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KENAI RIVER BANK EROSION
TECHNICAL REPORT
KENAI, ALASKA

May 2006

SUMMARY

This report presents the findings of a technical investigation of bank erosion along the Kenai River at the city of Kenai, Alaska. The Secretary of the Army was directed in the Energy and Water Development Appropriations Act of 2002, Senate Report 107-039, to expend up to $500,000 to conduct a "special technical evaluation of bank stabilization needs along the lower Kenai River."

The city of Kenai and the lower reach of the Kenai River are located on the Kenai Peninsula, approximately 65 air miles and 155 highway miles southwest of Anchorage via the Sterling Highway. The section of riverbank being studied is along the north bank of the river, between the mouth of the river and the city.

Erosion of the bank along the Kenai River at Kenai has continued to encroach upon city, commercial, and private utilities and structures. The city has had to relocate utilities and roads, and cannot move forward with planning and development of the area along the bluff. Erosion has also resulted in properties and structures being abandoned or condemned. The steep and unstable bank is a safety risk to residents and visitors to Kenai. The city and residents currently incur an average annual loss of $151,000 due to reduced value of lands and buildings and relocation of buildings and utilities.

A number of forces contribute to the bank erosion such as wind, waves, foot traffic, overland drainage, groundwater seepage, and river currents. The primary contributor of erosion is groundwater seepage out of the bank face, which causes the piping of fine sand material from the upper bank and weakening of the lower silt/clay layer. The eroded material is initially deposited on the bluff toe where it is then subjected to further erosion from wind, waves, and river currents. Further studies and bank stabilization project designs should first address groundwater seepage.

To estimate the impacts of a stabilized bank it was assumed that the bank stabilization conceptual design by Peratrovich, Nottingham, and Drage, Inc. (PND) in their February 2002 report was the with-project condition. Primary features of this concept would consist of an armor stone layer along the lower bank with the upper bank cut to a shallower grade and revegetated. Groundwater seepage out of the bank face would be routed through a collector drain and discharged to the river. Although it is recognized that the PND design was at a conceptual level, additional analysis and design should first focus on groundwater seepage and collection.

There is the potential for direct and indirect loss of habitat from stabilization of the bank. Direct habitat loss would occur from project construction in the intertidal area and also result in a loss of potential nesting habitat for swallows if the bank grade is altered. Change of the bank grade would remove numerous spruce trees from the top of the bank. Bald eagles commonly use these trees to perch and overlook the river and associated wetlands. If the bank is cut back to a more shallow, stable slope and subsequently revegetated, it is likely that the new vegetation will provide some bird habitat. There will likely be disturbance and displacement of birds during some phases of construction. Many adverse impacts to birds can be avoided through the use of construction windows.

Hydraulic modeling was performed to compare the existing and with-project conditions. Results of the modeling indicate that the project would have minimal encroachment on the river flow path and would have an insignificant impact on river currents.

Indirect impacts would encompass effects of the erosion control project that are encountered outside the project footprint. Of particular concern are the sand dunes and the large intertidal area in front of the dunes and the sewage treatment plant. According to the sediment impact analysis, see Appendix C, the impacts to the dunes from an erosion control project are expected to be minor. Although armoring the bank would decrease the amount of sediment entering the system, this quantity is small in comparison to the overall amount of sediment contributed from other sources in the river.

Although the bluff is receding, geotechnical analyses indicate that the slope is stable and that massive slope failures are not contributing factors to the erosion. Both the sand and clay slope faces, however, are susceptible to surface raveling, sloughing, and wind and water erosion. Well flow tests were also conducted along the bluff. The tests indicate that the sand layer of the bluff is highly permeable. However, the number of tests performed was insufficient to adequately map groundwater flow patterns suitable for detailed design of a bluff stabilization project.

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1.0 STUDY AUTHORITY

This study is in partial response to the Rivers and Harbors in Alaska resolution, adopted by the U.S. House of Representatives Committee on Public Works on 2 December 1970. This resolution reads in part:

> *Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on Rivers and Harbors in Alaska, published as House Document Numbered 414, 83rd Congress, 2nd Session;…and other pertinent reports, with a view to determining whether any modifications of the recommendations contained herein are advisable at the present time.*

The Secretary of the Army was directed in the Energy and Water Development Appropriations Act of 2002, Senate Report 107-039, to expend up to $500,000 to conduct a "special technical evaluation of bank stabilization needs along the lower Kenai River."

2.0 STUDY PURPOSE AND LOCATION

2.1 Purpose and Location

The purpose of this study is to conduct a technical investigation of bank erosion and stabilization along the lower Kenai River at Kenai, Alaska. The city of Kenai and the lower reach of the Kenai River is approximately 65 air miles and 155 highway miles southwest of Anchorage via the Sterling Highway. The bank is along the north bank of the river, between the river and the city. The location of Kenai is shown on Figure 1. A detailed photograph of the lower Kenai River is shown on Figure 2.

2.2 Study Scope

The scope of this investigation includes identification of the mechanisms for bank erosion, analysis of bank stability, measurements of groundwater flow, and impacts to the environmental resources and the river and coastal environment from a bank stabilization project.

Figure 1. Location Map

Figure 2. Lower Kenai River

3.0 PREVIOUS STUDIES

Section 905(b) (WRDA 86) Analysis, Kenai River Bluff Erosion, U.S. Army Corps of Engineers, July 2005. This report provides a reconnaissance level analysis to determine if there is Federal interest in a cost-shared feasibility study.

"Kenai Coastal Tail and Erosion Control Project", Peratrovich, Nottingham, and Drage, Inc., February 2002. This report provides a design concept of bank stabilization and a pedestrian trail along the bank.

"Erosion at the Mouth of the Kenai River, Alaska", Orson Smith, William Lee, and Heike Merkel, April 2001. Report contains a sediment budget analysis with regard to the proposed "Kenai Coastal Trail and Erosion Control Project", PND Feb 2002.

Draft "Bluff Erosion Study, Kenai River Sedimentation Study", TAMS Engineers, November 1982. This report identified groundwater seepage from the bank face as the primary mechanism of bank erosion and recommended control of this seepage as the first order of work towards bank stabilization.

"Erosion and Sedimentation in the Kenai River, Alaska", U.S. Geological Survey, 1982. This report presented an assessment of erosion and sedimentation of the entire Kenai River.

4.0 EXISTING CONDITIONS

4.1 Community Description

History. Prior to Russian settlement, Kenai was a Dena'ina Athabascan Indian village. Russian fur traders first arrived in 1741. At that time, about 1,000 Dena'ina lived in the village of Shk'ituk't, near the river. The traders called the people "Kenaitze," or "Kenai people." In 1791, a fortified Russian trading post, Fort St. Nicholas, was constructed for fur and fish trading. In 1869 the U.S. military established a post for the Dena'ina Indians in the area, called Fort Kenay, which was abandoned in 1870 after Alaska was purchased by the U.S. A post office was established in 1899. Through the 1920s, commercial fishing was the primary activity. In 1940, homesteading enabled the area to develop. The first dirt road from Anchorage was constructed in 1951. In 1957, oil was discovered at Swanson River, 20 miles northeast of Kenai - the first major Alaska oil strike. The City was incorporated in 1960. In 1965, offshore oil discoveries in Cook Inlet fueled a period of rapid growth. Kenai has been a growing center for oil exploration, production and services since that time.

Culture. The Kenai River is a major sport fishing location for Anchorage residents and tourists. The river is world renown for trophy king and silver salmon. The Kenaitze (Tanaina Athabascans) live borough-wide and utilize the rich resources of Cook Inlet.

Economy. The City is the center of the oil and gas industry for the Kenai Peninsula, providing services and supplies for Cook Inlet's oil and natural gas drilling and exploration. Tesoro Alaska's oil refining operations and Unocal's urea plant are located in North Kenai. Both in-state and out-of-state visitors provide a significant industry on the Peninsula. Other important economic sectors include sport, subsistence and commercial fishing, fish processing, timber and lumber, agriculture, transportation services, construction and retail trade. 234 area residents hold commercial fishing permits. The largest employers are the Borough School District, Unocal, Peak Oilfield Services, the Borough, and Central Peninsula General Hospital. The Challenger Learning Center of Alaska was completed in Spring 2000. Logging of spruce bark beetle-killed timber also occurs in the area.

Facilities. Water is supplied by three deep wells and is piped to 75% of households. Sewage is piped and receives secondary treatment. The remaining 25% of households use individual water wells and septic systems. Natural gas is primarily used for home heating purposes. Homer Electric Assoc. operates the Bradley Lake Hydroelectric Project and is part owner of the Alaska Electric Generation & Transmission Cooperative. The Borough landfill is located in nearby Soldotna.

4.2 Physical Environment

The City of Kenai is located on the Nikishka Lowland geomorphological subdivision of the Kenai Lowland. This region is characterized by a modified morainal topography, which is separated by an interlacing pattern of swamps and muskegs developed in abandoned drainage channels and broad depressions. The topography and surficial deposits of the region are primarily the products of repeated glaciations, which advanced from ice centers in the surrounding mountain ranges. Near the City of Kenai, the glacial moraines are fronted by a

broad coastal plain consisting of terraced and channeled sand and gravel deposits, which terminate as steep sea bluffs above a series of raised tidal flats.

The topography in the area of the Kenai River mouth consists of a bank approximately 70 feet high opposite a low-lying wetland and tide flat area. The topography indicates that the river valley historically has experienced much higher flows during periods of glacial retreat. Both the bed material and the channel pattern reflect previous glacial discharges and, except for the lower 12 miles the river, is undersized.

The bank at the mouth of the river is composed of three distinct material types. An organic mat top layer approximately 2 feet thick, a fine sand layer approximately 37 feet thick, and a silt/clay layer that varies from 35 to 45 feet thick. A more detailed description of the physical environment of the project area is provided in Appendices B, C, and D.

4.3 Environmental Resources

Surveys in the project area to inventory birds, mammals, fish and invertebrates were conducted. The Kenai River estuary is a very biologically productive area noted for its abundant fishery resources including all 5 species of salmon. Other species include, stickleback, lamprey, eulachon, rainbow trout, Dolly Varden, juvenile marine species such as walleye pollock, Pacific cod, tom cod, sole, Pacific herring, sand lance, Pacific sandfish, sculpins, snail fish, and shrimp species. Fish and macroinvertebrates were sampled, stomach content analysis, and partial food webs were constructed for the estuary. Time series temperature and salinity indicated a highly dynamic nature of the physical environment in the estuary. Invertebrate species sampled in the project footprint area were limited due to the hard substrates. Uncompacted substrates on the south shore provided habitat for small clams (Telina sp.) and marine worms, which are prey for many bird species. The shoreline and wetland in the area are used seasonally for nesting, foraging and staging by a variety of gulls, waterfowl, and bald eagles. Along the face of the bank, the most common birds were ravens, magpies, herring gulls and swallows. Harbor seals are routinely observed near the river mouth. Beluga whales were also observed.

There are the remains of 3 archaeological sites and at least 25 structures in the general project area. Of the approximately 25 structures, 7 are eligible for the National Register of Historic Places and the remainder must be evaluated for the Register. In addition, a portion of the project is within the boundaries of a locally designated historic district. A more detailed description of the environmental and cultural resources is provided in Appendix A.

5.0 PROBLEMS AND OPPORTUNITIES

5.1 Problem statement

The town of Kenai is located along the bank of the Kenai River at its mouth in Cook Inlet. Erosion of the north river bank has continued to encroach upon city, commercial, and private utilities and structures. The city has had to relocate utilities and roads and cannot move forward with planning and development of the area. Erosion has also resulted in properties and structures being abandoned or condemned. The steep and unstable bank is a safety risk to residents and visitors to Kenai.

5.2 Opportunities

- Reduce repair and relocation costs of public utilities
- Reduce relocation cost of public, commercial, and private structures
- Reduce repair and relocation cost of public roads
- Allow for long-term planning and development of lands adjacent to the banks
- Reduce safety risk to individuals walking along the bluff

6.0 EVALUATION OF BANK EROSION AND STABILIZATION

6.1 Bank Erosion Process

Bank erosion along the Kenai River mouth is a product of several conditions, with varying degrees of contribution. The erosion mechanisms are discussed in detail in Appendix B. The mechanisms acting on the bank include:

Wind - Erosion due to winds along the bank is common. However, this volume of material is minimal and does not contribute significantly to the total erosion along the bank face.

Waves – Erosion from large wave action is generally limited to the section of the bluff along Mission Avenue due to its open exposure to Cook Inlet. The section of bluff downstream (seaward) of Mission Avenue is protected by coastal dunes and is generally not subjected to wave action. Wave action at the bluff section upstream of Mission Avenue is an infrequent occurrence due to the partial protection provided by the wetlands to the south and the shoal at the river mouth. Wave action at this section requires a combination of storm surge and high tide to overtop these natural barriers.

Groundwater Seepage – Groundwater seepage out of the bank face at the sand and silt/clay layer interface transmits sand particles, which weakens the upper layer. Also, water running down the face weakens the lower silt/clay layer.

Overland Flow - The upper banks along the Kenai are susceptible to erosion from overland flow. Flow over the top of the bank, if left uncontrolled will readily erode the sand in the upper bank.

6.2 Bank Erosion Rate

The Sediment Impact Assessment (Appendix C) estimated the bluff erosion rate at 1.2 feet per year. This estimate was based on a comparison of aerial photographs from 1965 and 1995. The sediment budget study performed by the University of Alaska Anchorage was based on aerial photographs from 1976 and 1999. Comparison of these photographs provided an estimated erosion rate of 2.5 feet per year. The erosion rate (3 feet per year) used in this report is considered conservative (faster) than the actual erosion rate. A conservative erosion rate was used to bracket the maximum extent of damages under the without-project condition.

6.3 Sedimentation

Erosion from the bluff at Kenai contributes an estimated 21,300 tons of sediment to the Kenai estuary annually. Sediments from the bank consist of a mixture of gravels, sands, silts and clays, with most of the noncohesive soils in the horizon comprising the upper half of the bank. About 50 percent of these upper horizon soils are sands in the size classes found in the Kenai Dunes. Thus, the bank contributes an average of 10,600 tons of noncohesive sediments to the system each year. This represents about 7 percent of the sand flux into the system. About 60,000 tons are delivered annually by the Kenai River from upland and streambank erosion upstream of the estuary, and about 100,000 tons are delivered by longshore transport in Cook Inlet. Most of these sediments pass through the estuary, but some are deposited on the tidal flats and the Kenai Dunes.

Stabilization of the bank would affect the sediment dynamics in the estuary. The overall impact of the reduction in sediment load if the bank is stabilized would be very minor, however, as the system is aggradational and the reduction in sediment volume slight. Changes in the morphology of the tidal flats and dunes are not expected given the net surplus of sediment in the reach, and the coastal morphology indicates that the dunes are primarily fed by longshore transport and wave action. Detailed information on the sediment assessment is provided in Appendix C.

6.4 Riverine Characteristics

The general effect of a bank stabilization project was evaluated using the Hydrologic Engineering Center River Analysis System (HEC-RAS). The model was run to determine potential changes to the river velocities for the existing and with-project condition. Results of the analysis indicate that the project would cause an insignificant (0.1 feet per second) to the river velocity. This is due to the limited amount of encroachment into the river's flow path by the project. More detailed information on the geotechnical investigation is provided in Appendix B.

6.5 Geotechnical Investigation

The purpose of the geotechnical investigation was to determine if slope stability was contributing to the recession of the bank. In addition to the stability investigation, a well flow test was conducted to estimate soil permeability. The well flow test indicated that the sand layer of the bank is highly permeable.

Although the bank is receding, the collected soil data, laboratory testing, and analysis indicate that the slope is stable and that massive slope failures are not contributing factors to the erosion. Both the sand and clay slope faces, however, are susceptible to surface raveling, sloughing, and wind and water erosion. More detailed information on the geotechnical investigation is provided in Appendix D.

6.6 Environmental Evaluation

6.6.1 Cultural Resources

There are the remains of two archaeological sites and four structures eligible for the National Register of Historic Places that could be impacted by continued erosion during the project's period of analysis. There are about 14 additional structures that could be impacted. The historical significance of these structures is unknown and should be investigated if additional studies are performed.

6.6.2 Environmental Impacts

There is the potential for direct and indirect loss of habitat from stabilization of the bank. Direct habitat loss would occur by placing riprap in the intertidal area and also result in a loss of potential nesting habitat for swallows if the bank grade is altered. Changing the slope of the bank would require numerous spruce trees to be removed from the top of the bank. Bald eagles commonly use these trees to perch and overlook the river and associated wetlands.

Indirect impacts would encompass effects of the erosion control project that are encountered outside the project footprint. Of particular concern are the sand dunes and the large intertidal

area in front of the dunes and the sewage treatment plant. According to the recent sediment impact analysis, the results of the proposed erosion control project are expected to be minor. Although armoring the bank would decrease the amount of sediment entering the system, this quantity is small in comparison to the overall amount of sediment contributed from other sources in the river.

If the bank is cut back to form a more gentle, stable slope and subsequently revegetated, it is likely that the new vegetation will provide some bird habitat. For instance, eagles could perch in the trees once they grow to an adequate size. Vegetation selected for planting should be similar to existing vegetation in the area.

There will likely be disturbance and displacement of birds during some phases of construction. The timing of construction will be important since construction impacts to many birds can be avoided. Gulls nest in large numbers on the inside bend wetlands near the mouth of the river across from the bank and it is unknown how they might react to construction disturbance. Shorebirds use the intertidal areas in the project vicinity to forage for prey to fuel their migration to breeding grounds. Impacts could be avoided if construction was timed to avoid the weeks that they are present. Eagles often perch along the bank of the inside bend wetlands and could also be disturbed by construction activities. At low tides, gulls, eagles, shorebirds and ducks forage on the intertidal mudflats. This intertidal area is much closer to the bank than the inside bend wetlands that are only periodically covered at high tides in the spring and fall.

It is difficult to predict the degree of disturbance that may arise from construction. In the summer months, there is always a large amount of boat traffic near the mouth of the Kenai from both commercial and recreational boaters. The degree of disturbance from construction may be a factor of the type and duration of the noise produced from construction.

Seals foraging in the river mouth may be disturbed by construction activities such as excavation and placement of riprap. Since the riprap will be above the water line except for high tides, the effects after construction are likely to be minimal.

Summary. Since most bird usage occurs outside the project footprint and the project is not expected to affect the dunes and mudflats down-river, it is unlikely that birds will be negatively affected in the long-term due to the proposed erosion control project. However, short-term impacts are likely for several species due to construction activities. These effects could be minimized if construction was timed properly. Further consultation will be necessary to determine the construction timing to minimize affects to birds and marine mammals.

6.7 Economic Impacts

6.7.1 Current without-project Conditions

The bank at Kenai has experienced severe erosion over the past 48 years. The erosion rate of three feet per year as used to bracket the maximum extent of damages under the without-project condition. The bank averages a loss of approximately a half-acre per year to erosion. The average value of this lost land is approximately $42,000 per year over the past 48 years ($2 Million). An average value per acre was taken of lots near the bank that are unaffected by erosion and used to calculate the lost value caused by erosion.

Twenty-nine lots have lost some or their entire footprint to erosion. The following figure shows the lots in relation to the existing bank line.

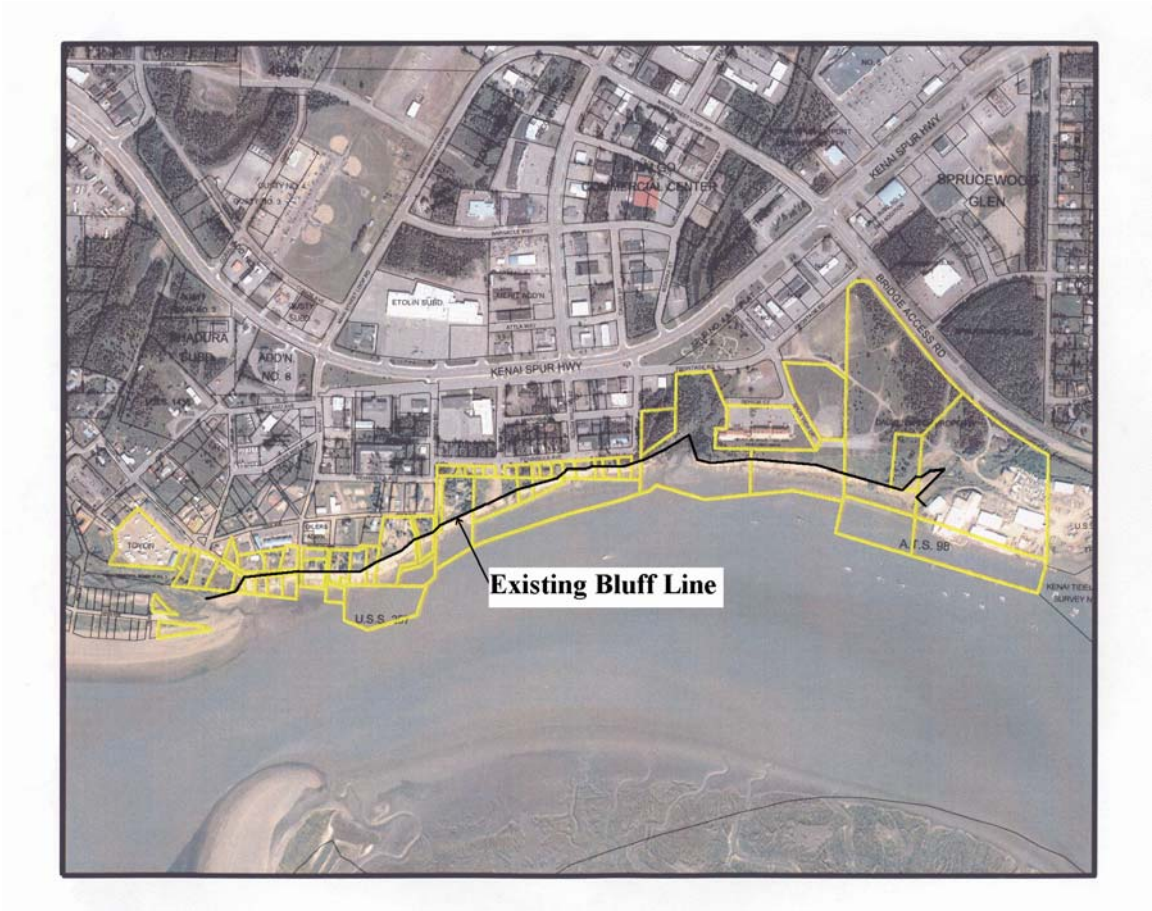

Figure 3. Kenai Bank Lots and Existing Bank Line, Used by permission of the city of Kenai.

At the current rate of erosion, the bank will continue to lose approximately a half-acre per year and land will continue to lose value. Once land becomes eroded to a certain point, the resale value decreases. It can be reasonably assumed that once the erosion reaches a certain percentage (i.e.… 50%) of the land, that even if the land is assessed at a value, no buyer is willing to take the risk of purchasing the lot. Twenty-six lots adjacent to the bluff are approaching a loss of 50% due to erosion. The existing value of these lots is $540,000 according to the city's tax assessment records. This existing value is considered a lost value since the land has close to no resale worth.

Utility locations are also a concern for the city of Kenai. A sewer line was moved away from the bank in 2002. Approximately 500 feet was moved at a cost of $135,000. It was recognized 4-5 years prior to the work that the sewer line was at risk of damage due to the bank eroding. The street (Mission Avenue) adjacent to the sewer line also had to be moved at a cost of approximately $125,000. A total of $260,000 was spent to make these relocations. Figure 4 shows the abandoned section of sewer line that had to be relocated as well as the sections of line that are closest to the bank line that will have to be relocated if the erosion problems are not addressed.

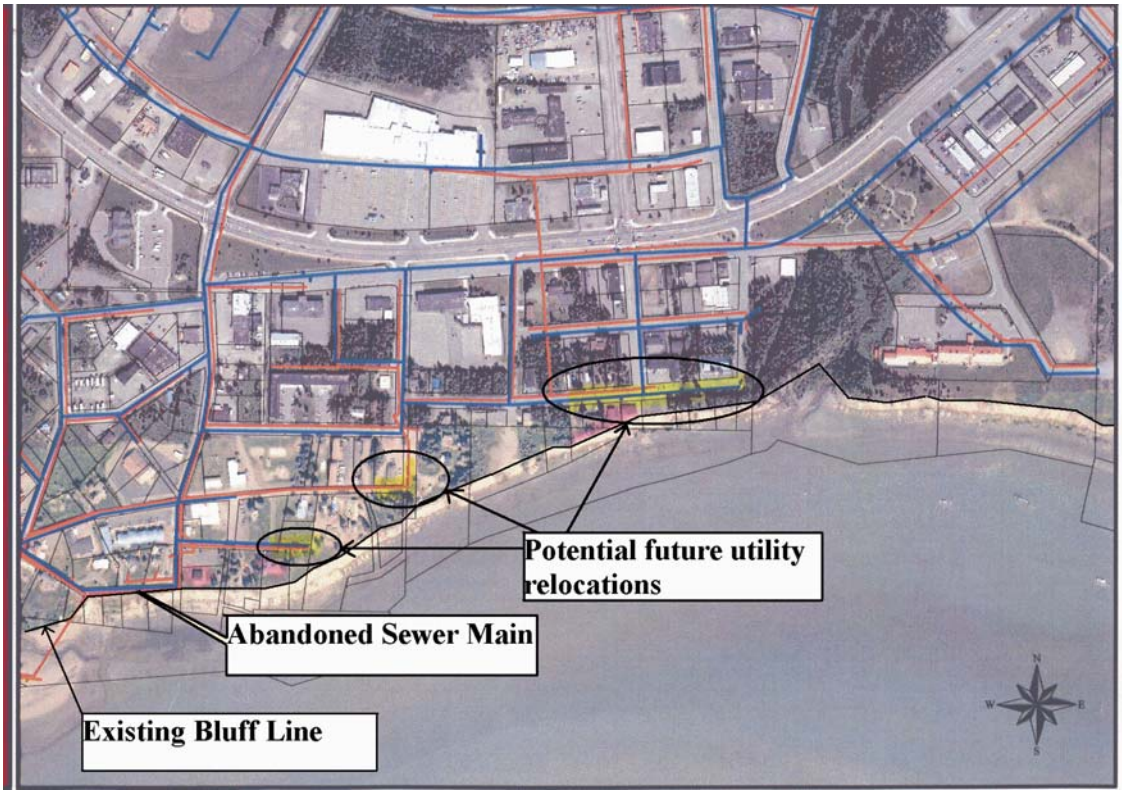

Figure 4. Kenai Utility Locations and Existing Bank Line, Used by permission of the city of Kenai.

In addition to the land eroding, the buildings that reside on those lots are at risk of bank erosion. Currently there are two buildings that are at immediate risk of falling into the river. One of the buildings has part of the foundation hanging off the edge of the bank, while the other building is on the border. In order to move the buildings out of harms way, the buildings must be pulled off their foundations, placed on beams and transported to another location. It is estimated that it would cost on average approximately $50,000 per structure to complete a move to another location. A total cost of $100,000 is anticipated for the immediate movement and relocation of these structures.

A total cost of 2.9 Million dollars has been incurred by the city over the past 48 years due to the erosion of the bank. This is an annual cost of $60,000, with the majority of the costs taking place within the last 20 years.

6.7.2 Future without-project conditions

The erosion is anticipated to continue at the current high-end estimate of 3 feet per year. This erosion will continue to lead to lost value in land at the current 2004 cost of $42,000 per year.

Utilities and street relocations will also continue. It is estimated that at least an additional 1,000 feet of road and utility lines are at risk of erosion. These roads and lines are anywhere from 40 to 100 feet from the bank. At the current pace of erosion, additional streets and sewer lines will need to be replaced within the next 20 years. It can be estimated that replacing 1,500 feet of utility lines would cost $405,000 and the roads, $375,000. A total cost of $780,000 in 2004 dollars can be estimated for the relocation of roads and lines in the next 20 years. An annual cost of $39,000 is anticipated for the movement of utility lines.

There are approximately another 20 structures that will be at risk of the erosion of the bank within the next 20 years. It is estimated that movement of these buildings will cost in the range of $50,000 to $90,000 per structure. It is assumed that at least one building will need to be relocated each year at a cost of $70,000.

The annual cost for the future without-project condition is $151,000.

6.7.3 Future with-project conditions

Though it is difficult to predict the value of land in the with-project condition, there is no doubt that the attractiveness of the land will increase dramatically resulting in additional value and added benefits to the project. The current benefits are calculated on current values of property nearby the bank.

The benefits from a project that stops the existing erosion problems are the increased value of land and resale ability and the end to the relocation of buildings and utility lines. Total annual benefit of the project is estimated to be $151,000.

7.0 CONCLUSION

7.1 Bank Stabilization Design Considerations

Further study and design of bank stabilization measures should first address groundwater seeping out the bank face. Any solution that does not address the groundwater will not solve a major source of erosion. Options that may be considered to address the groundwater include: a cutoff wall and pump system to intercept the groundwater, draw down wells to reduce the water table along the bank face, a horizontal drain system into the face of the bank to collect and divert the water, a free draining retaining system to hold back the bank material and still allow free drainage of water from the face of the bank, or creation of drainage channels to alter the groundwater gradient.

7.2 Additional Study Requirements

The findings of the Corps' 905(b) report indicate that bluff stabilization may be feasible from a technical engineering perspective. However, the amount of national economic development benefits available would not support Federal participation in a cost-shared feasibility study under existing shore protection authorities until changes in the socioeconomic or physical environment warrant a restudy of the area.

If the local interest desires additional technical assistance it can be requested through the Corps' Planning Assistance to States Program. Technical assistance can also be pursued through additional congressional legislation.

If Federal participation in a feasibility level study of bank stabilization is conducted, evaluation would be required under the Clean Water Act, National Historic Preservation Act, National Environmental Policy Act, Coastal Zone Management Act, Essential Fish habitat, Endangered Species Act, and Fish and Wildlife Coordination Act.

7.3 Conclusion

Stabilization is technically possible and could be performed in such a manner to minimize its effect on the environment. Additional studies should focus on field data collection to address erosion from groundwater seepage, identification of cultural resources, and analysis and design of bank stabilization measures.