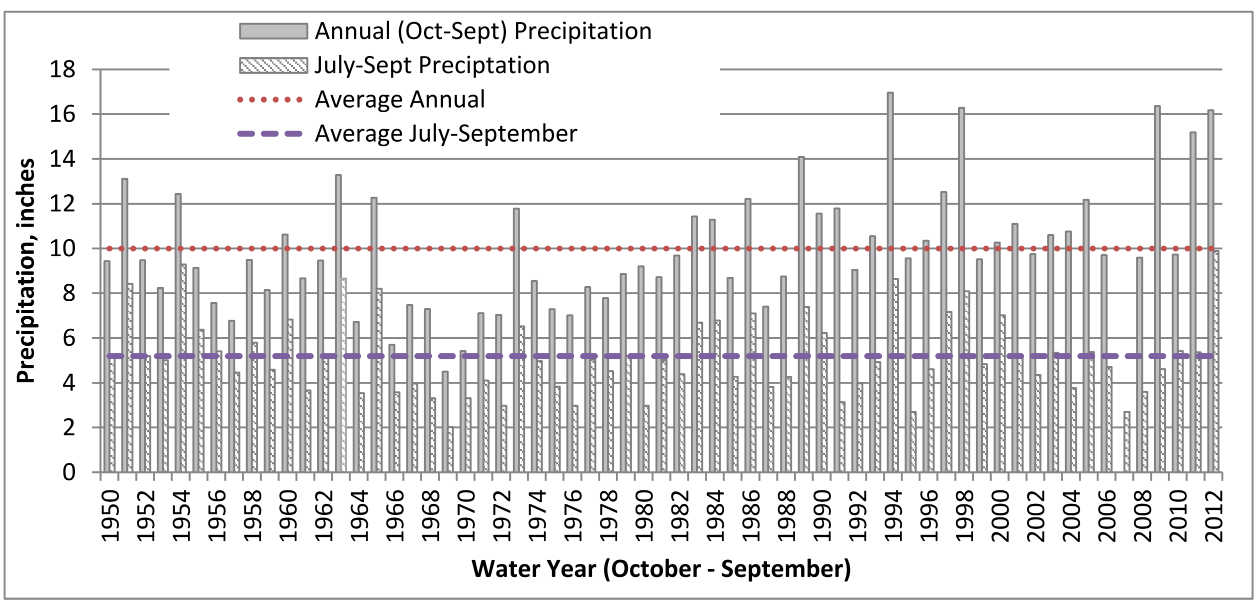
Figure 7: Average Monthly Precipitation and River Flow



Precipitation at Kotzebue Ralph Wein Memorial Airport Alaska, 1949 – 2012
Flow in Noatak River, U.S. Geological Survey (USGS) Gage 1574600, 1965 – 1971

Annual and late summer precipitation depths at Kotzebue Airport are shown in Figure 8. As mentioned above, although these values were not measured at Noatak, they provide a representation of the variability of precipitation from year to year and illustrate years of higher than normal precipitation. Note in particular the high precipitation in late summer 2012, corresponding with the erosion event that occurred in August 2012 as compared to the long-term July-September average.

Figure 8: Historic Precipitation at Kotzebue Ralph Wein Memorial Airport Alaska Period of Record: 1950-2012



Projected Climate Setting. In addition to year-to-year variability, the climate setting is experiencing decade-to-decade variability (Pacific Decadal Oscillation) and a trend towards long term warming.

Long term warming causing permafrost degradation due to deepening of the active (seasonally thawed) layer has been well documented (Romanovsky et al, 2010). The Scenarios Network for Alaska and Arctic Planning, University of Alaska, (SNAP, 2013) has developed projections of temperature and precipitation for communities in Alaska. Table 1 shows a summary of the projected increases in precipitation and temperature for Noatak through 2040.

Table 1: Historic and Projected Temperatures and Precipitation at Noatak

Temperature (^oF)		Precipitation (inches)	
Historic	Projected	Historic	Projected
(1961-1990)	(2031-2040)	(1961-1990)	(2031-2040)
26	27.3	12.4	14.9

Other climate factors, such as entering into a 'cold' period of the Pacific Decadal Oscillation (PDO) might have other effects. For example, during cold periods of the PDO, above average summer flows may occur (Brabets and Walvoord, 2009). Since there is less seasonal frost in warmer months, higher flows during those periods are more likely to transport materials deposited by slumping or to cause active particle erosion, as occurred in 2012.

These trends of higher precipitation and warmer temperatures, if continued, will accelerate normal thermal erosion processes. As noted above, higher flows related to fall precipitation occur at times when the banks are not frozen, so that both particle erosion and sediment transport of thermally eroded sediment can occur. Although the projected increase in precipitation has not been quantified by season, if it were to occur in late summer, it would likely cause corresponding high flows, leading to further bank erosion.

In general river processes, peak erosion events do not necessarily correlate with peak flows, indicating that erosion can occur at a steady rate. It is also common, in other settings, to have relatively long periods of little erosion punctuated by short periods of marked erosion. Along the west bank at the Noatak Airport, where both thermal and particle erosion processes are in play, both ordinary and high flow events contribute to sediment removal and bank erosion.

4.3 River Characteristics

Split Channel. As indicated in both the R&M study and the USACE letter report (UASCE, 2002) the split between the East and West channel is present, with the dominant flow in the East Channel at present. The USACE letter report indicates that the bifurcation appears to be fairly stable. Local observers (Kirk 2013) confirm that the East Channel continues to be the main channel. This is also apparent in a 2006 aerial photo (Figure 3).

Although the channels of split-channel rivers are generally more stable than braided channeled rivers, the history of channel-shifting upriver from Noatak indicates that this could happen again. Since the process leading to this shift is not well understood, a shift back to the West Channel cannot be discounted.

River Planform and Migration. Another pattern of the Noatak River in this area is its sinuosity, typical of braided and split-channel rivers, as shown by its arcuate channel forms. As mentioned previously, erosion along the bank at the airport and Village of Noatak are not isolated cases and are part of a more pervasive trend of channel migration in this arcuate pattern.

Underlying Materials. The Noatak River has capacity to move sediment, as evidenced by its mobile gravel bed and point bar islands. Its banks are comprised of erodible gravels, silts, and sands and there is a lack of any resistant material, such as bedrock control, to limit the erosion potential (Stevens et. al., 2003).

5 EROSION AND POTHOLING IN THE VICINITY OF THE AIRPORT

5.1 Erosion Processes in the Vicinity of the Airport

In the immediate area of the airport and village, localized effects of flow focusing, island position, channel plan form patterns, and bank protection affect the location of erosion.

Flow Focusing and Island Position. As discussed in the R&M study, the bifurcation of the West Channel into the A and B channels in the vicinity of the Village and the potential for changes in these channels creates more uncertainty about the trajectory of the water and timing of potential changes. Focusing the flow, and higher flow, towards the west bank, would accelerate erosion.

Channel Planform Patterns. The general pattern of planform of the Noatak River in this reach of the river is sinuous and arcuate (Figure 2) and the projected erosion extents in the R&M study reflects this. The leading edge of the erosion observed in 2004 and 2012 follows that pattern. Notable at the Noatak Airport, downriver from articulated mat, is a long stretch of linear rather than curved channel pattern. As discussed in the R&M study and apparent from observed erosion, a meander pattern is likely to develop. The upgradient bank armoring may have forestalled this channel migration and failure in that armoring may accelerate erosion.

Localized Bank Protection. Silt is the predominant foundation soil in the vicinity of the airport (DOT&PF, 1986) and there is a lack of any bedrock control. Although permafrost can act as erosion protection, its loss due to thermal erosion provides a thaw mechanism to accelerate erosion. However, the presence of the articulated concrete mat up river is likely to be affecting the flow such that it is focused parallel to the bank adjacent to the airport apron, and somewhat more towards Point C in Figure 6. Failure of the articulated mat could move the focus of the flow more towards the apron and accelerate erosion along a longer section of riverbank adjacent to the runway.

5.2 Pot-holing of Pit Road

Pot-holing and depressions in the access road parallel to the runway have occurred. The four most likely and interrelated reasons are non-homogeneous subgrade, thermokarsting, freeze-thaw action, and active piping of soil.

1. Non-homogeneous material can settle differentially, particularly when subjected to variable moisture conditions (dry early summer, wet late summer) and freeze-thaw conditions. A March 8, 1981, letter from the Alaska Village Electrical Cooperative to DOT&PF indicated that scrap metal had been buried in the road to the apron and that freeze-thaw action had brought it to the surface. While it is not known if this is in the same vicinity of the current areas of concern, it is an example of the possibility of non-homogenous material. Given comparatively light traffic usage on this road, it may take a longer time for the subsurface discontinuities to appear. But

given the 20+ years since the fill was placed and the road put into service, it is likely that these will continue to occur.

2. Thermokarsting. This phenomenon occurs when ice-rich lenses in the foundation material below the surface (in this case, below the road embankment) become thawed and melt water flows out. Melt water from these lenses can flow laterally through subsurface material and seep out of bluffs or cut faces, such as riverbanks, or it can wick up through the overlaying material, particularly if the material is fine-grained, where it pools on the surface and evaporates or flows off. As melt water leaves, the voids it occupied collapse, resulting in subsidence at the surface.

   Logs of boreholes installed by DOT&PF NR (to maximum depths of 8 feet) in the vicinity of the runway and apron in September 1986 (DOT&PF, 1986) noted ice-rich soils or lenses in three boreholes at depths from 1 to 6 feet below ground surface, and depth to frozen soil of no more than 5 feet. If the ice lenses were also present along the road alignment, which is likely, this would provide the setting for thermkarsting to occur.

   Note that by contrast, logs of boreholes installed (to maximum depths ranging from 10 to 13 feet) in September 2006 (DOT&PF 2008) in the apron area and along the runway indicate depth to frozen soil of 8 to 11 feet and no notations of ice lenses above the frozen soil. Although there is likely year-to-year variability in active layer thickness (in this case approximated by depth to frozen soil in September), the difference between a maximum of 5 feet in 1986 and a minimum of 8 feet in 2006 may also be reflective of a trend in permafrost degradation.

3. <u>Freeze-thaw action</u>. Localized depressions caused by settling, whether due to thermokarsting or non-homogenous subsurface material, will accumulate water. If water accumulates just before freeze-up, for instance due to late summer rains before it can evaporate or infiltrate, its expansion during winter freezing and subsequent contraction during breakup can cause potholing as well.

4. <u>Piping</u> is a mechanism of internal or subsurface erosion caused by seepage. When water accumulates, as in a temporary sinkhole caused by thermokarsting, and hydraulic pressures rise, seepage forces can erode fine soil particles, leading to loss of material and failure of the embankment or surface. Assuming the road is underlain by more permeable material (gravel) than the adjacent foundation soil, this offers a preferential pathway for the water to seep towards the riverbank, accelerating the loss of subsurface fines and leading to subsidence, and in some cases, more dramatic failure.

   Given the observed conditions of permafrost degradation and proximity to the eroding riverbank, it's likely that the sinkholes and depressions found in Pit Road are related to the mechanisms causing the riverbank failure.

6 CONCLUSIONS

6.1 Riverbank Erosion

The prognosis is that the west bank of the Noatak River in the vicinity of the Noatak Airport will continue to erode as suggested in the R&M study. The vertical face of the west bank of the Noatak River will continue to slump due to thermal erosion. As the slumped material is removed by river flow, the west bank will recede towards the west.

This prognosis is based on evidence of continued slumping since 2003 and environmental factors.

1. Evidence of Slumping. Major episodic sloughing of the banks next to the airport occurred in 2004 and 2012. Slumping and erosion of the west bank has also occurred in other places up and down the river.

2. Environmental Factors. The factors that contribute to the continuing potential for significant erosion are still at play, as follows:

   - Even in stable temperature regimes, slumping due to thermal erosion is a characteristic of rivers in areas with continuous permafrost. With projected warming trends, this thermal erosion is likely to accelerate, due to accelerated permafrost degradation.
   - Projected increase in precipitation is likely to increase the incidence of high flows leading to particle erosion.
   - Continued deterioration of the articulated mat upriver from the apron may lead to more failure in that vicinity. Failure in that area would likely change the trajectory of the flow and bring more shear stress and turbulent flow to bear on the riverbank adjacent to the airport apron. Changes in flow patterns in the West Channel immediately upriver from the Village (so called channels A and B) may also change the flow trajectory.
   - The upstream bifurcation of the East and West channels continues to shunt the water towards the east, which will reduce the risk somewhat, especially if depositional processes there maintain the East Channel as the dominant flow channel. While currently stable, if more water were to flow in the West Channel, it is more likely to cause accelerated erosion on the west bank in general and potentially in the vicinity of the Noatak Airport.

The timing of major erosion events is difficult to predict. The August 2012 erosion appeared to be due to extremely high precipitation and flow, while the 2004 event did not appear to be correlated with precipitation.

6.2 Access Road Deterioration

Based on information related by site observers, thermokarsting and piping appear to the contributing causes for sinkholes and depressions in Pit Road. The piping is accelerated as the distance to the cut bank is reduced, such that continued west bank erosion may cause more thermokarsting to occur by providing a path for melt water to dissipate.

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Noatak River Erosion Update

Site Visit: March 25th, 2015

6/10/2015

On March 25th, 2015, the Department of Transportation and Public Facilities held a community meeting in Noatak discussing information about relocating the Noatak Airport. The relocation is necessary because of the encroachment of the Noatak River towards the apron; intrusion of the runway safety areas; and to construct the necessary updates required to meet FAA standards for safe and efficient operation of a rural airport.

The previous site visit where the DOT&PF recorded measurements of the embankment was in 2013.

As shown in the graphic attached, there are two significant locations labeled in negatives (black and white) which display the total perpendicular distances of the far edge of haul road to the gravel pit to the edge of the eroding riverbank.

Distance (1) which was recorded in 2013 was taken at 102 feet. Distance (2) which was recorded in 2015 was taken at 96 feet. This two year interval indicates there is a loss of **6 feet** at this particular section of the haul road.

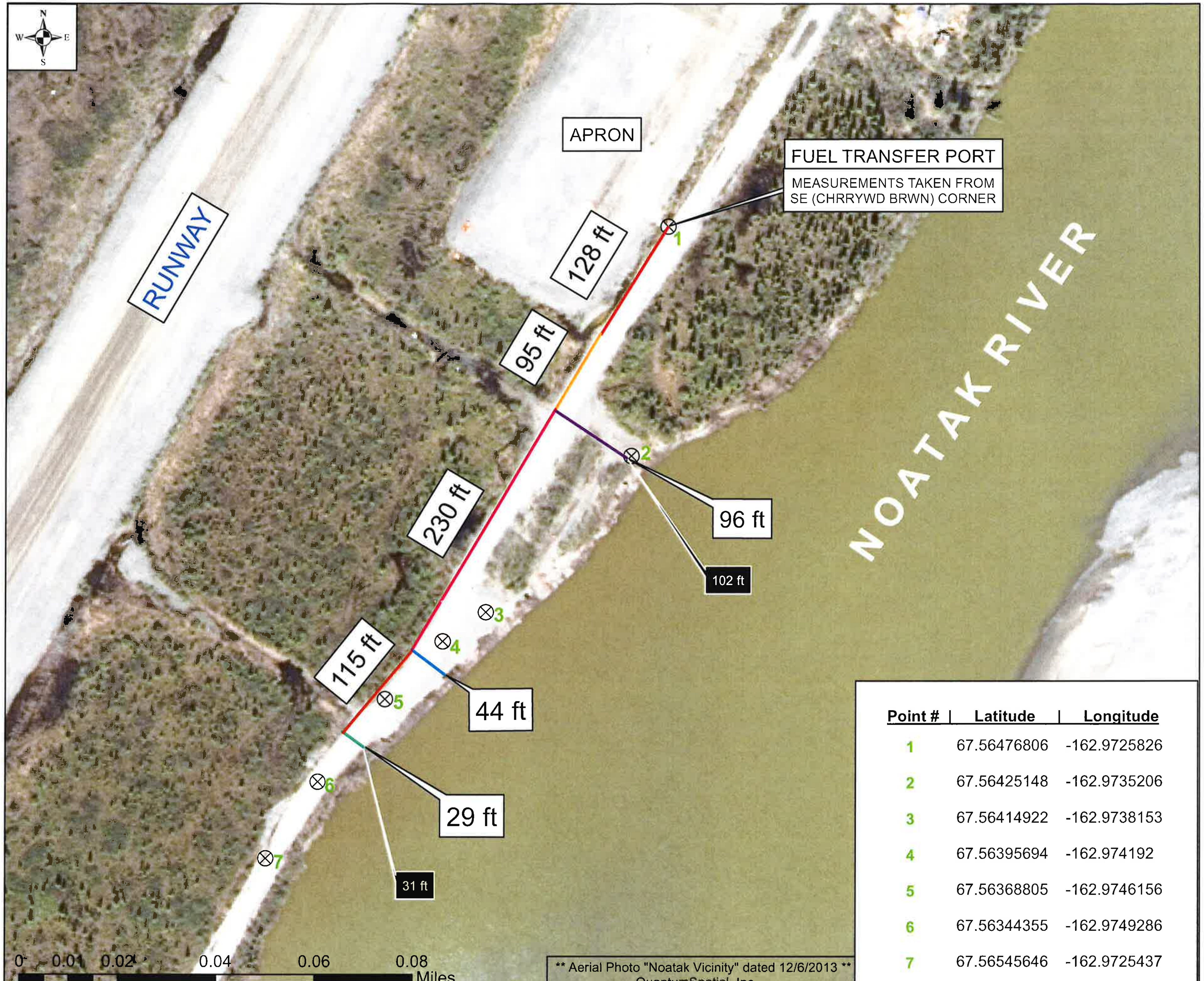
Distance (3) was also recorded in 2013 was taken at 31 feet. Distance (4) was recorded in 2015 was taken at 29 ft. This displays a loss of **2 feet** at this particular section of the haul road.

Since 2000, the community of Noatak and the DOT&PF has recorded a loss of more than **40 feet** of embankment.

** The DOT&PF recently received notices as well as the provision of photos of the gravel cliff from residents of Noatak, displaying the aftermath of ice-breakup and the effects of the continually thawing and exposed active layer of permafrost.

Following the graphic of the erosion occurring is a few recent photos of the erosion from a community member, for the DOT&PF.

Noatak Riverbank Erosion Update 2015



** Aerial Photo "Noatak Vicinity" dated 12/6/2013 **
QuantumSpatial, Inc.

Point #	Latitude	Longitude
1	67.56476806	-162.9725826
2	67.56425148	-162.9735206
3	67.56414922	-162.9738153
4	67.56395694	-162.974192
5	67.56368805	-162.9746156
6	67.56344355	-162.9749286
7	67.56545646	-162.9725437

Legend

⊗ 25/03/2015 Erosion Coordinates

*** Projected Coordinate System: ***
Name: NAD_1983_Alaska_Albers

Geographic Coordinate System:
Name: GCS_North_American_1983

DATES OF RECORDED MEASUREMENTS:

BLACK ON WHITE TEXT: 25/03/2015

WHITE ON BLACK TEXT: 12/06/2013

State of Alaska
Department of Transportation and Public Facilities

DRAWING: BJK | DATE: 6/2015