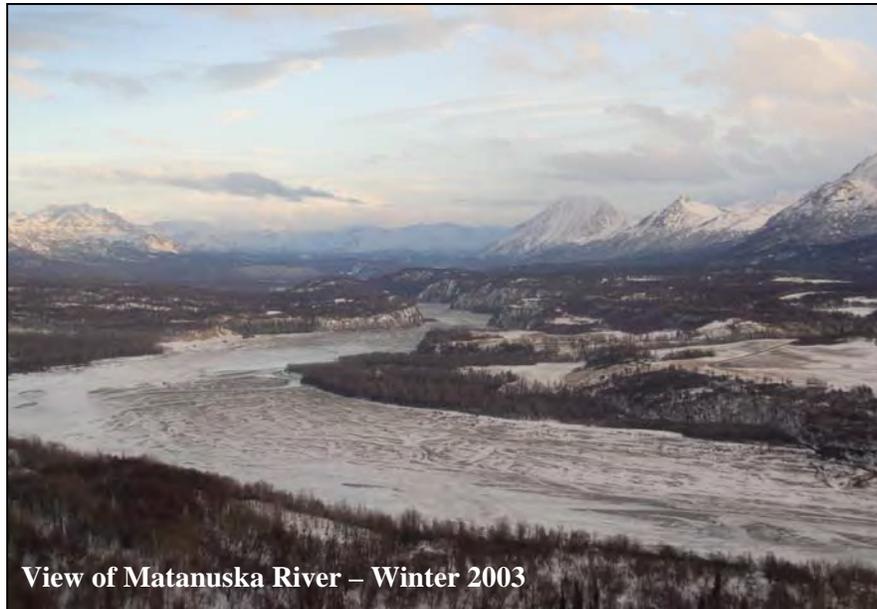


MATANUSKA RIVER EROSION ASSESSMENT

Design Study Report – Final

VOLUME I: REPORT

MWH Job No. 1851040.010107



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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
cfs	cubic feet per second
EPA	U. S. Environmental Protection Agency
GIS	Global Information System
LiDAR	Light Detection and Ranging
Mat-Su	Matanuska-Susitna
mg/L	milligrams per liter
mm	millimeter
NAAQS	National Ambient Air Quality Standards
nhc	Northwest Hydraulic Consultants
NRCS	Natural Resources Conservation Service
O&M	operation and maintenance
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WWTP	wastewater treatment plant

EXECUTIVE SUMMARY

In response to community concerns of bank erosion along the Matanuska River, Alaska, the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) was granted funding from the U.S. Congress for a study of river processes and an assessment of options to control the erosion. NRCS awarded a contract to MWH through a competitive process to conduct this study and assessment. The MWH project team included additional expertise from Northwest Hydraulics Consultants, and Northern Economics, Inc. The Study Area encompasses the river floodplain and adjacent riparian lands on both sides of the river from the Old Glenn Highway Bridge downstream approximately 6 miles, through the Bodenburg Butte area. The project team conducted the evaluation from October 2003 through November 2004.

RIVER PROCESSES

Initial steps involved reviewing the river processes and transport capabilities, using available historical information, and quantifying watershed characteristics, sediment loading, flow velocities, and geology. In addition, other background analyses including permitting processes, land use controls, and markets for gravel materials were performed. This background information was compiled in a series of technical memoranda, which are included as Volume II – Appendices. The investigation concentrated on the flow, river morphology, and sediment transport capabilities of the Matanuska River and what changes to the river may possibly be applied to affect erosion control.

Braided rivers like the Matanuska River have a complex, transient morphology characterized by flows that diverge and converge around major assemblages of emergent bars and vegetated islands. The splitting and re-joining of flow paths around channel deposits results in a very dynamic rate of channel activity relative to other types of channels.

Based on field investigation and modeling information, the MWH project team calculated the long-term average gravel replenishment rate for the Matanuska River at approximately 420,000 tons per year. Sand sized material dominates the suspended load at discharges less than 3,000 cubic feet per second (cfs), but there is a dramatic increase in the silt and clay fraction above that flow rate in conjunction with runoff from headwater glaciers. The daily discharge varies over a year from approximately 500 to 15,000 cfs, with occasional peak midsummer flows ranging from 20,000 to 30,000 cfs.

ALTERNATIVE EROSION CONTROL METHODS CONSIDERED

Using this background information, the project team and NRCS jointly developed several alternatives for affecting erosion control. Each action alternative was considered to have a reasonable likelihood to control the bank erosion to threatened areas along the riverbank. Numerous other alternatives were eliminated from further consideration based on construction feasibility, effectiveness to this size and type of river, and/or other factors. Alternatives that were considered include:

- Alternative 1 – Gravel Removal

- Alternative 2 – Bank Protection
- Alternative 3 – Non-Structural Approach
- Alternative 4 – Combined Actions
- Alternative 5 – No Action

Gravel Removal. This method has been considered in the Study Area previously, but without an in-depth examination of the changes that may occur downstream, the size of excavation needed to affect the channel morphology, relative costs, and environmental consequences. The project team used computer modeling to estimate the effect of the channel excavations on flow pattern, hydraulic characteristics and sediment transport in the Study Area under various discharge rates. Results indicate that excavation trenches can be successful in reducing the velocity of the flow along the riverbanks, if careful consideration is given to the location and design of the excavation. Since braided channels, such as the Matanuska River, are subject to rapid shifting in response to sediment erosion and deposition, the trenches would need annual maintenance and adaptive management to remain stable and effective. The gravel removal excavations can reduce bank erosion, but will not eliminate the need for bank erosion protection of key facilities, properties, and locations of direct flow impingement on the bank.

Challenges include constraints imposed by fish migration, spawning, and rearing; cold weather operations during low-flow periods; and controlling flows to optimize access and excavation techniques.

Bank Protection. Spur dikes and riprap methods have both been used previously to provide bank protection along the Matanuska River. These methods have proved to be effective in providing erosion protection along the portion of riverbank where they have been applied. The existing spur dikes were installed near the Circle View Estates subdivision in 1991 and have withstood flows up to approximately 40,000 cfs. As has been the experience with the existing spur dikes, construction logistics and maintenance are challenges in the dynamic river environment. Furthermore, these methods are limited to the specific location where they are applied. Similar to those posed by gravel removal, flows affecting banks upstream or downstream of the bank protection would remain susceptible to bank erosion, and the effectiveness of the protection may be eliminated if the channel shifts away from the protected section of bank.

Non-Structural Approach. This method involves using land use controls to remove or minimize the human occupation along threatened portions of the riverbank. Public purchase of private property and regulatory mechanisms, including zoning restrictions, are potential approaches. While this alternative does not provide any protection of the bank to erosional forces, it removes the direct effect on the inhabitants in the area. Challenges include resistance from the community and the ability to enforce zoning restrictions.

Combined Actions. This method involves a combination of gravel removal, bank stabilization, and land buyout or set asides of selected areas. This alternative addresses the likelihood that each of the other alternatives is only feasible in specific locations. For example, due to the dynamic characteristics of the Matanuska River, the gravel removal option is not likely to

provide bank protection in all areas of the river. The excavation should take place in reaches prone to high velocities and shear stresses that undermine the bank and cause erosion, such as the lower portion of the Study Area. Spur dikes and riprap would be placed where the bank erosion risk is greatest. The non-structural policies would be applied to those areas that are currently undeveloped.

No Action. This method does not provide any protection to the community or the riverbanks. The alternative was evaluated on the basis of land value loss due to annual erosion.

COMPARISON OF ALTERNATIVES

In comparing the alternatives, the feasibility and costs must be addressed. The feasibility of each alternative is tied directly to the technical difficulty in implementing the alternative, the potential environmental consequences and associated permitting constraints, and the political ramifications.

Feasibility. A summary of the feasibility of each alternative is presented in Table ES-1. The alternative with the highest technical complexity is gravel extraction. Numerous operational issues are related to a large gravel removal operation in an active floodplain. To be effective, nearly 1.8 million cubic yards of material would have to be removed during initial construction. Additionally, annual excavation on the order of 500,000 tons of material would be needed to maintain the trenches once constructed.

Table ES-1 Comparison of Feasibility of Alternatives

Alternative	Bank Protection Effectiveness	Technical Difficulty	Institutional Feasibility	Inspection And Maintenance Requirements
Gravel Removal	Moderate	High	High permitting constraints	Continuous/High
Bank Stabilization (riprap and spur dikes)	High	Moderate	Moderate permitting constraints	Yearly/Moderate
Non-Structural Approach	Low	High	Local authorization (City and Borough) needed; Highly political.	Infrequent/Low
Combined Actions	Highest	High	High permitting constraints; many stakeholders involved.	Continuous/High
No Action	Low	Low	Locally controversial	None

Fish and aquatic wildlife resources are a principal concern in comparison of alternatives. However, baseline data on the fish resources of the Matanuska River are sparse. Sport, commercial, and subsistence fisheries on the Matanuska River are limited compared to other Southcentral Alaska streams. Permit constraints are likely to include limiting operations in the floodplain to periods of low flow and minimal fish migration. This constraint adds another level of difficulty to gravel extraction operations, as well as some constraints to construction of bank stabilization structures.

Both the Non-Structural and No Action Alternatives have potential political ramifications. The Non-Structural Alternative is likely to be difficult to implement in those areas with current

development, due to resistance from the community to be bought out or relocated. The No Action Alternative does not result in protection to the community or the riverbanks. This alternative, while simple and relatively easy to implement on a technical standpoint, would not address the public concern that resulted in this study.

Cost. In comparing the cost of each alternative, assumptions were established to provide some basis of comparison. For gravel removal and construction of bank stabilization structures, cost estimates included assumptions on the type of equipment, hours of use, size and type of material, and value of the gravel. The Non-Structural and No Action alternatives make assumptions on the value of developed and undeveloped land, and the amount of land that would be lost per year.

The costs for implementing the Gravel Removal, Bank Stabilization, or the Combined Action Alternatives are relatively high (Table ES-2). This relates directly to the construction required to implement each alternative. The Non-Structural Approach Alternative has a relatively low cost, both initially and over the long-term (50 years). The Non-Structural approach, however, may have high political ramifications, as may the No Action Alternative, which has the lowest cost of all the alternatives.

Table ES-2 Comparison of Costs of Alternatives

Alternative	Initial Capital Cost (\$/ft)	Equivalent Annual Cost (\$/ft/yr)¹
1. Gravel Removal ²	661	31
2. Bank Stabilization	1,236 (major riprap) 706 (spur dikes)	83 47
3. Non-structural Approach ³	248 (developed land) 135 (undeveloped land)	17 9
4. Combined Actions	804	74
5. No Action	None	4 2

Key:

1 – Based on a current value of 4 percent over a 50-year period.

2 – Annual cost is offset by revenue from sale of gravel.

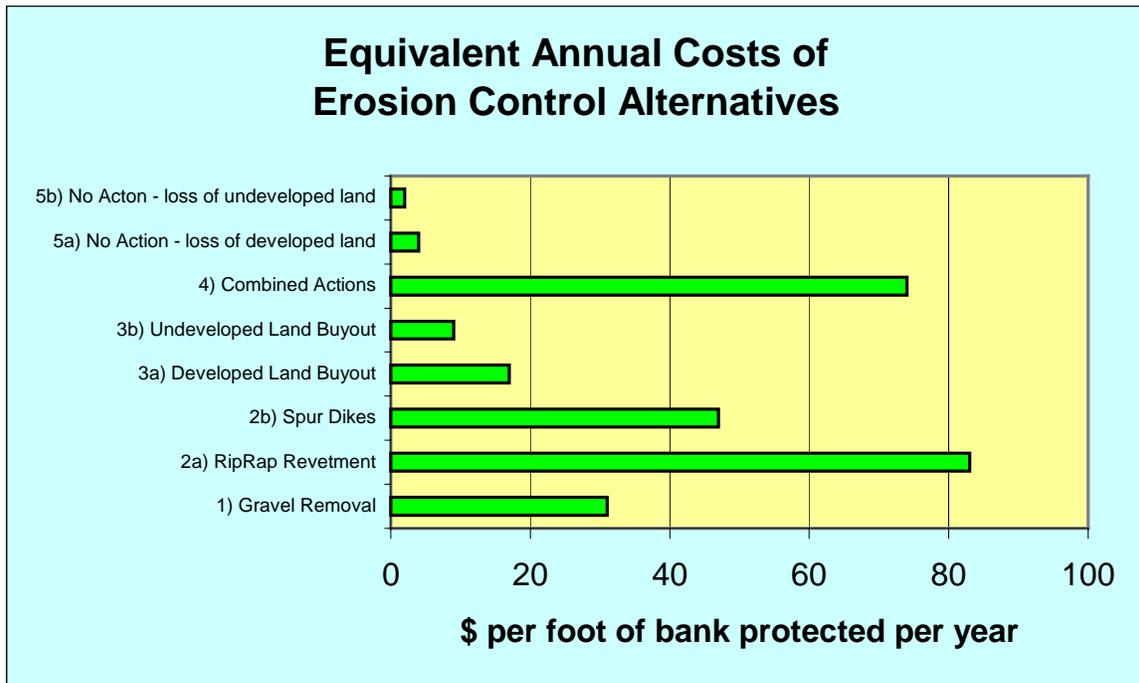
3 – Assumes that this approach is applied to the entire Study Area, costs will vary for specific locations.

\$/ft – dollars per foot

yr – year

Relative equivalent annual costs of the five erosion control alternatives are illustrated on Figure ES-1. The figure illustrates that the cost of any action alternative exceeds the estimated costs associated with allowing the continued loss of property due to erosion. Buyout of property has the lowest cost of any of the action alternatives, with higher costs associated with gravel removal and structural improvements.

Figure ES-1 Equivalent Annual Costs of Erosion Control Alternatives



IMPLEMENTATION OF EROSION CONTROL MEASURES

Each of the alternatives considered in this evaluation has difficult issues associated with it. Costs for reducing erosion potential are considerable, and require appraisal of the benefits to the landowners or public at-large compared to potential commitment of funds.

The decision to move forward with an action plan requires the identification of an entity to lead the effort. The Matanuska Susitna Borough has implemented improvements in the past, but has not been able to muster public support for continual ownership and maintenance of a large-scale program. The Borough does have power to establish a service for implementation of capital improvements and maintenance costs associated with erosion protection. The State of Alaska would have significant interest as the land manager of the riverbed, owner of materials, and permitting agency. The Federal Government has no direct interest or mandate to offer any of the alternatives, although payback could be a source for funding through political channels. Private interests do not look like a solution due to the expense of infrastructure development required to achieve payback. Close consideration and public input is needed before a recommendation for action is developed.

1.0 INTRODUCTION

This section presents the need for action, land use, an overview of the project, a summary of background information and data collection, and closes with an introduction to the preliminary design concept phase of the work.

1.1 PURPOSE AND NEED

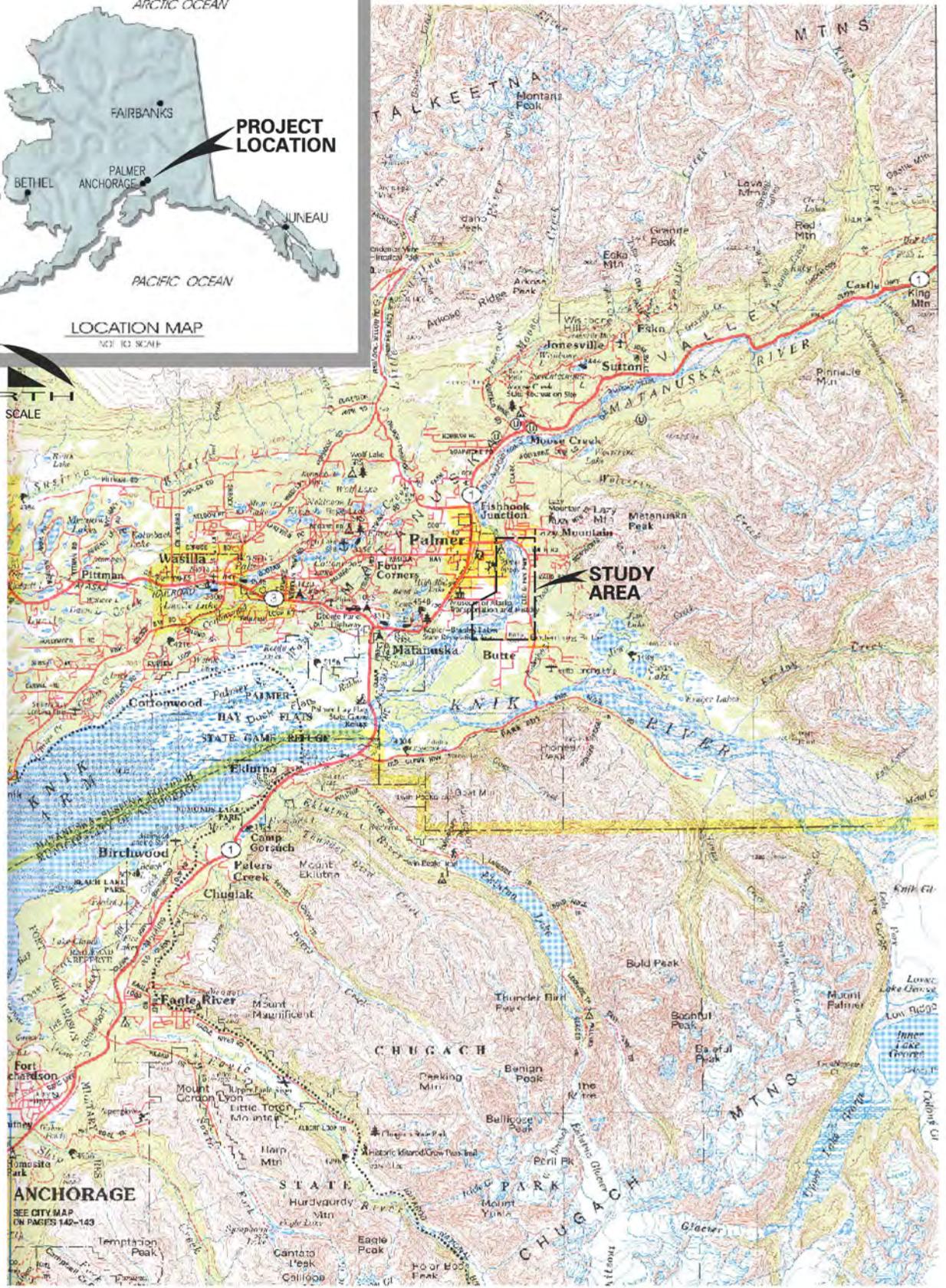
Since establishment of the Matanuska Colony in the 1930s, residents of the Matanuska Valley have enjoyed a rural lifestyle under the grandeur of Pioneer Peak, Lazy Mountain, and other peaks of the Talkeetna and Chugach Ranges (Figure 1-1). Within this valley is the magnificent Matanuska River, with typical midsummer flows reaching 30,000 cubic feet per second (cfs) or more, and carrying a tremendous burden of sediment from the Matanuska Glacier and the upper valley. As the river approaches Palmer and Bodenbug Butte, the stream gradient lessens and sediment is deposited, sometimes accumulating so rapidly that the water is abruptly forced to seek a new watercourse.

The resulting braided channel is characterized by a high width to depth ratio, and a propensity to migrate horizontally in relatively short time periods, eroding the toe of the banks on the margins of the floodplain. As the toe of the banks is attacked by the river, sloughing occurs and property at the terrace level is sacrificed to the river bottomlands, which are under ownership of the State of Alaska. Structures are also at risk, as sloughing of the banks undermines foundations of buildings and utilities. Over the years, structures and acres of farmlands have been swallowed by high water eroding the streambank. This ongoing erosion and threat to structures and land necessitated a closer look at erosion control options and the potential for success, as described in detail in this report.

1.2 LAND USE

Land use varies on the east side of the Matanuska River near Palmer. The Old Glenn Highway parallels the river along the eastern side, from the bridge to Bodenbug Butte. Near the Old Glenn Highway, the area is primarily residential, with some small businesses and agricultural use. The area downriver remains primarily residential, with some farming. A power transmission line owned by Matanuska Electric Association extends across the river from the Circle View Estates area towards the City of Palmer.

On the western side of the Matanuska River lies the City of Palmer and the Palmer Airport. The airport is in relatively close proximity to the Matanuska River, although it does not appear to be in imminent danger from erosion. Farther downriver, but still within the City of Palmer, is the Palmer Wastewater Treatment Plant (WWTP). This treatment plant was threatened by erosion prior to the mid- to late 1980s, when the active channel was located on the west side of the river. With the exception of the WWTP and a small gravel pit, land use along this area of the bank is typified by residential use.



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FIGURE 1-1
 USNRC
 MATANUSKA RIVER EROSION ASSESSMENT – DESIGN STUDY REPORT
LOCATION AND VICINITY MAP

1.3 PROJECT OVERVIEW

MWH was contracted by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) to evaluate erosion problems along the Matanuska River near Palmer, Alaska. The Study Area extends from the Old Glenn Highway Bridge to the tidal influence zone near the confluence with the Knik River (Figure 1-2). MWH was tasked with assessing the erosion along the Study Area and evaluating potential long-term solutions to minimize future erosion problems. Northwest Hydraulics Consultants (**nhc**) and Northern Economics were subcontracted by MWH as part of the team for this study. The work was divided into two phases in order to ensure a scientific approach to the problem of erosion control, as discussed below.

1.3.1 Phase 1 – Background Information

The first phase of work primarily involved data collection and background information. Numerous documents exist that examine the Matanuska River. The majority of available literature dates back to the early 1980s, with some documents dated as early as 1972 (Appendix A). Existing literature encompassed newspaper articles to reports on the design and installation of the existing bank protection (spur dikes). These reports included a variety of information on the history of the river and areas threatened by erosion.

1.3.1.1 Field Information

Field investigation included several steps: field reconnaissance, survey data, and sediment data gathering. First, MWH, **nhc**, and NRCS personnel conducted the field reconnaissance as the initial step in understanding the river hydraulics (Appendix B). Second, a topographical survey of the Matanuska River was conducted along the Study Area using Light Detection And Ranging (LiDAR), combined with field surveying techniques. The survey data included detailed mapping and profiles of the channel, which were used as base profile information for later modeling efforts and added to the understanding of channel morphology.

Lastly, the field investigation included sampling of the bedload sediment (Appendix C) and observations on surface material. This investigation was conducted to determine the type of material present in the channel, the propensity for material transport (based on its size), and to gain a better understanding of the river hydraulics.

1.3.1.2 Background Information

The next piece of background information collected was hydrologic data. MWH gathered information and evaluated the watershed characteristics, streamflow patterns, and precipitation data, among other information (Appendix D). This data shows how the watershed and river respond to climatic change, especially temperature and precipitation.

Information from the existing literature, field investigations, hydrologic analysis, and the survey and LiDAR data were gathered together in order to conduct a channel hydraulic analysis. The analysis was conducted using the HEC-RAS 3.1 one-dimensional flow model, developed by the Hydrological Engineering Center, U.S. Army Corps of Engineers (Appendix E). This evaluation was used to develop boundary conditions for the two-dimensional model in Phase 2.

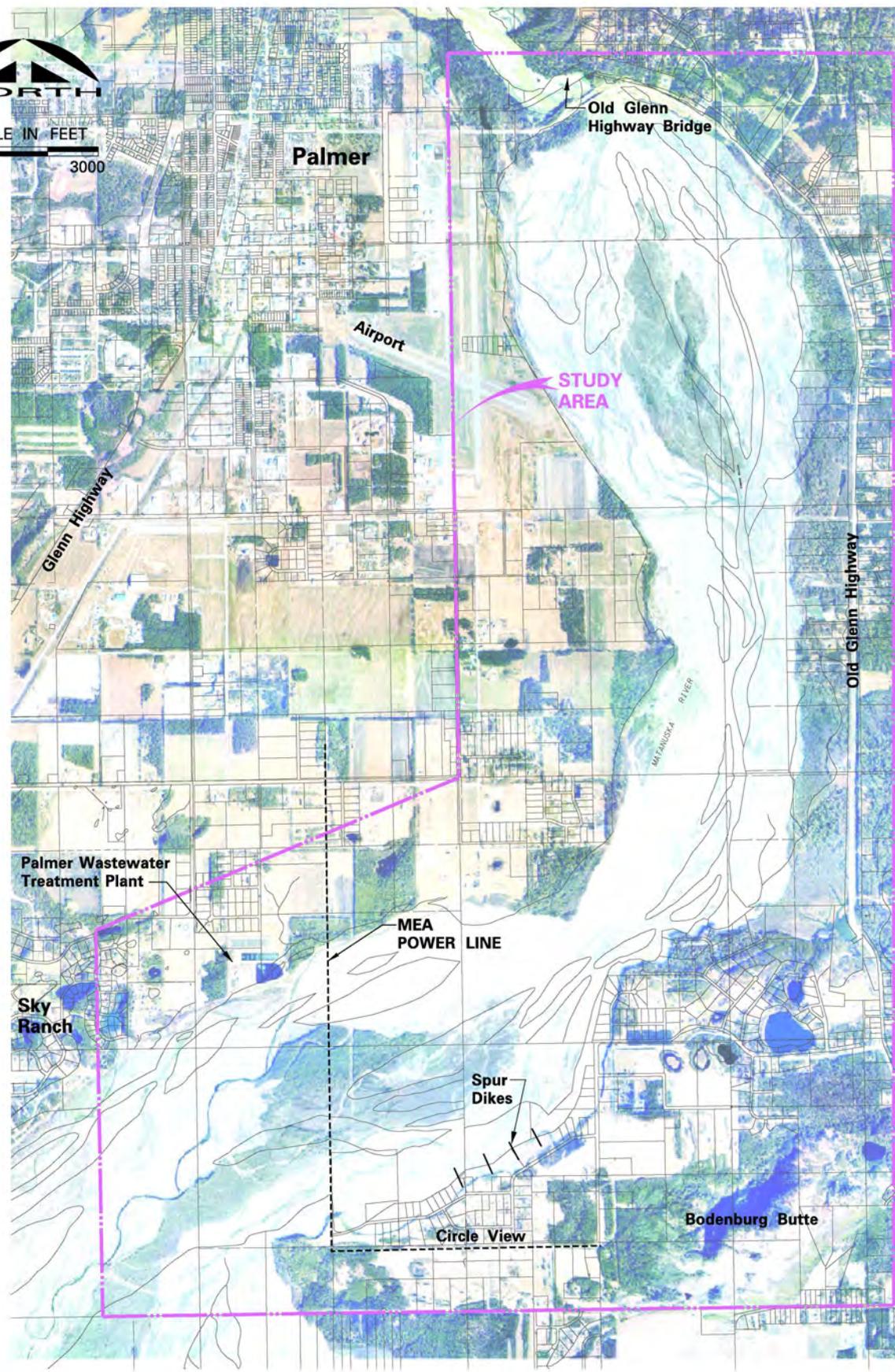


FIGURE 1-2
USNRC
MATANUSKA RIVER EROSION ASSESSMENT – DESIGN STUDY REPORT
MATANUSKA RIVER STUDY AREA



Channel stability analysis was then conducted by **nhc** using the above information and additional site inspections (Appendix F). During the summer of 2004, the Matanuska River reached a flow of approximately 40,000 cfs, which resulted in severe bank erosion within the Study Area in the days and weeks following the peak discharge. Observations of the river during this time period added to the understanding of the river flows and erosion patterns for use in modeling potential future river behavior.

Permitting, regulatory, and environmental constraints were also evaluated during Phase 1 to establish potential data gaps. This provided an outline of the potential roadblocks to management activities within the Matanuska River, including the primary agencies that would have involvement in any management activity within the river (Appendix G).

1.3.2 Phase 2 – Preliminary Design Concepts

MWH and **nhc** evaluated the information gathered in Phase 1 for feasibility and the potential for successful erosion control on the Matanuska River in the Study Area. There are numerous elements of the Matanuska River that will define the requirements for an effective erosion control scheme. The key features of the Matanuska River are summarized below.

River Characteristics. The Matanuska River is typical of a glacial fed river. There are wide, highly braided reaches with vegetated islands separated by narrower, more stable zones. The multiple channels in the wide braided reaches will continue to sweep across and fill (or partly fill) the braided surface. The narrower sections are controlled by the presence of less erodable materials in the riverbank. Braided streams are characterized by a high sediment load carried during certain times of the year (associated with high flow levels), and limited sediment transport during low flow periods. Total sediment load carried by the river is comprised of suspended sediment and bed loads.



Bank erosion near a powerline.

Suspended Sediment Load. Suspended sediment load is the material in the river flow that will not settle out in the Study Area. The suspended sediment is broken into suspended sand load and total annual suspended load. Average annual suspended sand load is estimated at 1.63 million tons per year (**nhc**, June 2004). The total suspended load is estimated to be 6.65 million tons annually. Therefore, silt-clay material comprises nearly 80 percent of the total suspended material, with sand comprising approximately 20 percent.



Bed load material

high. The estimated annual average bed load amounts to 0.5 million tons of material per year. This material ranges in size from fine sand to coarse gravel. Based on a review of the channel profile and available bed material samples, it is believed the Study Area can be nominally considered a “transport reach,” with increasing deposition as the river flattens and approaches the tidally influenced zone near the river mouth.

Channel Sediments. The channel deposits contain an appreciable amount of sand, up to approximately 20 percent in some samples. This implies some of the suspended sand load could be deposited in excavations, if gravel removal is used for erosion control.

These factors were taken into consideration in development of the alternatives presented in Section 3. They were used to determine which of the considered alternatives should be excluded from further analysis.

2.0 THE AFFECTED ENVIRONMENT

This section describes the physical, biological, and human environment of the Study Area. The information in the sediment transport subsection of the physical environment is particularly important for the formulation of project design concepts and alternatives.

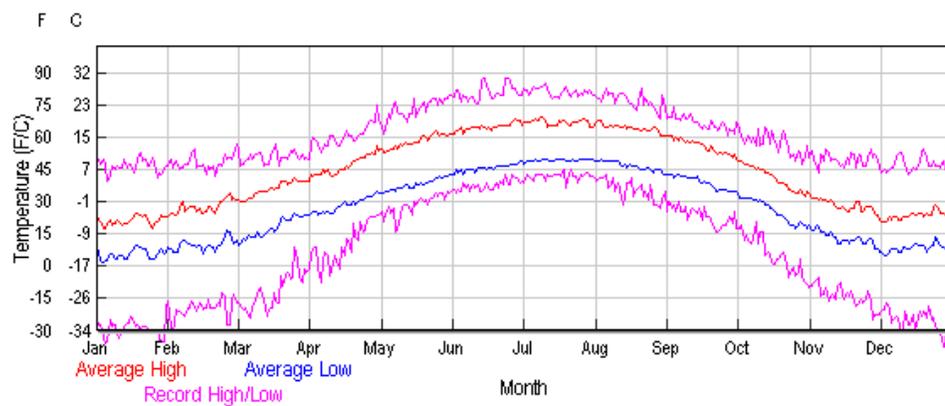
2.1 PHYSICAL ENVIRONMENT

This subsection describes the climate, air quality, physical features, hydrology, and sediment transport. Information on geology and soils is included in the physical features subsection. Sediment load is described in the subsection on sediment transport.

2.1.1 Climate

The Study Area is within the Matanuska-Susitna (Mat-Su) Borough, just outside the city limits of the City of Palmer, Alaska. The number of daylight hours in the Palmer area ranges from about 5 to 19 per day. The climate is considered “mild coastal,” with temperatures ranging from 6 to 67 degrees Fahrenheit (°F). The average temperature in December and January is 13°F, with the average temperature in July and August at 58°F (Mat-Su, 2003). A graph of the average temperatures (www.weatherunderground.com) for the area is shown on Figure 2-1.

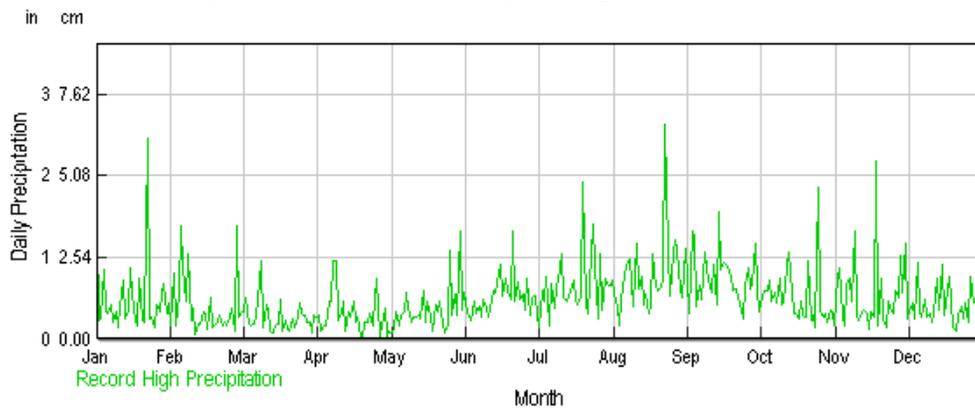
Figure 2-1 Average Temperatures and Records for Palmer



The Alaska Range and the Talkeetna Mountains to the north and Chugach Mountains to the south protect the Matanuska Valley from the extreme winter cold of the Alaska Interior. Thawing temperatures can occur in midwinter under the occasional invasion of warm maritime air from the south and southwest. Normal winter patterns result in little snow and primarily clear skies.

The area averages 16.5 inches of precipitation per year, with the highest average monthly rainfall at 2.65 inches and the highest average monthly snowfall at 9.3 inches. A graph illustrating the distribution of precipitation producing events is shown on Figure 2-2.

Figure 2-2 Record Daily Precipitation for Palmer



2.1.2 Air Quality

In compliance with the 1970 Clean Air Act and the 1977 and 1990 Amendments, the U.S. Environmental Protection Agency (EPA) promulgated the National Ambient Air Quality Standards (NAAQS) and regulations. NAAQS have been issued for six “criteria” pollutants: sulfur oxides, carbon monoxide, ozone, nitrogen oxides, lead, and inhalable particulate matter. Alaska has adopted the federal NAAQS.

The Study Area is in the Cook Inlet Intrastate Air Quality Control Region, which is designated as unclassified for the six criteria pollutants. The area is also within a Class II airshed designated by the Alaska Department of Environmental Conservation under 18 Alaska Administrative Code 50.015. Class II airsheds are generally free of pollution and may accommodate some industrial activity.

Although some industrial activity exists, air quality in the Study Area is considered good. Localized emissions of particulate matter, carbon monoxide, sulfur oxides, nitrogen oxides, and hydrocarbons are possible. EPA data for the Mat-Su Borough, where the Study Area is located, indicated that 152,902 total tons of emissions were released into the air during 1999. Table 2-1 presents the breakdown of emission types.

Table 2-1 Air Emissions in the Mat-Su Borough

Emission Type	Tons (in 1999)
Particulate matter <2.5 micrometers in size	10,013
Particulate matter <10 micrometers in size (inclusive)	23,094
Carbon monoxide	116,915
Volatile organic compounds (hydrocarbons)	7, 129
Others (Nitrogen oxides, sulfur dioxide, ammonia)	5,764

Key:

< – less than

The Mat-Su Borough is growing in population and economy. An increase in the amount of emissions is expected with growth; however, it has not been quantified for the area. In addition,

the area is subject to smoke from wildfires and dust particles entrained in the air from the floodplain.

2.1.3 Physical Features

Physical features are presented below as topographic or geologic.

2.1.3.1 Topography

The Matanuska River valley lies between the Talkeetna Mountain Range to the north, and the Chugach Mountains, to the south and east. Portions of the upper reaches of both the Talkeetna and Chugach Mountain tributaries to the Matanuska River are covered with glaciers, so stream tributaries to the Matanuska River may be glacial or non-glacial in origin (MWH, 2004d). The primary glacier in the watershed is the Matanuska Glacier, which begins above Norway Peak and extends to Lion Head. The average elevation of the drainage is 4,000 feet, and it encompasses over 2,000 square miles.



The lower portion of the Matanuska River, starting near the Old Glenn Highway Bridge in Palmer, is typified by a broad, braided floodplain. Bedrock outcroppings constrain the river at several locations, with the channel being influenced by several active fault lines. The sandy gravel channel banks allow for significant lateral migration of the river bottom across the floodplain. In some areas, the floodplain is up to 1-mile wide. As shown in the photo to the right, the channel meanders across the floodplain, with possible changes in the main channel location based on snowmelt and storm events.

2.1.3.2 Geology

The lower Matanuska Valley lies in a structural trough that trends northeast-southwest. The northwest border of the trough is defined by the Castle Mountain Fault, along which older rocks of the Talkeetna Mountains (mostly Cretaceous and tertiary-age granitic intrusives and sedimentary rocks) (LaSage, 1992) have been thrown up against younger rocks on the valley floor (Barnes, 1962). The Chugach Mountains are composed of Cretaceous-Jurassic metasedimentary and metaigneous rocks. The Talkeetna Mountains are composed of granitic and gneissic rocks (MWH, 2004d).

Faulting occurs throughout the region. Major faults include the Castle Mountain Fault in the Talkeetna Mountains to the north, and the Border Ranges fault in the Chugach Mountains to the south (ADNR, 1998). Folding and faulting has deformed the rocks of the valley floor. The

March 27, 1964, earthquake caused regional subsidence of about 2 feet in the lower third of the valley (Plafker, 1969).

Younger deposits in the basin are the result of the last major ice expansion. Glacier drift, including till, was deposited over scoured bedrock and, as the ice receded, ice-contact deposits such as kames, eskers, and crevasse fills produced uneven terrain. Winds in the lower valley resulted in aeolian deposits northwest of the mouth of the river (Trainer, 1961).

The Matanuska River flows through a variety of deposits. Glacial outwash deposits are common and consist of primarily stratified sediments, chiefly sand and gravel with some silt and clay intermixed. Outwash is characteristically removed or washed out material from a glacier by meltwater streams and deposited in front of or beyond the terminal moraine or the margin of the active glacier. Materials generally grade to a finer texture with increasing distance from a glacial source (ADNR, 1998).

Other deposits present in the Matanuska Valley include moraines, glacial drift (material deposited by the glacial ice), floodplains, terraces, and alluvial fans. Glacial drift is an unsorted and unstratified mixture of clay, sand, gravel, and boulders. Floodplain, terrace, and alluvial fan deposits are typically well stratified silt, sand, and gravel (ADNR, 1998).

2.1.3.3 Soil Classification

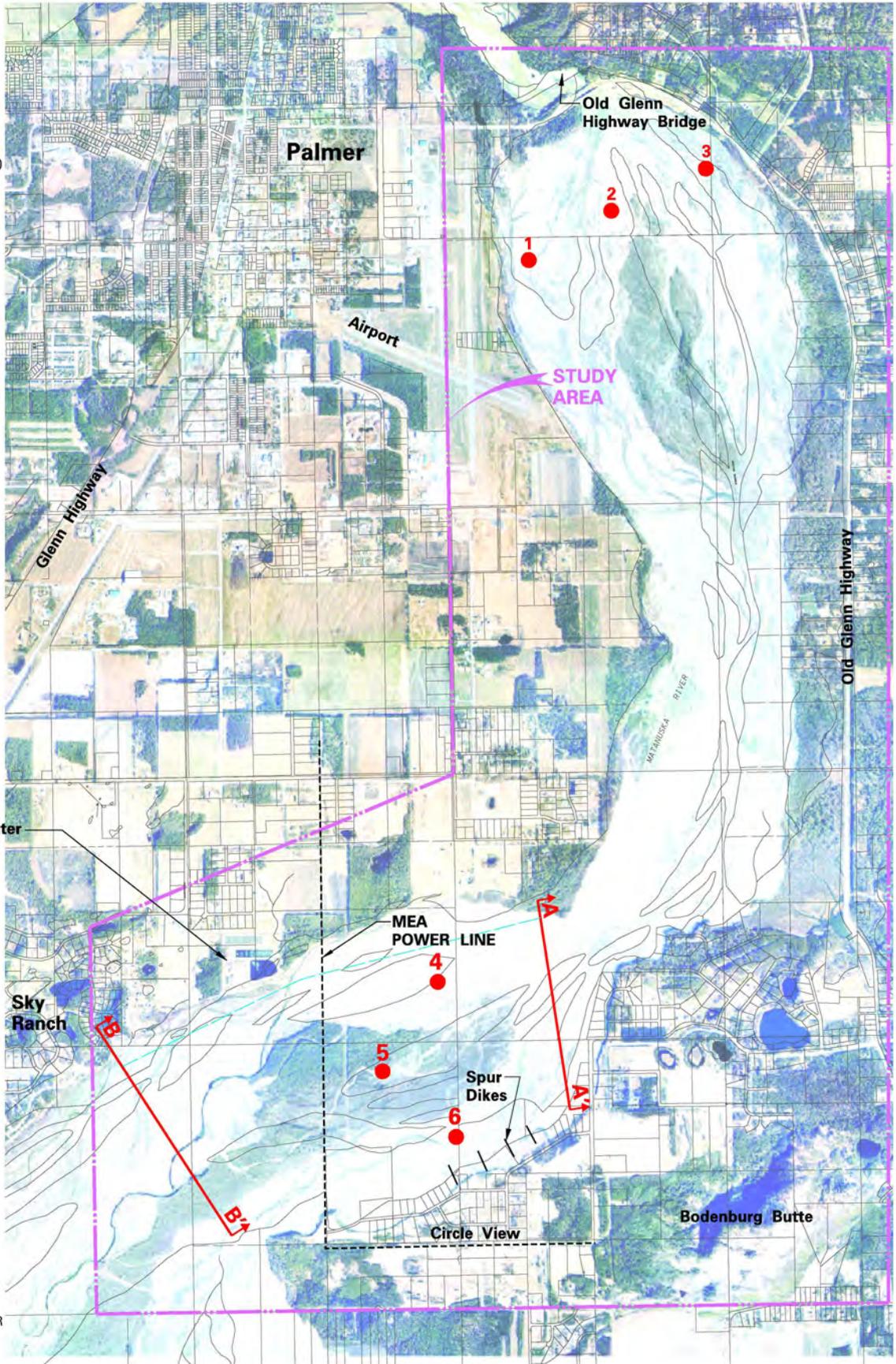
A sediment investigation was conducted in December 2003 to characterize the material present in the Matanuska River channel bottom (MWH, 2004b). Samples were collected at two cross-sections within the Study Area (Figure 2-3) and sieve analyses conducted. Sieve results indicated that the subsurface material is relatively uniform at both cross-section locations. An average D_{90} value of 37.13 millimeters (mm) and a D_{50} of 11.71 mm was identified along the channel. The D_{90} value represents the grain size where 90 percent of the sample (by weight) passes the given size class. Investigation results also indicated that cobbles are only apparent along the active channel. Coarse gravel was the predominant surface material identified. Sediments that are cobble and gravel size are primarily quartz and granite.

2.1.4 Hydrology

Hydrology is presented from both a water quantity and quality perspective.

2.1.4.1 Water Resources – Quantity

USGS Stream Gage #15284000 is located on the Matanuska River at the Old Glenn Highway Bridge in Palmer. Daily mean average flows are available from the gauge for water years 1950 through 1972, 1986, 1992, and 2002, with partial records for 1973 and 2000. Figure 2-4 shows the daily discharge from 28 years of records, compared to daily discharge record from 2004. Discharge typically varies seasonally from approximately 500 to 15,000 cfs during higher flows. A peak flow of 82,100 cfs occurred in 1971, but this reading was affected by the failure of a lake embankment on Granite Creek, a tributary of the Matanuska River (ADNR, 1998). The historic peak discharge, for the USGS record through 2001, actually occurred in 1995, with a discharge



Palmer Wastewater Treatment Plant

Sky Ranch

MEA POWER LINE

Spur Dikes

Circle View

Bodenburg Butte

LEGEND

● SEDIMENT SAMPLE LOCATIONS
MWH DEC. 2003

↗ **A** Source:
DOWL ENGINEERS
DECEMBER 2003
MATANUSKA RIVER
CROSS-SECTIONS

FILE: \\usancis-files\server\cod\proj\USNRC\MAT-SU\Design\StudyReport1\Final\Fig2-3.dgn

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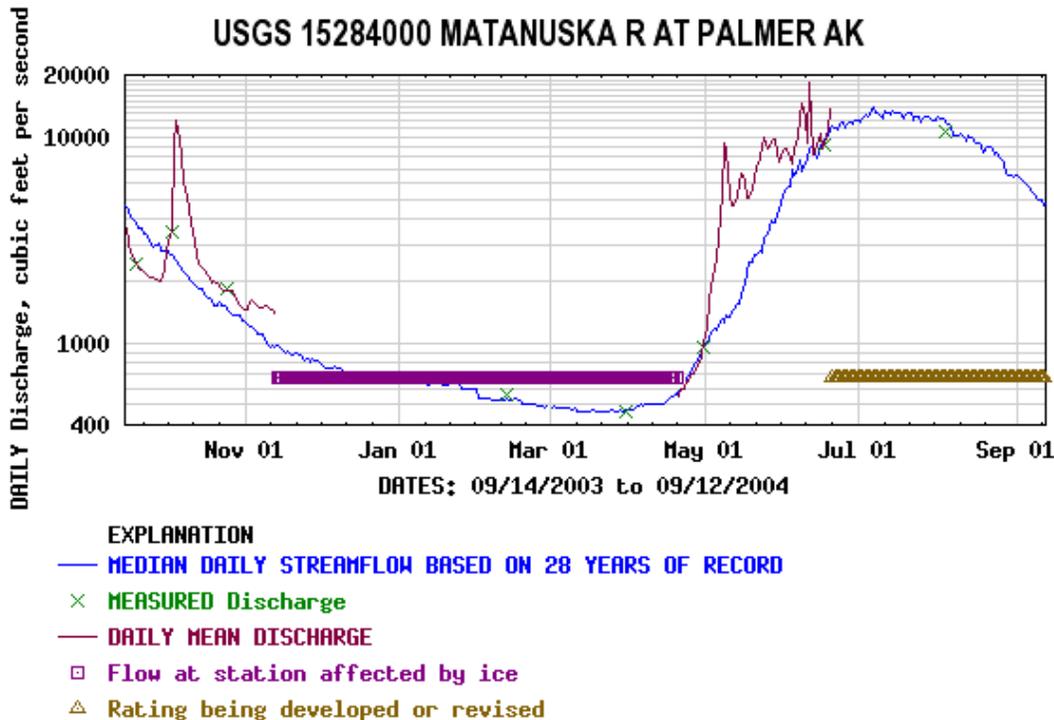


FIGURE 2-3

USNRC
MATANUSKA RIVER EROSION ASSESSMENT – DESIGN STUDY REPORT
**SEDIMENT SAMPLE AND
CROSS-SECTION LOCATIONS**

of approximately 46,000 cfs. A higher historical peak discharge may have taken place during the July 2004; however, this data is provisional and not included in Figure 2-4.

Figure 2-4 Daily Discharge in the Matanuska River at Palmer



The quantity of water in the Matanuska River is highly dependent on both precipitation and the melt rate of the upland glaciers. Streamflow shows a strong seasonal variation, with 70 percent of the annual flow occurring from June through August (MWH, 2004d). Mean monthly flows are lowest during March and April, with discharges of approximately 450 to 500 cfs in a typical year. This coincides with the lowest levels of precipitation during the year. During this period, the Matanuska River is closest to its annual baseflow. Groundwater discharge becomes the dominant water supply to the river during this period (ADNR, 1998).

Groundwater flow in the Palmer area trends from the south to the southwest (Jokela et al., 1990; TERRASAT, 1998). Aerial photography interpretation and well log data also indicate that the reach immediately downstream from the Old Glenn Highway Bridge is a losing reach, with water leaving the river along that reach and contributing to the ground water recharge. Along the lower portion of the Study Area, groundwater from the surrounding area adds to the river discharge.

2.1.4.2 Water Resources – Quality

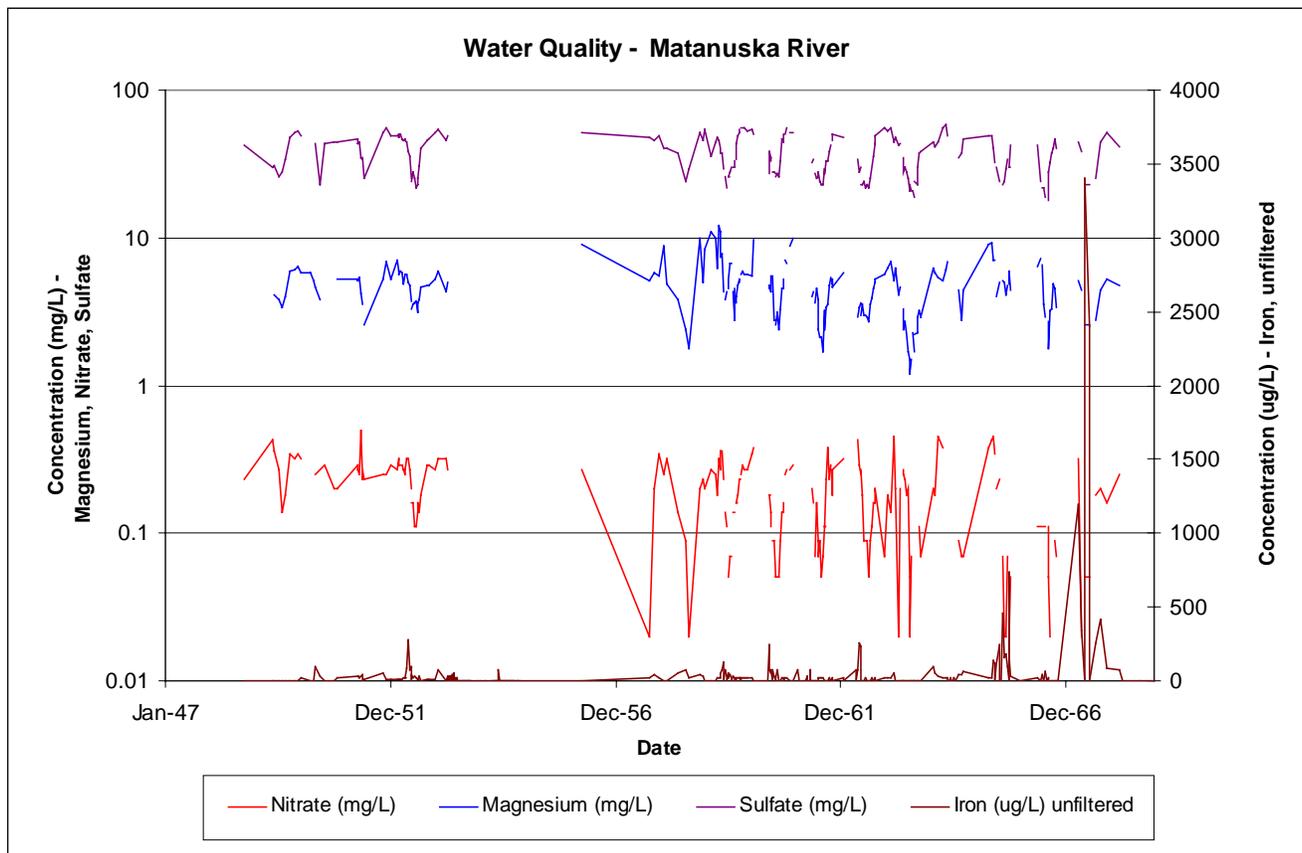
USGS records at the Old Glenn Highway Bridge gauging station provide the majority of the available water quality data for the Matanuska River in the Study Area. The data gathered at this station includes 548 data points for parameter groups such as: basic stream flow, nutrients, major

and minor inorganic constituents, and physical and sediment properties. Most of these records are inadequate for use in evaluating the water quality of the watershed. Water quality parameters with importance in watershed evaluation, in addition to apparently adequate records, included discharge, specific conductance, nitrate, magnesium, sulfate, iron, and suspended sediment. Most of these records span the years from 1948 to 1954, 1957 to 1968, and then only periodic measurements through 2003. Based on the other parameters with an adequate record, a picture of the water quality variability between 1947 and 1968 can be seen. Data after 1968 is too infrequent to make comparisons.

Likely the most significant water quality parameter for the Matanuska River is the high level of suspended sediment load. Runoff from the Matanuska Glacier drives the transport of sediment derived from the glacier and tributaries throughout the Matanuska Valley.

As shown on Figure 2-5, nitrate, magnesium, and sulfate had adequate records and were used in evaluating the Matanuska River water quality, but these provide only limited information. Magnesium values ranged from 1.2 to 12 milligrams per liter (mg/L), and sulfate ranged from 18 to 58 mg/L. The range of values is higher than expected, considering that glaciers and snowmelt waters do not contribute minerals to the river water. Nitrate values ranged from 0 to 0.56 mg/L, which is relatively low, but also expected since the watershed is 80 percent undeveloped and well vegetated. Iron concentrations increase in the late 1960s; however, the record is inadequate to determine if this is a long-term change.

Figure 2-5 Matanuska River Water Quality



Changes in the water quality of the Matanuska River are primarily associated with variations in the quality of the runoff from changes in the intensity, location, and type of uses in the watershed, not from the snowmelt or glacial contributions. An increase in human activities in the watershed can have an effect on the water quality and potential for contaminants. Currently, approximately 2 percent of the watershed is used agriculturally and 8 percent is considered roaded and urban, but this does not consider location.

2.1.5 Sediment Transport

The Matanuska Glacier is a principal source of sediment for the Matanuska River. Sediment discharge from the glacier (discharge from meltwater pools) is not coincident with peak discharge. Rather, it appears that the release of coarse sediment from the glacier is more dependent on drainage networks within the glacier ice than on peak discharges (Pearce et al., 2003). Steep, non-glacial tributaries downstream of the Matanuska Glacier, particularly those from the Talkeetna Mountains on the north side of the valley, are thought to contribute significantly more bedload to the river than the Matanuska Glacier. The Matanuska Glacier is likely to contribute more of the suspended load.

2.1.5.1 Sediment Load and Transport

A total sediment budget is the volume of sediment moving past several locations, or gauging stations, along the mainstem of a river system. The total sediment volume is generally made up of suspended load and bedload. The suspended load consists of silt, clay, and sand and does not deposit on the bed of the river. Bedload consists of a portion of the sand load, plus the gravel load, that moves along the bed of the river. It should be noted that the sand load moves both as suspended load and bed load, but predominantly moves as suspended load. In gravel rivers, sediment measurements represent the suspended load, and researchers estimate the gravel (bedload) to range from 0 to 20 percent – depending on river characteristics.

The suspended sediment budget for the Matanuska River at Palmer was originally estimated by **nhc** (January 2004) as 5 million tons per year, with a bedload of 400,000 tons per year based on watershed characteristics. Subsequent technical analysis by **nhc** (June 2004) revised these estimates upwards to 6,650,000 tons per year for total suspended load and 420,000 to 685,000 tons per year for bed load. Annual total sediment load (including wash load) greater than 11,000,000 tons 10 percent of the time, greater than 7,130,000 tons 50 percent of the time, and greater than 4,300,000 tons 90 percent of the time. For the sediment budget analysis, the original 5,000,000 and 400,000 tons per year were used for suspended sediment and bed load, respectively.

The sand load, defined as material coarser than 0.063 millimeters (mm), was estimated to consist of 20 percent of the suspended load. The remaining material comprising the suspended load consisted of silt and clay finer than 0.063 mm. The proportion of sand-sized material dominates at low discharges, below 3,000 cfs, but the silt and clay fraction increases dramatically above this discharge value.

The bed load material was based on the available U.S. Geological Survey (USGS) data. Samples collected at discharges less than 1,500 cfs consisted primarily of sand, with a median grain size

of less than 1 mm. Grain size increased with discharge, to a maximum grain size of 16 mm. Sediment transport volumes were then calculated based on water years with complete data sets, by correlating the rating curves to the flow record using a flow-bed load rating curve equation (nhc, 2004b). The average annual total bed load of approximately 420,000 tons is based on 27 years of data. This represents about 6.3 percent of the total annual suspended load and 26 percent of the suspended sand load.

Using bed-load equations and morphological methods, nhc estimated the annual loads presented in Table 2-2.

Table 2-2 Suspended Loads in the Matanuska River at Palmer

Load Type	Amount (tons/year)
Total suspended load	6,650,000
Suspended sand load	1,630,000
Gravel bed load (direct measurement)	420,000
Gravel bed load (stream power equation)	685,000
Gravel bed load (morphologic method)	426,000

The variability of annual bedload is defined by correlation coefficients of the sediment rating curves and standard deviations in the long-term (27-year) sediment transport statistics.

The sediment rating curves are:

- Suspended load (including wash load) – Correlation coefficient (r^2) of 0.95
- Suspended bed material (>0.063 mm) load – Correlation coefficient (r^2) of 0.97
- Bed load – Correlation coefficient (r^2) of 0.75

The long-term sediment transport statistics are presented in Table 2-3.

Table 2-3 Long-term (27 Years) Sediment Transport Statistics

Characteristic	Average Annual Amount (net tons)	Standard Deviation (net tons)
Total sediment load (bed material + wash load)	7,070,000	2,360,000
Total bed material (greater than 0.063 mm) load	2,050,000	720,000
Suspended load (including wash load)	6,650,000	2,260,000
Suspended bed material (>0.063 mm) load	1,630,000	620,000
Bed load	420,000	98,000

Key:

> – greater than
mm – millimeters

The results provide a reasonable degree of confidence that the long-term average gravel replenishment rate is on the order of 0.5 million tons per year.

Contributions from the major tributaries were based on an approximate specific sediment yield value of 2,500 tons per square mile per year, and a higher value was used for the glacier reach. The result was an approximate suspended sediment budget, as shown by the upper line on Figure 2-6.

Figure 2-6 also shows that the load continues to increase until it reaches the wide Palmer Reach, then declines towards the delta. A preliminary approximation of the gravel budget is also presented (lower line). The plot indicates a loss of gravel into each wide alluvial fan reach. A large portion of the gravel generated from several large tributaries is trapped in the wide reaches, but serves as a future source of gravel.

2.1.5.2 Geomorphology

The Matanuska Valley is a narrow structural feature 5 to 10 miles wide. The features of the current valley are, however, primarily the result of glacial movement during the Pleistocene and the actions of the Matanuska River itself. As a result, the lower Matanuska Valley is a wide, flat-bottomed valley, and the upper valley has the characteristic “U” – shape cross section, typical of glaciated valleys (ADNR, 1998).

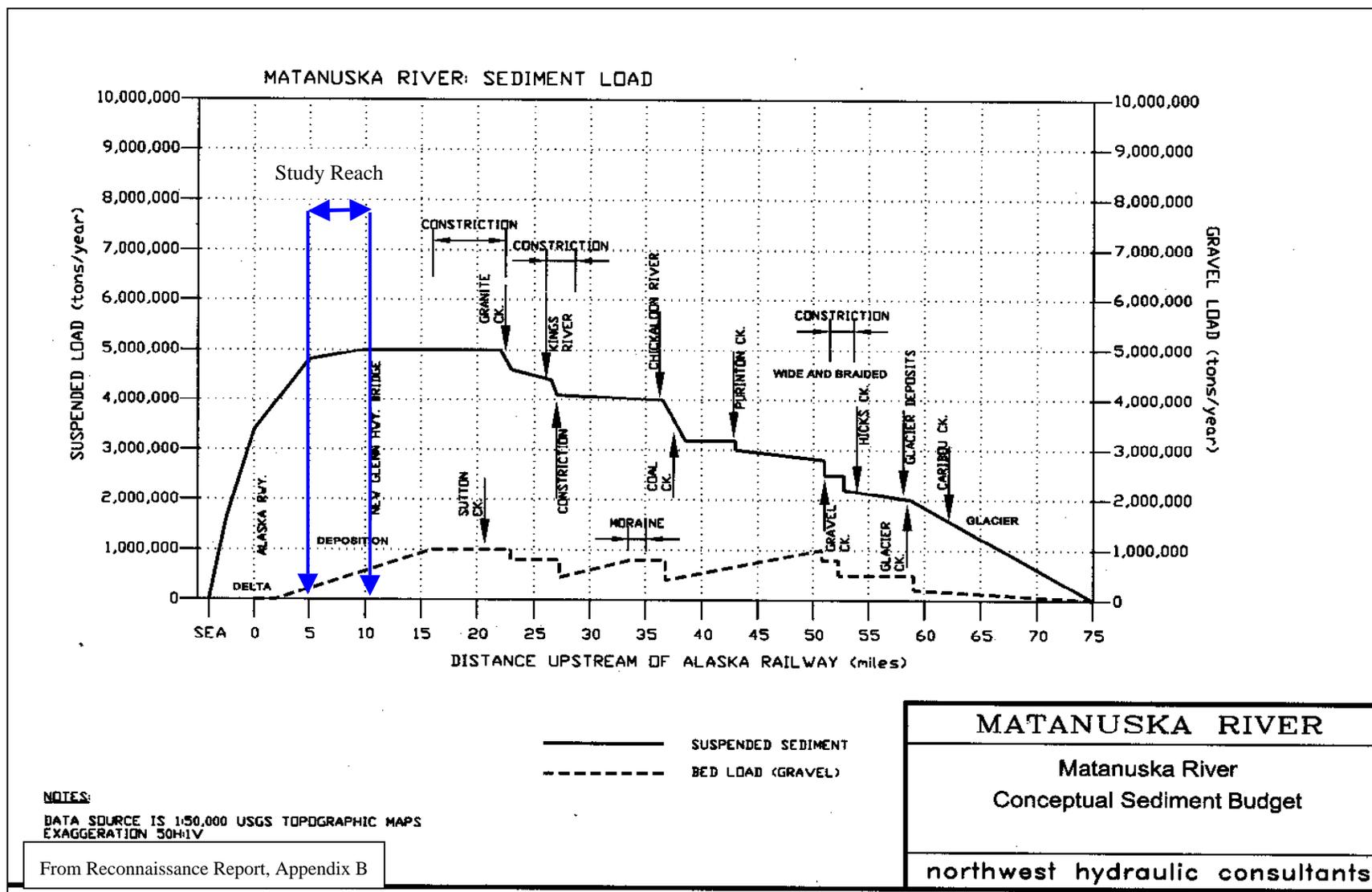
The Matanuska River has a watershed area of about 2,070 square miles, with about 10 percent (some 200 square miles) taken up by the Matanuska Glacier. The river empties into Cook Inlet where the Knik River joins it from the east. Large tributaries such as Gravel Creek, Chickaloon River, and Granite Creek contribute large quantities of sediment to the Matanuska River.

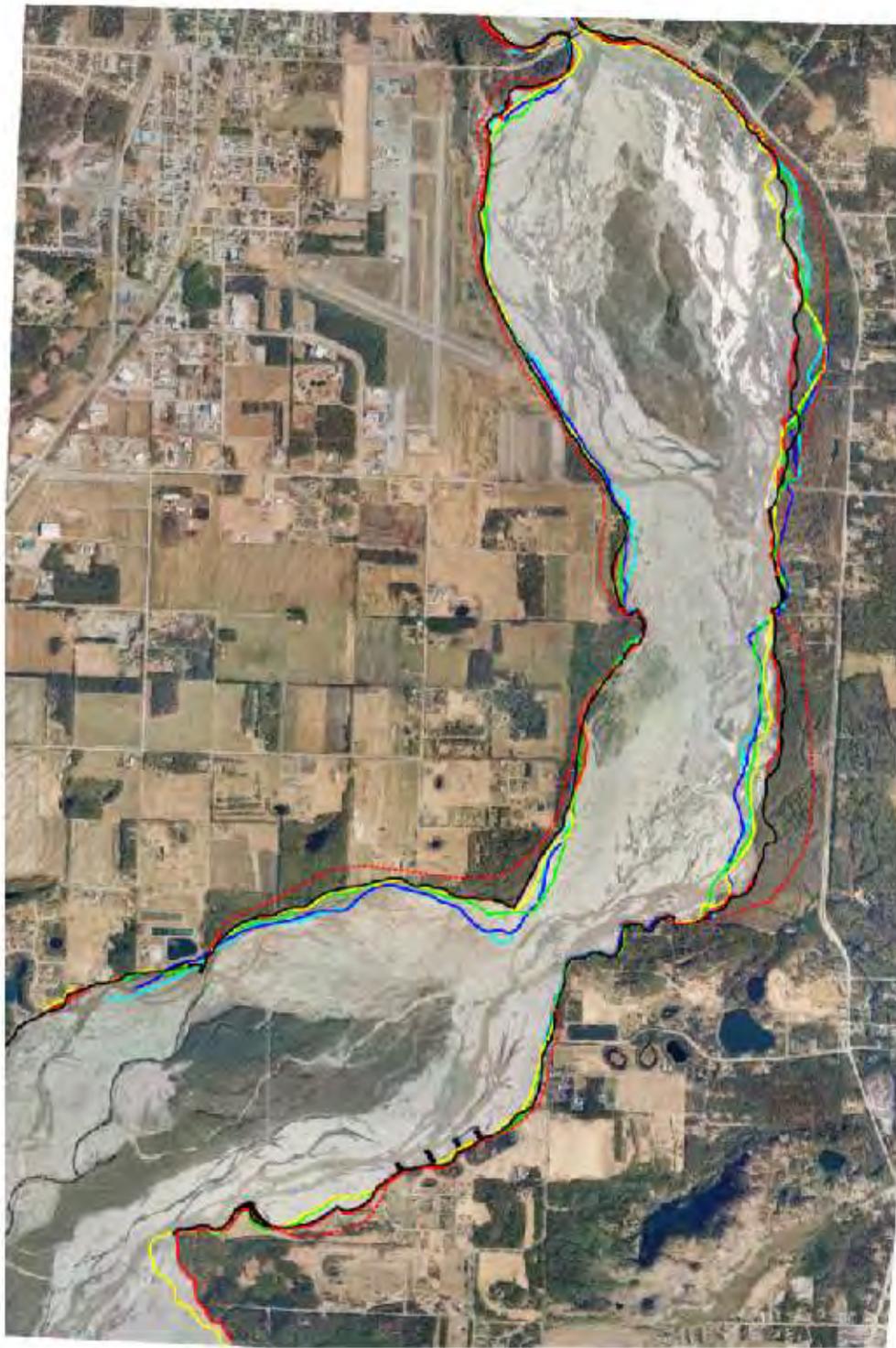
The Matanuska River has developed a series of confined alluvial fans that are separated by glacial debris or bedrock gorges, such as at the Old Glenn Highway Bridge at Palmer. This relatively narrow gorge results in a high velocity jet during high flows carrying sediment, which drops out as a central bar/island in the wide downstream river (nbc, 2004c). This deposition process results in the development of a confined alluvial fan, with the highest part of the fan being in the middle of the cross-section and active flow channels being pushed to each side – thereby eroding the channel banks.

In total, approximately 17 acres of riverbank were eroded between 1949 and 2000. These quantities represent only erosion of the floodplain or terraces adjacent to the outer riverbanks. Figure 2.7 presents the bank erosion progression from 1949 to 2003. This figure also shows a bankline forecast for 50 years in the future, showing the extent of erosion that is possible along the Study Area.

The total erosion and erosion rates over time from the Old Glenn Highway Bridge to the downstream pinch point (Reach 1), and from the pinch point to the end of the Study Area (Reach 2) are presented in Table 2-4. Erosion rates in feet per year are averages based on total square feet per year divided by reach length. This represents an increasing trend in erosion rate over the last 50 years for the Study Area.

Figure 2-6 Matanuska River Sediment Load





1000 0 1000 2000 3000 4000 Feet

500 0 500 1000 1500 Meters



-  Predicted bankline (50 Year forecast)
-  2003 Bankline
-  2000 Bankline
-  1985 Bankline
-  1975 Bankline
-  1960 Bankline
-  1949 Bankline
-  Bank protection

NOTES:

- 1) Background orthophoto dated May 9, 2000
- 2) Predicted bankline based on average yearly erosion rates and bank conditions
- 3) 2003 bankline interpretation based on LIDAR data analysis
- 4) Other bankline interpretations based on orthophoto analysis



MWH
Anchorage, Alaska

FIGURE 2-7

USNRC
MATANUSKA RIVER EROSION ASSESSMENT - DESIGN STUDY REPORT
PREDICTED EXTENT AND EROSION (50-YR)

Table 2-4 Reach Averaged Rates of Outer Bank Erosion

Period	Total Erosion (square feet)		Erosion Rate (feet per year)	
	Upper Reach	Lower Reach	Upper Reach	Lower Reach
1949-1975	122,902	110,530	2.71	7.15
1975-1985	128,119	37,856	7.35	4.47
1985-2000	263,184	81,601	10.06	6.42

The river slope averages approximately 0.005 feet per foot (Fahnestock and Bradley, 1973). The slope varies between the gorges and the confined fan reaches. Along the Study Area, the gradient is estimated at 0.0038 feet per foot, from a best-fit regression line through the long profile of the channel, based on the LiDAR survey data. Upstream from several gorges, the internal confined alluvial fans exhibit braided channel patterns that extend from valley wall to valley wall. A single dominant flow channel will sometimes be present, which shifts frequently across the gravel bed (nbc, 2004c). Figure 2.8 presents the existing channel geometry of the Matanuska River.

Braided rivers have a complex, transient morphology characterized by flows that diverge and converge around major assemblages of emergent bars and vegetated islands. The splitting and re-joining of flow paths around channel deposits results in a very dynamic rate of channel activity relative to other types of channels. As a consequence, bar migration, avulsions, and abandonment can all occur within a single flood event and, on small braided channels, significant channel change has been observed daily (Goff and Ashmore, 1994; Lane et al., 1995). Observed changes are also episodic, even at constant discharge, as sediment is delivered downstream in pulses (Nicholas et al., 1995).

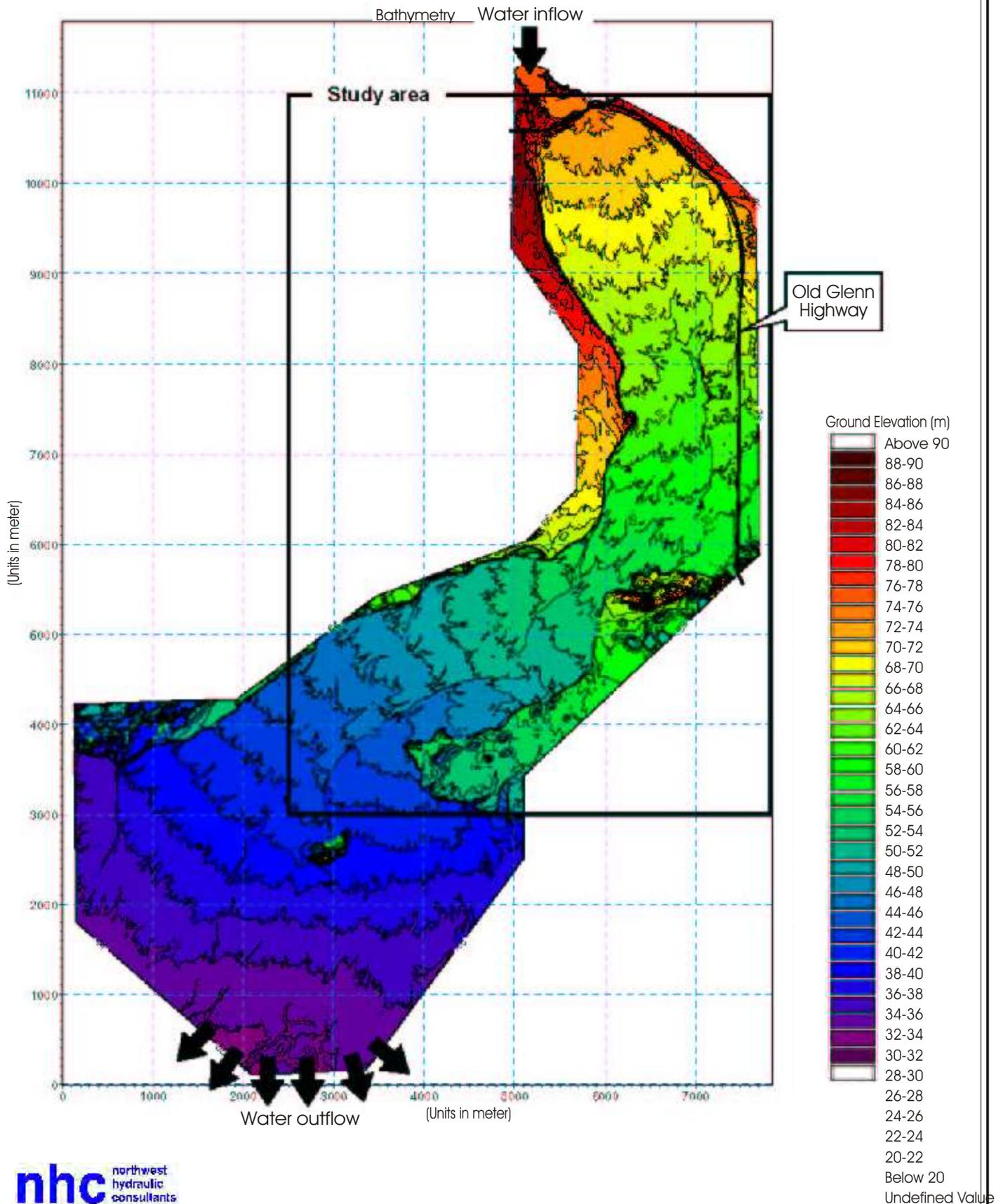
Larger braided channels tend to exhibit less variability, in general, because the volume of material stored within the channels is greater than the sediment flux rate, so the time required to complete major modifications exceeds the duration of a single flood or freshet. Nevertheless, Fahnestock and Bradley (1973) suggested that the Matanuska River can rework bars over many days, and that radical modifications are apparent annually. A qualitative examination of channel morphology from two dates (representing pre- and post-freshet conditions) of aerial photography taken in 1981 confirms this observation (Figure 2.9). In addition, many avulsions are known to have occurred along the river over the past half-century and the entire braided floodplain within the reach is estimated to turn over every 75 years (nbc, June 2004).

2.2 BIOLOGICAL ENVIRONMENT

The biological elements reported in this section include vegetation, wetlands, fish, amphibians, birds, mammals, and other wildlife. No threatened or endangered species have been identified in the Study Area.

2.2.1 Vegetation

The major vegetation type in the Matanuska Valley is boreal, or taiga, forest (Viereck et al., 1992). Boreal forests occupy the valleys of "interior" south-central Alaska. These forest are



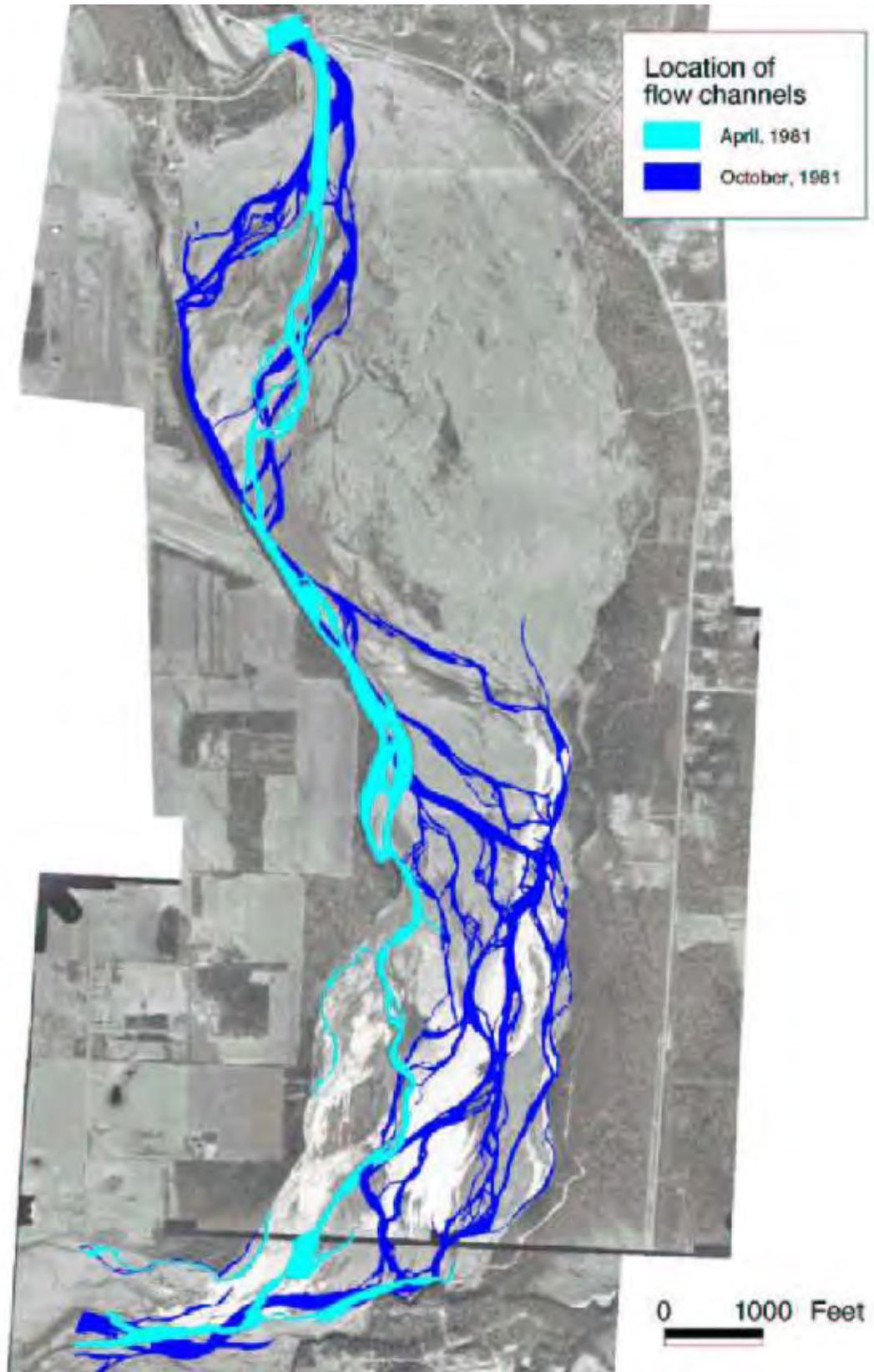
nhc northwest hydraulic consultants

MWH
Anchorage, Alaska

FIGURE 2-8

USNRC
MATANUSKA RIVER EROSION ASSESSMENT - DESIGN STUDY REPORT

EXISTING CHANNEL GEOMETRY



nhc northwest hydraulic consultants



MWH
Anchorage, Alaska

FIGURE 2-9

USNRC
MATANUSKA RIVER EROSION ASSESSMENT - DESIGN STUDY REPORT
**PRE- AND POST-FRESHET
MATANUSKA RIVER BRAIDED CHANNEL PATTERN**

dominated by coniferous forests of black and white spruce (*Picea mariana* and *P. glauca*., respectively), with extensive inclusions of deciduous paper birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*). Extensive mosaics of subarctic lowland sedge (*Carex* spp.), sedge-moss meadows, and bogs dominated by willows (*Salix* spp.), sweetgale (*Myrica gale*), or graminoids are common within the boreal forest vegetation type (MWH, 2003).

The boreal forest exists as a nearly continuous belt of coniferous trees across North America and Eurasia. Overlying formerly glaciated areas and areas of patchy permafrost on both continents, the forest is mosaic of successional and subclimax plant communities sensitive to varying environmental conditions. These forests now occupy valleys that were filled with glacier ice or glacial lakes during the last major glaciation. Boreal forests spread from interior Alaska (north of the Alaska Range) into south-central Alaska following the retreat of glaciers (<http://climchange.cr.usgs.gov/research/alaska/alaskaB.html>)

2.2.2 Wetlands

The general distribution and area of wetlands along the Matanuska River was mapped for the National Wetlands Inventory, and described in a U.S. Fish and Wildlife Service (USFWS) study of Alaska wetland status. The most common wetland delineation in the Project Area is Riverine, followed by smaller areas of Freshwater Forested/Shrub Wetland and Freshwater Emergent Wetland (Cowardin et. al., 1979).

The *Riverine* classification is given to wetland and deepwater habitats contained within a channel with periodically or continuously moving water. The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: 1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and 2) habitats with water containing ocean-derived salts in excess of 0.5 parts per thousand. A channel is “an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water” (Langbein and Iseri, 1960).

The Riverine System is bounded on the landward side by upland, the channel bank (including natural and man-made levees), or wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. In braided streams, the system is bounded by the banks, which form the outer limits of the depression where the braiding occurs.

The *Freshwater Forested/Shrub Wetland* is dominated by forests and shrubs – as its name implies. If vegetation (except pioneer species) covers 30 percent or more of the substrate, the Class is distinguished on the basis of the life form of the plants that constitute the uppermost layer of vegetation and that possess an areal coverage 30 percent or greater. For example, an area with 50 percent areal coverage of trees over a shrub layer with a 60 percent areal coverage would be classified as Forested Wetland (Cowardin et. al., 1979). An area with the same coverage of trees and shrubs, but with the trees less than 20 feet (6 meters) tall, would be classified as Scrub-Shrub Wetland.

Forested Wetlands are most common where moisture is relatively abundant, particularly along rivers and in the mountains. They occur only in the Palustrine and Estuarine Systems and normally possess an overstory of trees, an understory of young trees or shrubs, and a herbaceous layer. The Scrub-Shrub Wetland includes areas dominated by true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. Scrub-Shrub Wetlands may represent a successional stage leading to Forested Wetland, or they may be relatively stable communities (Cowardin, et. al., 1979).

The *Freshwater Emergent Wetland* classification is less common in the Study Area and is characterized by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens). This vegetation is present for most of the growing season in most years and is usually dominated by perennial plants. In areas with relatively stable climatic conditions, Emergent Wetlands maintain the same appearance year after year. In other areas, such as the prairies of the central United States, violent climatic fluctuations cause them to revert to an open water phase in some years (Stewart and Kantrud, 1972).

2.2.3 Fish and Amphibians

The Matanuska River watershed supports both anadromous and resident fish populations. The 11 species of fish within the Matanuska Valley watershed are: chinook, coho, and chum salmon, Dolly Varden char, rainbow trout, Arctic grayling, round whitefish, burbot, three-spine stickleback, nine-spine stickleback, and the longnose sucker. Spawning has been documented in both tributaries and the main stem of the Matanuska River (ADNR, 1998). Fish counts for the 1980s show increasing numbers of spawning chinook salmon in two tributaries of the Matanuska River. Data from 1989 indicates that the density of salmonids is, however, very low in several tributaries, as compared to other streams in Alaska. The distribution and numbers of these species within the Study Area is unknown.

For both anadromous and resident fish, an important habitat parameter is maintenance of stream flow for spawning and incubation success. Fish habitat types associated with the Matanuska River are the main-stem, slough, side channel, tributary mouth, and tributary. The changing morphology of side channels affects the number of salmon that spawn at the tributary mouth. Increased numbers of salmon are present when the channel shifts allow for additional access to the tributaries, providing adequate spawning habitat (ADNR, 1998).

2.2.4 Birds, Mammals, and Other Wildlife

The majority of information available on the wildlife along the Matanuska River pertains to the Moose Range that was established in 1984. This area, however, is located in the watershed upriver from the Study Area, to the north of the Matanuska River itself.

Moose are generally found throughout the watershed, including the Study Area. The watershed supports numerous other mammals including brown bear, black bear, caribou, Dall sheep, and mountain goat. Furbearing species within the watershed include: wolf, coyote, red fox, lynx, wolverine, mink, marten, weasel, red squirrel, Arctic ground squirrel, snowshoe hare, hoary

marmot, pica, porcupine, beaver, muskrat, and others (ADNR, 1998). The distribution and numbers of these species within the Study Area is unknown.

Raptors likely to occur in the watershed include: bald eagle, golden eagle, northern harrier, sharp-skinned hawk, northern goshawk, merlin, rough-legged hawk, Swainson's hawk, red-tailed hawk, American kestrel, peregrine falcon, gyrfalcon, boreal owl, saw-whet owl, great gray owl, great horned owl, short-eared owl, snowy owl, and hawk owl. The northern goshawk was the only raptor observed in summer and winter. Many of these species may use the watershed as a migration corridor to Interior Alaska in early spring. The "open mixed forest" habitat type had the highest concentration of bird species, with a total of 24 species. Many of these species are summer residents. Birds that may be present in winter include the raven, black-billed magpie, northern shrikes, and ptarmigan (ADNR 1998).

Tidal and adjacent wetlands around the mouth of the Matanuska River are regionally important for waterfowl as staging and nesting habitat. The areas along the lower river are valuable moose wintering and calving habitat. Upriver and tributary areas of the Matanuska River provide important riverine habitat and migratory paths for many birds and mammals (USACE, 1999).

2.2.5 Threatened and Endangered Species

Before a plant or animal species can receive protection under the Endangered Species Act, it must first be placed on the Federal list of endangered and threatened wildlife and plants. The USFWS listing program follows a strict legal process to determine whether to list a species, depending on the degree of threat it faces. An "endangered" species is one that is in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered in the foreseeable future. The USFWS also maintains a list of plant and animals native to the United States that are candidates or proposed for possible addition to the Federal list. All of the USFWS's actions, from proposals to listings to removals ("delisting"), are announced through the Federal Register (USFWS, 2004a).

A total of 10 animals and 1 plant are listed as either threatened or endangered in the State of Alaska. Of these, none are found within the Mat-Su Borough or Cook Inlet. A single candidate for listing has been identified in the Cook Inlet waters – the Cook Inlet beluga whale (*Delphinapterus leucas*). No threatened or endangered species are known to be present within the Study Area (USFWS, 2004b).

2.3 HUMAN ENVIRONMENT

The human environment is presented in terms of land ownership and use, economy, socioeconomics, cultural resources, visual resources, noise, recreational resources, and subsistence use.

2.3.1 Land Ownership and Use

This section presents population growth before describing land use.

2.3.1.1 Population

According to the U.S. Census Bureau, the 2003 population of the Mat-Su Borough is estimated at 68,335 people. The population increased by 49.5 percent from 1990 to 2000, and by an estimated 15.2 percent from 2000 to 2003. This growth rate makes the borough the fastest growing in the State and among the fastest growing areas in the country (U.S. Census, 2004).

Most of the residents are approximately 34 years of age, with about 88 percent of them being white. Residents resided in an estimated 27,485 housing units in 2002. With a land area of nearly 25,000 square miles, the population density remains low, with only 2.4 people per square mile (U.S. Census Bureau, 2000 data). Approximately one-half of the population in the Mat-Su Borough resides within a 100 square mile area between and around the cities of Palmer and Wasilla (Mat-Su, 2003).

2.3.1.2 Land Use

Coal was mined in the Matanuska Valley from 1916 to 1967 in the vicinity of Chickaloon and Eska on the north side of the river (WCC and Goodson, 1984). The City of Palmer is the largest urban area in the valley and is located to the west of the river within the Study Area.

In the 1930s, lands northwest of the mouth of the Matanuska River were opened to agricultural development. The farming area is located in a roughly rectangular area 10 to 12 miles wide and extending from the Chugach Mountains west some 15 to 20 miles. Only a portion of this farmed area is within the Matanuska River watershed (MWH, 2004d). In 1997, the National Agricultural Database reported that farming lands in the Mat-Su Borough, Anchorage, Valdez, and Cordova area accounted for approximately 40,000 acres. The majority of this land, while not broken down in the national data, was located in the Mat-Su Borough.

Agriculture and mining are not expanding in the basin; some agriculture land is being converted to urban use and old mines are being reclaimed. Rapid urban growth continues, as evidenced by the 4.5 percent annual population growth in the City of Palmer over the last 10 years. However, much of the watershed remains undeveloped. An estimate of the current land use areas is shown in Table 2-5 (MWH, 2004d).

Table 2-5 Estimated Areal Extent of Land Uses in the Matanuska Valley

Type of Land Use	Area (square miles)	Percent of Total Area
Agriculture	40	2
Mining	<20	<1
Roads and Urban	150	8
Undeveloped – vegetated	1,670	80
Undeveloped – glacier	250	12
Total	2,070	100

Key:

< – less than

2.3.2 Economy and Socioeconomics

Services and *professional* are the predominant classification of employment for the region, making up just over 65 percent of the job market in the area. The current income and employment distribution is presented below.

2.3.2.1 Wage and Income

In 1999, the average annual wage for workers in the Mat-Su Borough was \$26,893, compared to \$35,557 in Anchorage. The biggest reason for this differential is that a much larger percentage of the Mat-Su employment mix is in lower paying sectors, such as services and retail, and not in the sectors of oil, government, and transportation.

Personal income does not reflect the lower wages in the Mat-Su Borough. Some of this difference is attributed to the fact that many residents (approximately one-third) work in the higher paying sectors in Anchorage and elsewhere in the state (Mat-Su, 2003). The income distribution data from the 2000 U.S. Census is presented in Table 2-6.

Table 2-6 Income Distribution

Category	Anchorage	Mat-Su Borough
Per Capita Income	\$ 25,287	\$ 21,105
Median Household Income	\$ 55,546	\$ 51,221
Median Family Income	NA	\$ 56,939
Persons in Poverty	NA	6,419
Percent Below Poverty	7.3	11.0

Key:

Mat-Su – Matanuska-Susitna

NA – not available

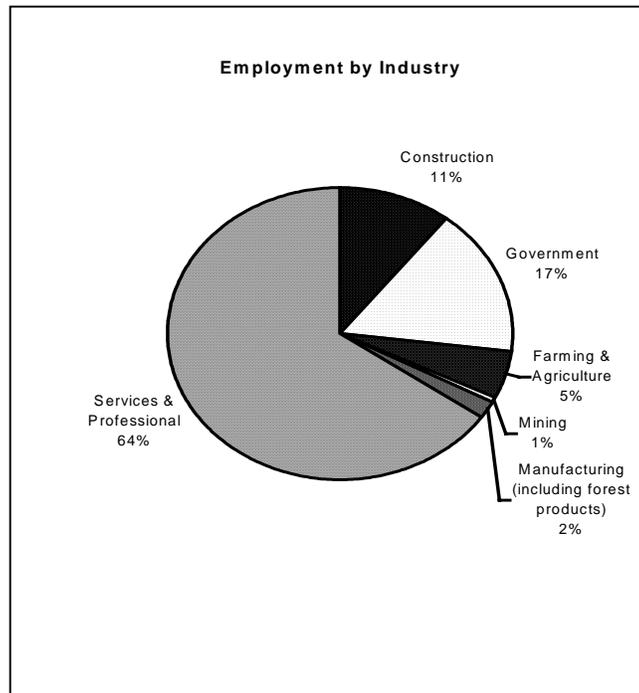
2.3.2.2 Employment

Mining and agriculture were the first major economic influences. Although the Mat-Su Borough remains the state's biggest agricultural producer, other economic forces now drive the economy. For the last four decades, the single biggest reason for the Borough's growth has been its proximity to the state's largest city (Anchorage). Recent reports estimate that about one-third of the Borough's labor force now commutes to Anchorage for employment (Mat-Su, 2003). Palmer's economy is based on a diversity of retail and other services, light manufacturing, and city, borough, state, and federal government (GPCC, 2004).

Employment in the area varies from construction to tourism. The University of Alaska has an Agricultural and Forestry Experiment Station Office and a district Cooperative Extension Service office in Palmer, along with the University's Matanuska Research Farm (GPCC, 2004). The primary employment in the area is classified as services and professional, with 64 percent,

as shown on Figure 2-10 (Sonoran, 2002). Farming and agriculture are diminishing due to the rapid expansion of population in the area.

Figure 2-10 Employment by Industry



2.3.3 Cultural Resources

The Mat-Su Borough has a Historic Preservation Commission that oversees cultural preservation projects. The Borough assists in supporting six museums, each portraying local history in disparate geographical regions. Within the Mat-Su Borough, there are over 22 individual sites and four historic districts listed on the National Register of Historic Places. The 11 sites within the Palmer area are primarily located with the City of Palmer, or along the New Glenn Highway. The historic districts listed are: Palmer Colony Project, Talkeetna Mining Community, Golden Zone Mine, and Independence Mine (Mat-Su, 2003). Of these, only the Palmer Colony Project and Independence Mine are located within the Matanuska River Watershed. Neither location would be affected by activities within the Study Area.

The Old Glenn Highway follows part of a historic trail initially blazed by Lieutenant Castner in 1898. The highway was named for Castner's commanding Officer, Captain Glenn. The Glenn Highway is listed as a National Scenic By-Way (Mat-Su, 2003). The highway runs adjacent to the Matanuska River that separates two sets of scenic mountains, the Chugach and Talkeetna ranges. The Old Glenn Highway may be subject to erosion from the Matanuska River.

2.3.4 Visual Resources

Along the Study Area, the surrounding topography consists of relatively flat terrain located on a bench feature ranging from a few feet to 20 or 30 feet above the river. Bodenbug Butte is located to the southeast of the Study Area. The surrounding area consists of numerous mountains peaks. The Chugach and Talkeetna Mountains are both visible from the Study Area.

2.3.5 Noise

Current noise levels along the Study Area have not been measured. Known sources of noise in the area include the Palmer Airport, activities from periodic gravel extraction on the north side of the river, activity at the Palmer WWTP, maintenance of the existing spur dikes, and road construction. Little traffic is present in the area. Snowmachine and four-wheeler use may be present periodically along the dry portions of the river bed.

2.3.6 Recreational Resources

Recreational opportunities within the Matanuska River watershed are extensive. These include both summer and winter recreation. There are many trails and opportunities for those who enjoy hiking, hunting, fishing, berry-picking, four-wheeling, horseback riding, and biking in the summer, or snow machining, skiing, and dog mushing in the winter. The Matanuska River is home to a variety of game animals such as caribou, moose, Dall sheep, and bear. Area creeks, streams, and lakes contain extensive fishing opportunities (Mat-Su, 2003).

2.3.7 Subsistence Use

Subsistence use is documented within the Matanuska and Susitna River basins, which extend to the Cook Inlet, as grouped by the Alaska Native Science Commission and University of Alaska, Anchorage, Institute of Social and Economic Research. The Alaska Department of Fish and Game, Division of Subsistence, provided assistance to the research effort. Potential and historic subsistence use within distinct areas has been documented.

Within the Matanuska and Susitna River basins, subsistence use was identified. Subsistence items available include: berries, black bear, burbot, caribou, several fish species, moose, plants, several bird species and beluga whales. Limited subsistence use has been documented, but a greater amount of subsistence use than recorded may take place in the Study Area.

3.0 EROSION CONTROL ALTERNATIVES

This section of the report reviews five approaches to managing erosion along the Matanuska River in the study area:

- Alternative 1 – Gravel Removal
- Alternative 2 – Bank Stabilization
- Alternative 3 – Non-Structural Approaches
- Alternative 4 – Combined Actions
- Alternative 5 – No Action

Section 3.2, describing Alternative 2 – Bank Stabilization, presents several options that are eliminated from further consideration due to factors such as effectiveness, reliability, and constructability. The project team presents operation and maintenance (O&M) considerations, mitigation measures, and anticipated bank protection results for the gravel removal and bank stabilization alternatives (also called structural alternatives). Each subsection on an alternative ends with a description of its advantages and disadvantages. Section 3.5 presents the No Action Alternative (Alternative 5) and its advantages and disadvantages.

3.1 ALTERNATIVE 1 – GRAVEL REMOVAL

This alternative provides channel excavations (trenching) to re-route and alter the flow within the river. Channel excavation would be designed to reduce velocities and stresses upon banks during high and moderate flow events. In order to accomplish this, information regarding the dynamics of the river and where trenching would be most effective needed to be developed.

Computer modeling was used to estimate the effect of the channel excavations on flow pattern, hydraulic characteristics, and sediment transport in the Study Area. This evaluation was conducted for two flood events: the 2-year and 10-year peak flows. The flood flow hydraulics were numerically simulated for both existing and project conditions using the Danish Hydraulic Institute MIKE-21 two dimensional (2-d) fixed bed computer model (nhc, 2004e). Application of the MIKE-21 model provides a means to combine the computed hydrodynamic data, derived from topographic data and the HEC-RAS model (MWH, 2004c), with an understanding of geomorphic processes on the Matanuska River system to assess the outcomes of gravel extraction alternatives.

MIKE-21 is a recognized and tested tool for quantifying complex spatial flow hydraulics in braided channels characterized by irregular bed topography, such as the Matanuska River. This model was used to track alterations in flow depth, velocity, and sediment transport as a result of various bed configurations. The fixed-bed model, however, cannot predict changes in channel evolution due to changed hydraulic conditions and does not combine the hydrodynamics with the sediment transport computations.

The current sediment model is based on several assumptions: the bed topography is fixed, the water flow is steady, sediment is not routed between cells, and there is unlimited sediment supply to each cell. Therefore, the computed sediment fluxes represent the capacity of the water

flow to transport sediment, and not the actual sediment transport during a given hydrologic event. Results from the sediment transport computations presented can only be used to identify potential areas of erosion or deposition, and provide an indication of the initial rate at which sediment transport will occur. It must be recognized that the river system is dynamic and sediment transport will respond actively to changes in channel form associated with sediment flux.

Once the modeling of the river under existing conditions was completed, a series of excavated trenches were inserted into the model and their effects on the flows were determined. The location of the proposed gravel trenches and pit trap are shown on Figure 3-1.

The project team modeled three trenches that were 10 feet deep, 500 feet wide, and 2,500, 3,300, and 6,500 feet long – upstream to downstream. A gravel trap located at the downstream end of the upstream trench was 16 feet deep and 1,150 feet wide. The three trenches had a total excavated volume of 2.2 million cubic yards, or 3.3 million tons. The gravel trap excavated volume was 600,000 cubic yards, or 900,000 tons. Since the average bankfull cross-sectional area is approximately 5,431 square feet, these trenches create a large change in the channel configuration, which why sediment is trapped. These configurations were intended for initial base line modeling only, future planning and modeling will be needed to adjust the trenches to maximize effectiveness.

3.1.1 General Strategy

In order to provide reliable bank protection, the excavations need to maintain the main flow in the middle of the active channel to reduce river velocities and stresses near the erodable riverbank. Therefore, the risk of the river naturally bypassing the excavated channel needs to be addressed.

From a geomorphologic perspective, the behavior of the excavated channels is of concern on the Matanuska River, since natural river instability may impact the effectiveness of the trenches to re-direct flows and reduce water levels. Since braided channels characteristically exhibit irregular and unpredictable morphologic development, there can be no guarantee that the proposed excavations will remain stable for a significant time period (i.e. multiple freshet seasons) to reduce flood levels and redirect flows, as intended.

In addition, there is a risk that bank erosion could continue due to flow in the smaller sub-channels even if the trenched channels are constructed. If an appreciable amount of the flow remains outside of the excavated channel, bank erosion may continue. In addition, flows through the initially straight excavations will likely erode their banks and eventually result in irregular excavated channel patterns with flow paths deviating from the constructed alignment. Specific analytical techniques for assessing these processes are described in greater detail in the MIKE-21 Model Technical Memorandum (Appendix E).

An adaptive management approach for implementing and maintaining the gravel extraction trenches is highly recommended. Channel bed response in braided river systems is very unpredictable, and a high degree of uncertainty in predicted bed change and channel response

-  Predicted Erosion Boundary
-  Existing Bank Protection
-  Longitudinal Profile Location
-  Trench Cut Location
-  Pit Trap Location



MWH
Anchorage, Alaska

FIGURE 3-1

USNRC
MATANUSKA RIVER EROSION ASSESSMENT - DESIGN STUDY REPORT

MODEL EXCAVATION LOCATIONS

exists. After implementing a gravel extraction trench, observation of the locations and magnitude of channel bed deposition or erosion after a freshet season provide a means to assess project performance. For example, periodic modifications to the location, configuration, and size of both the trenches and gravel trap would be necessary to ensure their long-term effectiveness.

This empirical observation of bed change should be combined with updated hydraulic modeling to develop a revised excavation plan that reduces the adverse effects of channel deposition and avulsion, and reduces near bank velocity and depth. Responsibilities and technical requirements for assessing modifications to the operations would have to be carefully laid out for this alternative to be successful. In summary, in spite of the dynamic characteristics of the Matanuska River, the gravel extraction excavations can reduce bank erosion but will not eliminate the need for bank erosion protection of key facilities, properties, and locations of direct flow impingement on bank locations.

3.1.2 Modeling Results

Excavations were modeled to show their effectiveness on mitigating stresses on the banks during high flow regimes. The results are displayed in Figures 7 through 29 of the MIKE-21 Model Technical Memorandum (Appendix E). Modeling shows beneficial results of reducing flow velocities and shear stress on banks due to the two trenches near Bodenbug Butte. The uppermost excavation near the Old Glenn Highway Bridge adversely affected the east bank of the Matanuska River by increasing velocities and depths in this region. Therefore, excavation and gravel removal in the region of the two downstream trenches that were modeled should be considered. Additional analysis might define an upstream trench near the Old Glenn Highway Bridge that would be effective.

3.1.3 Gravel Movement and Stockpiling

The gravel removal operation requires developing access to the riverbed; excavating, loading trucks, and hauling the gravel out of the gravel trap and/or trenches; and stockpiling the material for later sale or use.

3.1.3.1 Riverbed Access

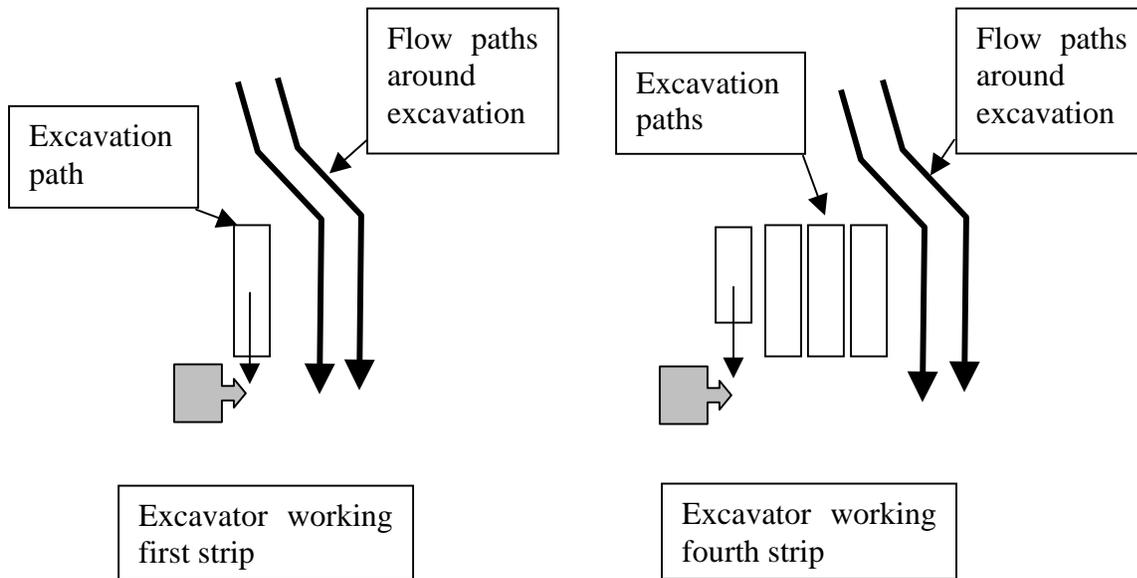
Access to the riverbed would be through public right-of-way, easement, or property purchases. On the west side of the river, there are possible access points near Mountain View Estates, Glenn View, or driveways just south of the airport along the riverbank. On the east side of the river, there are possible access points near the Circle View Subdivision along the spur dikes, at the 90 degree bend on the South Bodenbug Loop Road, and along the Old Glenn Highway just east of the end of the upstream island. Numerous other private access points are scattered along the river.

Access ramps likely will need to be constructed from the bank to the riverbed for equipment such as excavators, dump trucks, and other vehicles. Access ramps should be a minimum of 14 feet wide, and properly sloped and compacted to allow heavy equipment access.

3.1.3.2 Excavation, Movement, and Stockpiling

An excavator would likely remove material from the gravel trap and, if necessary, trenches in strips, each excavated from the outermost upstream point moving downstream. Each subsequent strip would be closer to the innermost edge of the designed excavation, as shown on Figure 3-2. The excavation could be bermed at the upstream end to prevent flow from entering the excavation to facilitate construction.

Figure 3-2 Excavation Plan



This excavated material would be placed in dump trucks (as large as feasible) and delivered to a buyer or a staging area. Staging areas for stockpiling need to be within close proximity of the river excavation. Ease of access to the site is also essential. Conveyors and crushers could be added to improve the quantity, quality, and the placement of the material in response to market demand.

3.1.3.3 Excavation Timing

Excavations should take place during low flow and minimal fish impact periods, likely prior to significant fish migration. This sets the excavation period in the challenging cold months of November through February or March, depending on anadromous fish smolt out-migration dates. Excavations must be coordinated with all permitting guidelines.

3.1.4 Constructability Issues

The size of the trenches would require construction of a large-scale mining operation. Initial construction of two downstream trenches would require excavating nearly 1.8 million cubic yards of material. Employing four excavators and twenty 22-yard end dump trucks, 24 loads per truck per day could result in the trenches being excavated in 250 days. If excavation is limited to

the 4 or 5 late fall to early spring months, it would be a challenge to construct the two trenches in less than 2 years.

In addition, groundwater may pose a significant challenge for excavations of this size in this reach of the Matanuska River. The use of specialized excavation equipment may be required to remove material from the excavation after initial removal is completed, if groundwater significantly infiltrates a trench. In addition, construction is anticipated to take place during low flow periods, which may limit the effect of groundwater on a trench. Since the potential for long-term groundwater issues and the type of equipment that may be needed cannot be foreseen, these were not included in estimating the cost of excavation activities.

3.1.5 Demobilization and Restoration

Due to seasonal excavation constraints, the ‘in-stream’ work will be demobilized on an annual basis during initial construction and annual maintenance. This demobilization will include removal of equipment from the riverbed, restoration of disturbed areas outside of the trench excavations, restoration of vegetation disturbed within the riverbed, and a survey of final excavations.

3.1.6 Operation and Maintenance

Equipment should stay out of waterways as much as possible to avoid unnecessary impacts to the riverbed and possible water hazards. Equipment should be cleaned, maintained, and frequently checked for leaks, fragile hoses, and piping.

Due to high sediment loads in the river, the extracted volumes of the trenches and gravel pit will be replaced with the transported sediment in a few (i.e., 2 to 5) years, assuming no annual gravel removal. Therefore, annual monitoring and maintenance of the excavations are necessary to ensure their long-term effectiveness and desired performance. Inspection and maintenance of the excavations should include:

- Condition of trench and amount of sediment holding capacity remaining in the trench.
- Effectiveness of trenching and impacts to side and downstream banks.
- Potential for avulsion (change in channel direction and form).
- Buildup of materials within adjacent areas.

Maintenance will include removal of gravel from the gravel trap and, perhaps, the trenched channels. Since annual gravel deposition is estimated on the order of 500,000 tons per year, two excavators and 10 end dump trucks making 24 round trips per day for 59 days may be needed to maintain the rate of gravel removal required for continued success of the gravel removal alternative. This gravel may be stockpiled for sale on the open market.

3.1.7 Mitigation Measures

Mitigation measures for gravel mining and excavation operations within the riverbed and floodplain include:

- Proper care and inspection of equipment to eliminate oil and other contaminant leaks and spills. Prepare spill plans, if necessary.
- Working in dry riverbed where possible to avoid in-stream work issues and hazards.
- Managing gravel extraction operations to avoid or minimize damage to riverbanks and riparian habitats.
- The cumulative impacts of gravel extraction operations to anadromous fishes and their habitats could be addressed by the federal, state, and local resource management and permitting agencies.
- Repairing, rehabilitating, and restoring the riverbed where disturbed (outside of the excavation area).

3.1.8 Anticipated Bank Protection Results

Modeling results show the potential for reducing the threat of erosion. However, the risk of an avulsion or other future river change that would de-stabilize the bank cannot be avoided. While short-term protection to the riverbank may be significant, long-term protection will require active maintenance and continued operation of gravel excavation. Even with long-term diligent trenched channel maintenance, the risk of bank erosion will not be completely eliminated. The likelihood that the excavation of gravel will provide protection during a 25-year flood event has not been quantified. In addition, a single event during the beginning of the summer flows could potentially fill the trenches and eliminate any bank protection achieved by previous excavations.

3.1.9 Advantages

The advantages of Alternative 1 include:

- Possible revenue generation from gravel mining.
- Ability to channel the river away from the susceptible banks.
- Ability to reduce the likelihood of bank erosion for the short-term.

3.1.10 Disadvantages

The disadvantages of Alternative 1 include:

- Winter operational challenges.
- Potential groundwater control challenges.
- Revenues not guaranteed, value of gravel and markets are variable.
- Bank stability not guaranteed, high flows may still affect the bank.

- Gravel mining must be continuous, adaptive, and long-term.
- Offers no protection from a rapid avulsion event.

3.2 ALTERNATIVE 2 – BANK STABILIZATION

The Bank Stabilization Alternative will use conventional river training and bank armoring structures to provide additional bank protection. This alternative was evaluated because gravel mining and other alternatives may not be feasible due to factors such as environmental regulations, economic viability, community needs, or inadequate technical performance.

3.2.1 Stabilization Options

Numerous bank stabilization methods have been used with varying successes within waterways of the United States. These are described in more detail in *Bank Stabilization Techniques* (MWH, 2004a). Based upon cost, constructability, permitting difficulty, and bank stabilization effectiveness, two methods that appear to be practical for long-term stabilization along the Matanuska River are riprap placement and spur dike installation.



Riprap. Riprap has been shown to be effective in protecting river banks in numerous applications. This option simply armors the bank with large rock that can withstand the forces and stresses from the river. Riprap would be installed from several feet above flood stage to several feet below channel bed elevations to the scour depth. Estimates of the length of bank needing protection have not been made in this report due to the subjectivity of these estimates.

Spur Dikes. Four spur dikes were constructed along the Matanuska River (near Bodenbug Butte) in 1992 to protect the bank from erosion (Figure 1-3). The existing spurs have withstood flows of over 30,000 cfs. These spur dikes have been effective in eliminating bank erosion along the stretches where constructed and should be considered for bank protection. New spurs are best located along the bank at locations that have experienced considerable erosion in the past, since they prevent the thalweg from reaching the bank.



3.2.1.1 Options Considered and Eliminated From Further Study

Numerous bank stabilization efforts were eliminated from possible further consideration due to constructability, effectiveness, and/or other factors. These alternatives are briefly discussed below.

Biotechnical Techniques. This effort includes woody plantings, or herbaceous cover. It was determined that the Matanuska River is too massive and the banks too easily eroded for these efforts alone to fortify the bank enough to withstand the forces of the river.

Subsurface Drainage Systems. These systems increase slope stability by decreasing soil-pore pressure. Subsurface drainage systems can be installed in a variety of configurations, including chimney drains, collection drains, and gravel seams. They may include gravity or pumped systems. A 1968 soil survey of the Matanuska Valley Area (USDA, 1968) describes the soil type in the Study Area as primarily Bodenbug association with Susitna-Nicklason association, to the south. Both of these soil types are well-draining silt or fine sands, and would not be practical for this application. These systems also appear to be impractical for the Matanuska River, since the river system is too large for this type of an application.

Floodplain Roughness. This technique consists of installing items within the river to reduce energy in the flow. An increase in roughness is affected by the presence of live trees, shrubs, and large woody or other debris in the floodplain. This was determined to be impractical for the Matanuska River, since the river system is too large and variable for this type of an application.

Gabions. These are rocks encased in metal cages that armor the bank. These appear impractical for the Study Area because they are expensive, labor intensive to construct, and can be subject to scour failure.

3.2.2 Operation and Maintenance

The condition of any bank stabilization method, especially spur dikes or riprap, must be inspected on an annual basis and after any high flow events. Maintenance may include replacement of the construction materials that shift or disappear during high flows.

3.2.3 Mitigation Measures

Mitigation measures for bank stabilization construction within the riverbed, banks, and floodplain include:

- Proper care and inspection of equipment to eliminate oil and other contaminant leaks and spills. Spill plans are to be completed as necessary.
- Working in dry riverbed, where possible, to avoid in-stream work issues.
- Repairing, rehabilitating, or restoring the riverbed where disturbed in construction areas.
- Ensuring imported materials are clean and from known sources.
- Protecting fish habitat should be maximized where possible.

3.2.4 Anticipated Bank Protection Results

Installed riprap protects a bank from the stresses of higher velocity water along it. This armoring is not meant to alter the flow of the river, but typically does cause some local scour. In addition, riprap usually provides protection only to the section of bank that is armored.

The intended effect of spur dikes is to shift the thalweg away from the bank. The new thalweg alignment may, however, affect the downstream channel or banks. Appropriate spacing and sizing of spur dikes is important to reduce effects on downstream banks.

3.2.5 Advantages

The advantages of Alternative 2 include:

- Immediate protection of erosion prone areas.
- Ability to protect specific areas.
- Effectiveness of spur dikes and riprap efforts are known.
- Continued development in protected areas may be acceptable.
- Possible increase in nearby property values.

3.2.6 Disadvantages

The disadvantages of Alternative 2 include:

- Stabilization construction efforts can be costly and labor intensive.
- Bank stabilization efforts require long-term access to the property for maintenance of structures.
- The bank stabilization is only effective in the immediate vicinity of where it is constructed.
- Spur dikes or riprap generally do not create a favorable habitat for aquatic life due to a lack of vegetation and cover.
- These structures create the need for a long-term maintenance program.

3.3 ALTERNATIVE 3 – NON-STRUCTURAL APPROACHES

Non-structural approaches do not require construction or physical alteration of the riverbank. These could include zoning, land use changes, riparian setbacks, easements, public education, or even relocation of human structures and residents.

Land use measures that guide growth and development represent a potentially cost effective means of addressing the impact of river erosion. Northern Economics, Inc. provided the project team with an overview of the planning framework that could be the foundation for land use measures to address the effects of erosion (NEI, 2004b).

One result is a recommendation that the Mat-Su Borough prepare an updated Flood Mitigation Plan. Such a plan would enable the Borough or other entities to qualify for Flood Mitigation Assistance grants. Eligible activities include elevation of structures, relocation of flood-threatened (erosion-prone) insurable structures, and acquisition. Monies are available through a state administered, cost-share program for grants that can cover planning for flood mitigation, technical assistance, and mitigation projects.

In addition, the following is recommended:

- Real estate disclosure is critical in appraising current homeowners and potential homebuyers about flood hazard risk. Disclosure of erosion hazard risk should be required in the real estate transactions.
- Provide local realtors and lending institutions with Global Information System (GIS) copies of the Flood Insurance Rate Maps.
- Utilize GIS and other technologies (e.g. modeling) to analyze erosion risk.
- The Mat-Su Borough should consider seeking public input on utilizing property acquisition as a technique for willing sellers to sell flood-prone property.
- Identify appropriate properties for protection because of flood risks. Depending on public input, the Mat-Su Borough should pursue acquisition, conservation easements, or flood hazard protection regulations.

Some techniques for implementing such non-structural methods are discussed further below.

3.3.1 Zoning And Land Use Change

Zoning along the Matanuska River is described as a “least restrictive” area. This means that there are minimal restrictions on the type of development near the river. In addition to this zoning regulation, land use must comply with the federal Coastal Management Plan requirements near the river. The Mat-Su Borough planning department has proposed more extensive zoning requirements for the Matanuska River area, but these ideas have not been adopted.



An erosion management option involves altering the existing zoning of the area to encourage development that is at lower risk of continual erosion. For example, the City of Palmer or the Mat-Su Borough could use zoning to limit the development of new residences in areas with a high potential for erosion. Zoning and land use issues are politically difficult to resolve and private landowners may be adverse to changes that alter property use or value.

3.3.2 Riparian Setbacks

Setbacks from the river may be another method of ensuring, at least temporarily, that structures are not at risk from erosion of the riverbank. The Mat-Su Borough has setback requirements for the Matanuska River of 75 feet from the high water mark to any structure or footing, although exemptions can be made to come within these limits. However, this setback requirement may not provide an adequate buffer, since 100 linear feet of previously usable land near Circle View Estates eroded in 2004 due to high summer flows.

3.3.3 Public Education

Public education is important in order to relay information to Borough and City officials, potential property owners, developers, and other interested parties who have property interests along the Matanuska River. Real estate transactions particularly should be accompanied by information on erosion risk for affected properties. This information could help influence and alter property use practices in the area voluntarily. Numerous sources such as television, radio, newspapers, real estate professionals, bulletins, flyers, and radio could disseminate information. This would require a long-term effort, avoiding complacency during periods of little active erosion.

3.3.4 Relocation and/or Acquisition

Homes and structures could be relocated to locations away from erosion threats. Public acquisition of conservation easements or whole properties would clearly eliminate the risks to private individuals associated with development of areas at risk. This would likely only occur through voluntary or compensatory methods. Compensation could be an expensive option and may not be acceptable to local landowners.

3.3.5 Anticipated Results

Non-structural approaches can reduce the cost of property damage due to erosion, but are also potentially controversial. Furthermore, non-structural approaches will not eliminate or reduce bank erosion. Costs for these non-structural efforts are potentially much less expensive relative to structural alternatives. They can, however, be difficult to implement.

3.3.6 Advantages

The advantages of a non-structural approach:

- Greatest protection for future development projects.
- Reduces property damage from erosion.
- Enhances riparian habitat.
- Costs could be significantly less than structural alternatives.

3.3.7 Disadvantages

The disadvantages of non-structural approach:

- Community resistance due to perceived loss of property rights.
- Does not reduce erosion.
- Eliminates property from future development potential.

3.4 ALTERNATIVE 4 – COMBINED ACTIONS

This erosion management approach involves a combination of channel removal, bank stabilization, and non-structural approaches. As discussed in Section 3.1, models show that trench excavation may help reduce riverbank and property erosion, but may not be all that is required to reduce this risk. Combined actions may be needed.

The combined action considered in this report is:

- Constructing **bank stabilization structures** where bank erosion is at greatest risk. This includes a combination of spur dikes and riprap.
- Adopting new, **non-structural** policies and/or regulations regarding land use planning, zoning, and setbacks for undeveloped land.
- Implementing an annual **gravel removal** operation. Excavation should take place in reaches prone to high velocities and shear stresses that undermine the bank and cause erosion, such as the lower two of three reaches studied for this report. The mining areas would be determined by refining the modeling presented in this report and targeting areas to be protected.

3.4.1 Advantages

The advantages of Alternative 4 include:

- Most effective of the studied alternatives for erosion management.
- Possible revenue generation from gravel mining.
- Ability to transfer the thalweg of the river away from the susceptible banks.
- Ability to dynamically manage river process changes as they occur.
- Immediate protection of erosion prone areas.
- Development along river remains an option due to protection.
- Possible increase in nearby property values.
- Protection of riparian habitat on land protected from human occupation.

3.4.2 Disadvantages

The disadvantages of Alternative 4 include:

- Loss of some future land development opportunities.
- Winter gravel removal operation challenges.
- Potential groundwater control challenges for gravel removal operation.
- Gravel removal operation revenues not guaranteed, value of gravel and markets are variable.
- Gravel removal operation must be continuous, adaptive, and long-term.
- Spur dike or riprap stabilization generally does not create favorable habitat for aquatic life due to lack of vegetation and cover.

- Bank stabilization structures create the need for a long-term maintenance program.

3.5 ALTERNATIVE 5 – NO ACTION

The No Action Alternative would include leaving the river, banks, zoning, and land use as is. This alternative would maintain current river dynamics with frequent wild fluctuations in river routing and significant erosion within several areas in the study area. No bank protection would be added, and land use would remain as currently practiced. The results of erosion mapping by **nbc** include a map of the predicted 50-year erosion and the 50-year erosion boundary (Figure 2-7) if no future action is taken. The project team interpreted this map into zones of high, medium, and low risk of future erosion (Figure 3-3). Almost 10 miles of the Matanuska River banks in the Study Area are potentially at high risk of erosion.

3.5.1 Advantages

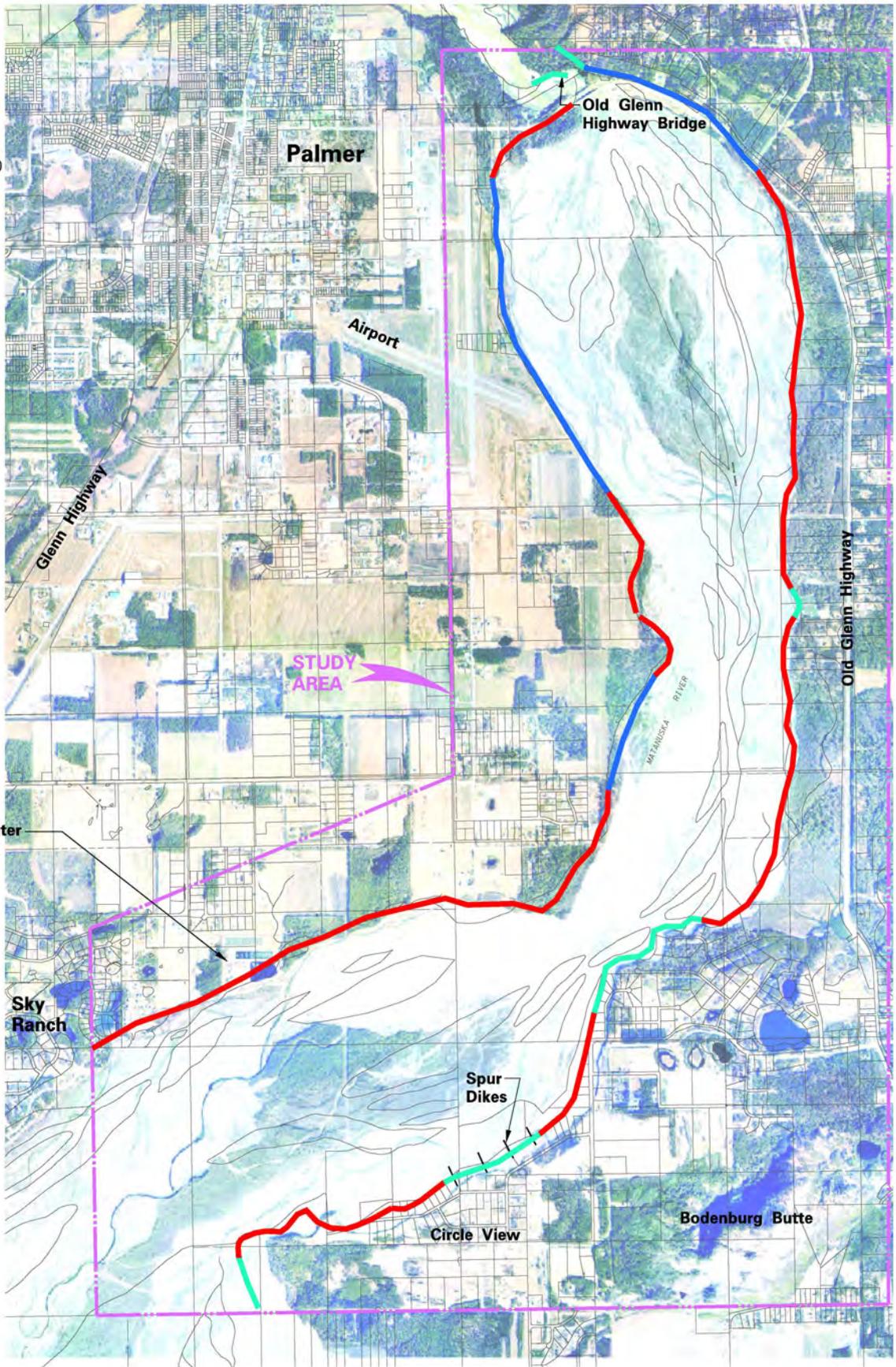
The advantages of Alternative 5 include:

- No short-term costs.
- No additional regulations to landowners.
- No planning or permitting efforts required.
- No loss of aquatic habitat due to structural approaches.

3.5.2 Disadvantages

The disadvantages of Alternative 5 include:

- Continued risk of erosion of property near Circle View Subdivision and other areas along almost 10 miles of Matanuska River bank in the Study Area.
- Risk of avulsion of the main river channels, resulting in erosion to areas not currently under erosion pressure.
- Continued lack of zoning and land use requirements.
- Catastrophic erosion could be politically unacceptable and possibly legally risky if bank protection efforts are not made.
- Costs to private landowners to protect property.



EROSION RISK

- HIGH
- MEDIUM
- LOW

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FIGURE 3-3

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 MATANUSKA RIVER EROSION ASSESSMENT – DESIGN STUDY REPORT
ZONES OF EROSION RISK POTENTIAL

4.0 COMPARISON OF ALTERNATIVES

This section presents a comparison of the five alternatives in terms of feasibility, cost, and environmental consequences. The cost subsection includes the current value of life cycle cost and its equivalent average annual cost.

4.1 FEASIBILITY

Several factors affect the feasibility of each alternative:

- Bank Protection Effectiveness – If installed as planned, what level of protection from erosion is provided?
- Technical Difficulty – How difficult is the alternative to construct or implement?
- Institutional Feasibility – What government agencies will be involved, how difficult is the permitting and regulatory process?
- Inspection and Maintenance Requirements – What is the required inspection frequency and maintenance effort?

These factors are compared in Table 4-1.

Table 4-1 Comparison of Feasibility of Alternatives

Alternative	Bank Protection Effectiveness	Technical Difficulty	Institutional Feasibility	Inspection And Maintenance Requirements
Gravel Removal	Moderate	High	High permitting constraints	Continuous/High
Bank Stabilization (riprap and spur dikes)	High	Moderate	Moderate permitting constraints	Yearly/Moderate
Non-Structural Approaches	Low	High	Local authorization (City and Borough) needed; Highly political.	Infrequent/Low
Combined Actions	Highest	High	High permitting constraints; many stakeholders involved.	Continuous/High
No Action	Low	Low	Locally controversial	None

4.2 COST AND BENEFITS

It is beyond the scope of this study to provide preliminary engineering of a preferred alternative. Hence, cost estimates are conceptual and based on typical elements, plans, and sections associated with the design concepts presented in Section 4.2.1.

4.2.1 Design Concepts

4.2.1.1 Gravel Removal

The concept is a trench or series of trenches 10 feet deep, 500 feet wide, and of various lengths from 2,500 to 6,500 feet (Figure 4-1). A gravel trap 1,150 feet wide and 16 feet deep is required for each 10,000 feet of trench. Other elements include an access road and a stockpile area on the alluvial terrace. Placement of the trenches and other elements must be determined during the design phase.

For purposes of conceptual cost estimating, the project team made the following assumptions for the initial excavation of the trenches and gravel trap:

- Use of four excavators and twenty 22-yard end dump trucks for initial excavation.
- Dump trucks make 24 round trips per day.
- Excavate and remove for 250 days.
- Monthly equipment lease rates.

The project team made the following assumptions for the annual excavation and gravel removal:

- 500,000 tons of removal per year.
- Use of two excavators and ten 22-yard end dump trucks for annual excavation.
- Dump trucks make 24 round trips per day.
- Excavate and remove for 59 days.
- Monthly equipment lease rates.

4.2.1.2 Bank Stabilization

The two design concepts are riprap (Figure 4-2) and spur dikes (Figure 4-3). Two types of riprap are shown. The moderate riprap is for use on banks adjacent to gravel removal trenches. The major riprap is for banks outside of the protection zone from any gravel removal operations.

The scour depth, riprap size, freeboard, and top of riprap must be determined during design. Similarly, the length, riprap coverage and size, angle to bank, and height of spur dikes must be determined during the design phase.

For purposes of conceptual cost estimating, the project team made the following assumptions for moderate riprap:

- Top of riprap will be 12 feet above existing grade.
- Two to one side slope.
- Toe to depth of scour will be 4 feet below existing grade.
- Toe width of 4 feet.
- 2-foot thick riprap on sides and in the toe.

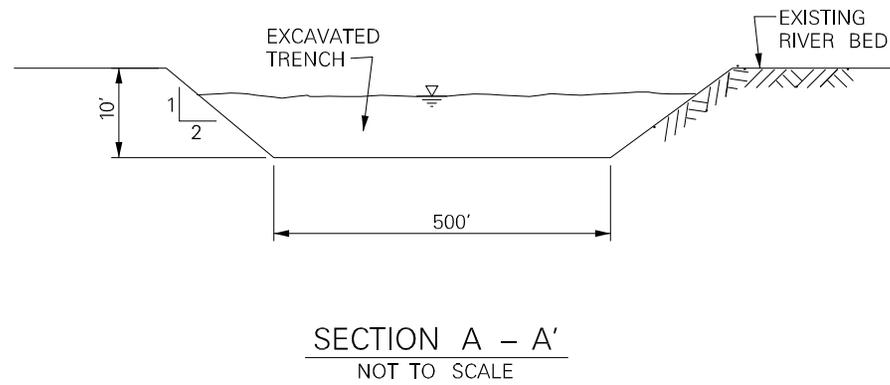
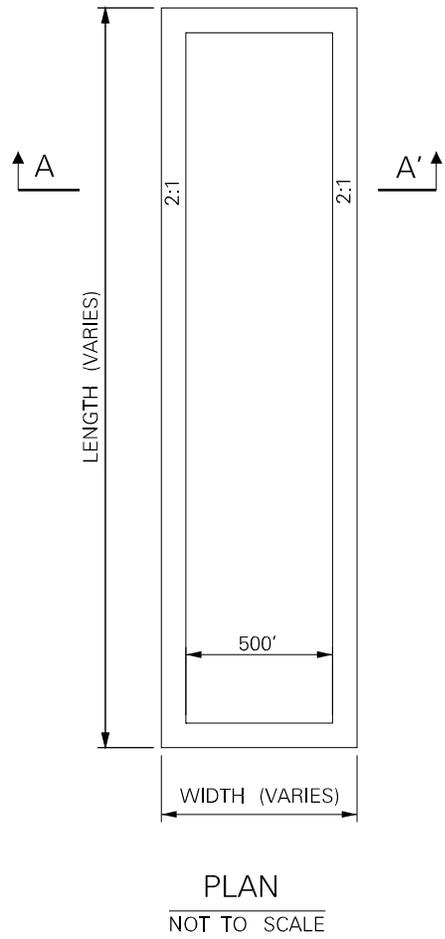
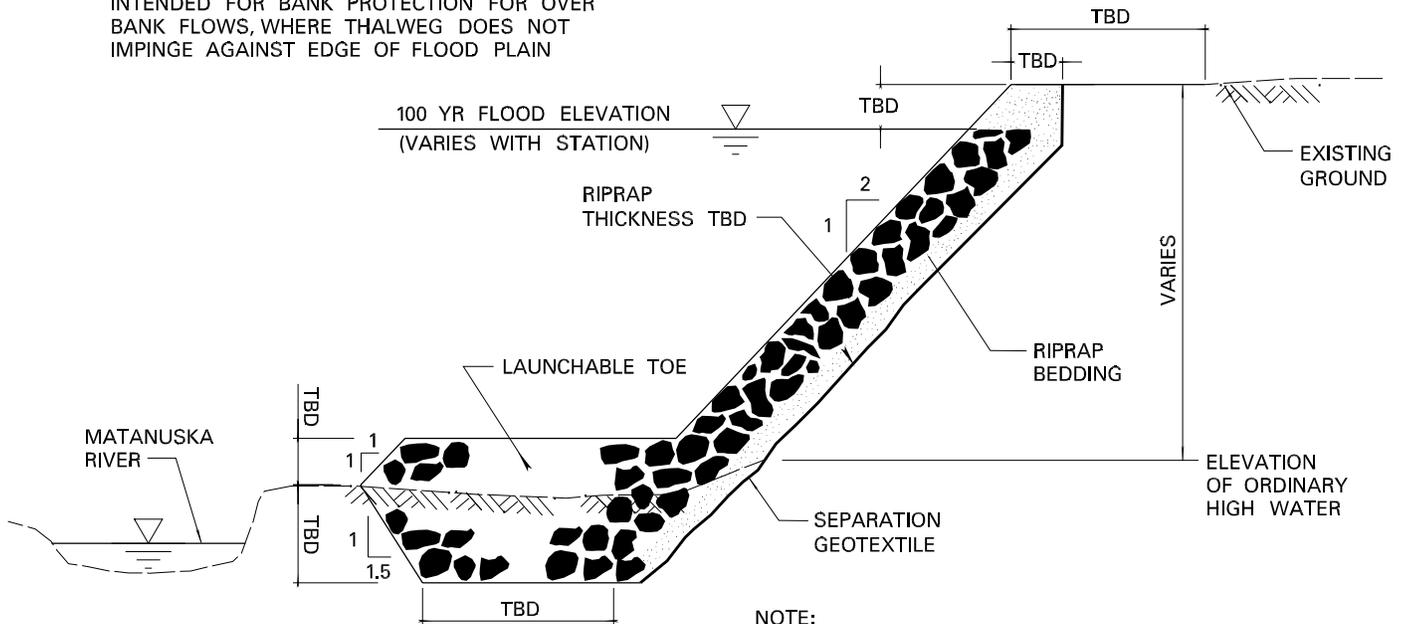


FIGURE 4-1

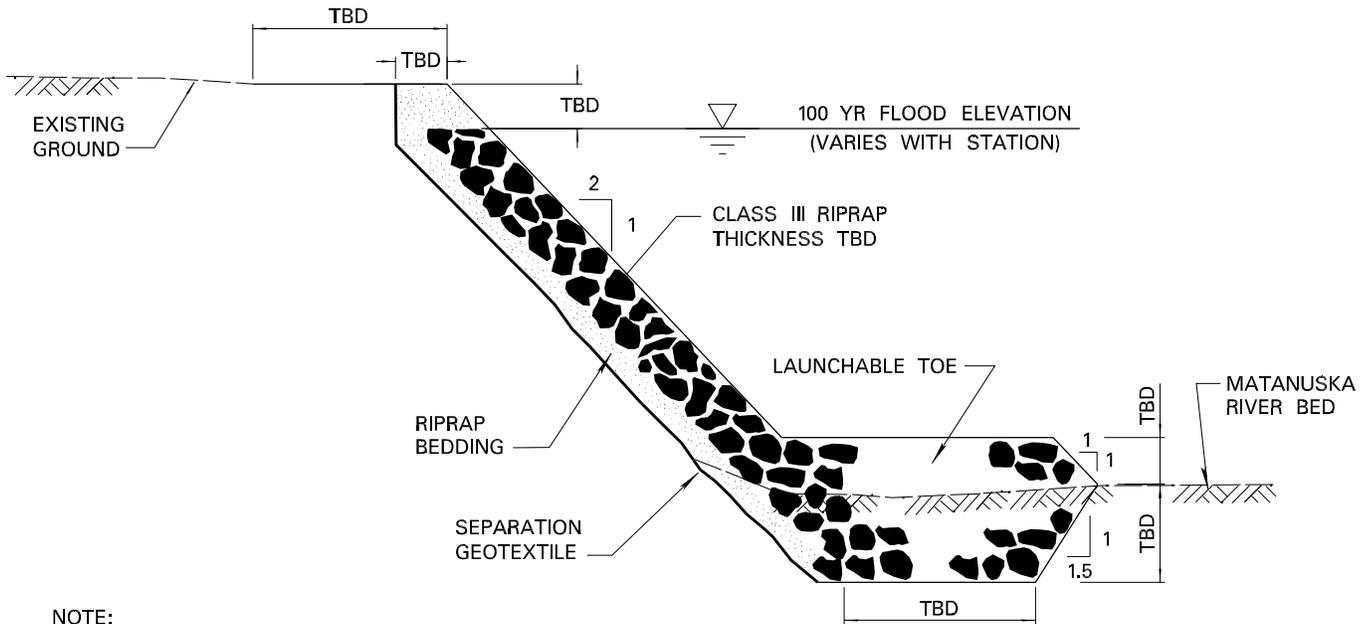
INTENDED FOR BANK PROTECTION FOR OVER BANK FLOWS, WHERE THALWEG DOES NOT IMPINGE AGAINST EDGE OF FLOOD PLAIN



NOTE:
 DEPTHS AND WIDTHS TO BE DETERMINED (TBD)
 DEPENDING UPON SITE SPECIFIC SCOUR DEPTHS,
 BANK HEIGHTS AND RIPRAP THICKNESS

MATANUSKA RIVER BANK STABILIZATION – MODERATE RIPRAP

NOT TO SCALE



NOTE:
 DEPTHS AND WIDTHS TO BE DETERMINED (TBD)
 DEPENDING UPON SITE SPECIFIC SCOUR DEPTHS,
 BANK HEIGHTS AND RIPRAP THICKNESS

MATANUSKA RIVER BANK STABILIZATION – MAJOR RIPRAP

NOT TO SCALE

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FIGURE 4-2

USNRC
 MATANUSKA RIVER EROSION ASSESSMENT – DESIGN STUDY REPORT

RIPRAP BANK STABILIZATION SECTIONS

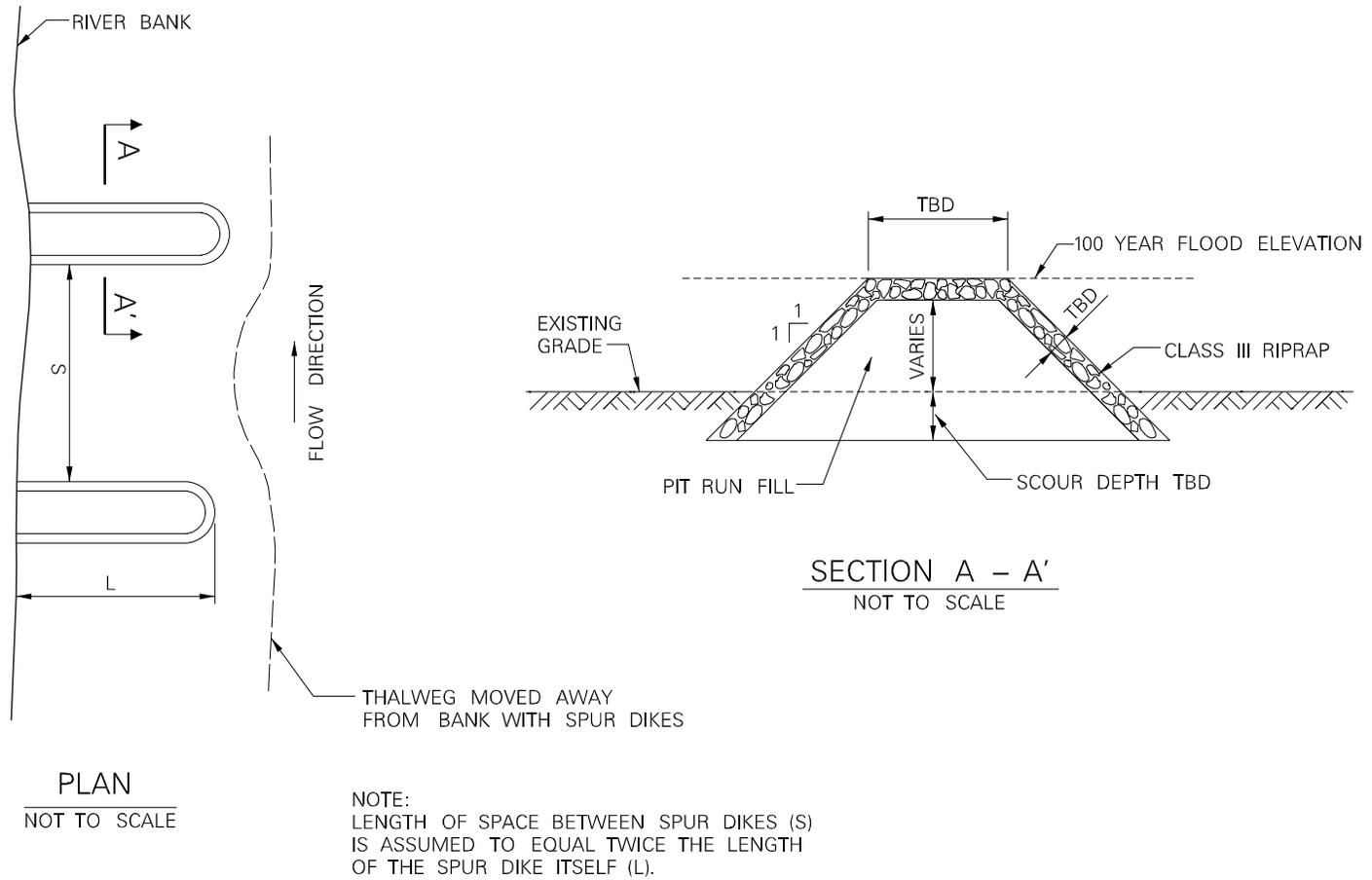


FIGURE 4-3

USNRC
MATANUSKA RIVER EROSION ASSESSMENT - DESIGN STUDY REPORT

SPUR DIKE PLAN AND SECTION

- 6-inch thick bedding material under riprap.
- Annual maintenance equals 2 percent of initial project cost.

For purposes of conceptual cost estimating, the project team made the following assumptions for major riprap:

- Top of riprap will be 16 feet above existing grade.
- Two to one side slope.
- Toe to depth of scour will be 4 feet below existing grade.
- Toe width of 6 feet.
- 3-foot thick Class III riprap on sides and in the toe.
- 6-inch thick bedding material under riprap.
- Annual maintenance equals 2 percent of initial project cost.

For purposes of conceptual cost estimating, the project team made the following assumptions for spur dikes:

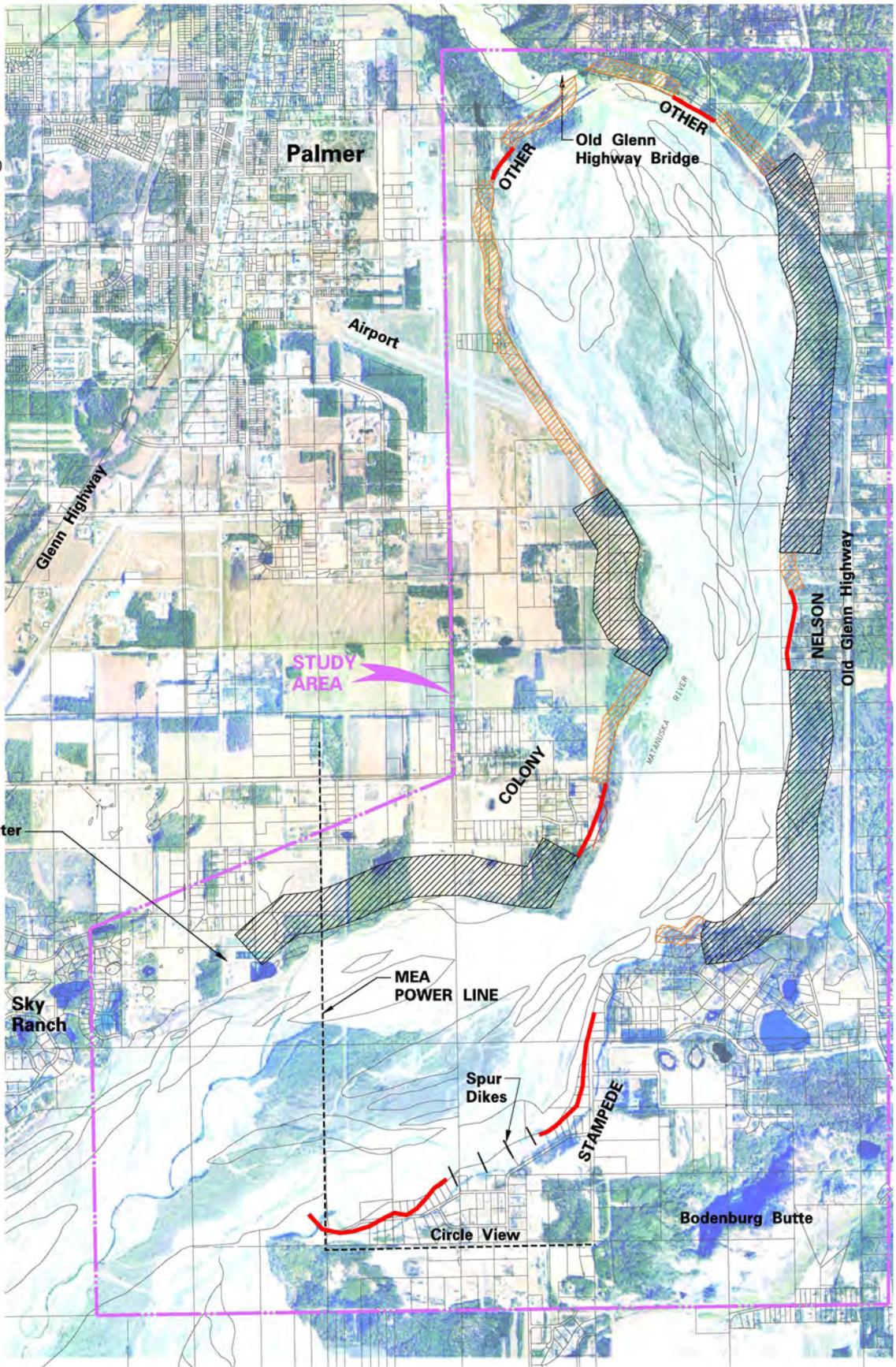
- Length of bank protected equals twice the length of the spur dike.
- Dikes will be 12 feet high and 14 feet wide at the top.
- One to one side slope.
- 3-foot thick Class III riprap on top and sides.
- 6-inch thick bedding material under riprap.
- Excavation and placement of new material 4 feet below existing grade.
- Dikes will be 200 feet long.
- Annual maintenance equals 2 percent of initial project cost.

4.2.1.3 Non-structural Approaches

The design concept is public land purchase or to legally set aside from human occupation land threatened by erosion from the Matanuska River. The project team estimated land value for two primary types of land purchase or protection from occupation: developed and undeveloped. These were further refined to account for the width of the protection zone and the density of the houses in the zone (Figure 4-4).

4.2.1.4 Combined Actions

The design concept is a combination of structural approaches (gravel removal and bank stabilization) and non-structural approaches (Figure 4-5). The project team assumed the total length of bank protection consists of 25 percent each: gravel removal with moderate riprap on one of the adjacent banks, major riprap, spur dikes, and land purchase or set aside. The team further assumed that the land purchased or set aside is undeveloped.

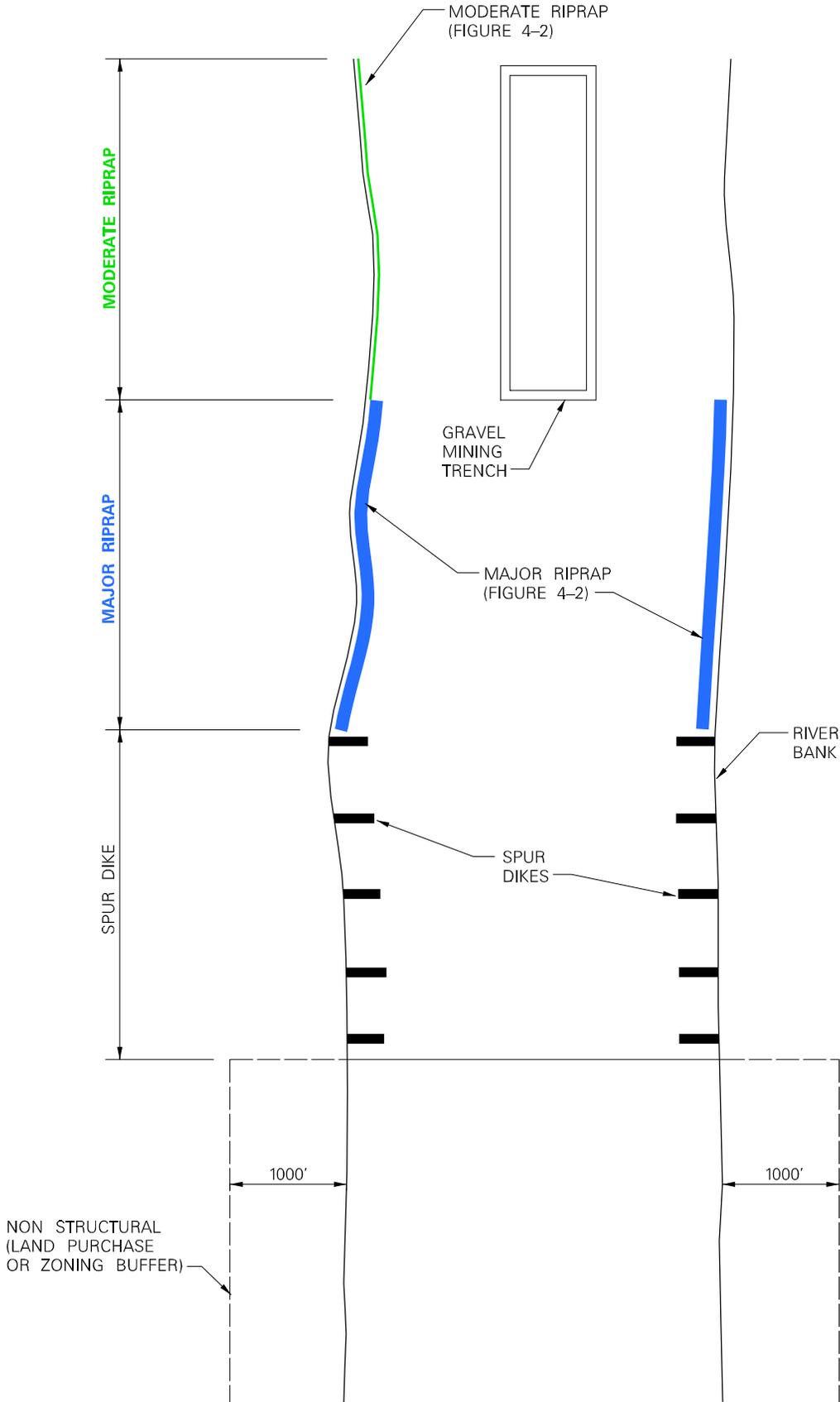


- EROSION RISK**
- DEVELOPED AREAS
 - UNDEVELOPED AREAS 300' WIDTH
 - UNDEVELOPED AREAS 800' WIDTH

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FIGURE 4-4
 USNRC
 MATANUSKA RIVER EROSION ASSESSMENT - DESIGN STUDY REPORT
LAND CLASSIFICATION - NON STRUCTURAL



NOT TO SCALE

FIGURE 4-5

USNRC
MATANUSKA RIVER EROSION ASSESSMENT – DESIGN STUDY REPORT

COMBINED ACTIONS – CONCEPTUAL PLAN

Note that a combined action could include purchase or vacating developed land, but this was not included in the cost estimate. The project team included moderate riprap on one bank for the gravel removal alternative to provide added protection in the event of a major channel shift or avulsion.

4.2.2 Cost Estimates

This section presents an estimate of the initial capital cost and subsequent annual O&M cost for each alternative. Costs are presented as total cost per foot of protected bank

4.2.2.1 Gravel Removal

The initial capital and annual O&M cost estimates for gravel removal are presented in Table 4-2.

Table 4-2 Initial Capital and Annual O&M Costs of Gravel Removal

Item	Unit	Cost Per Unit (\$)	# Units Per Foot of Protected Bank	Cost Per Foot (\$)
Initial Capital Cost				
Excavate Trenches	Cubic Yard	2.3	193	447
Excavate Gravel Pit	Cubic Yard	2.3	76	175
Access Track	Foot	10	0.5	5
Stockpile Area	Acre	3500	0.002	7
Mobilization And Office	Lump Sum	160,000	0.0001	16
Engineering And Surveying	Lump Sum	105,000	0.0001	11
Total				661
Annual O&M Cost				
Excavate Gravel Pit and Trenches	Cubic Yard	2.4	32	75
Annual Mobilization and Demobilization	Lump Sum	65,000	0.0001	7
Annual Engineering, Permitting, and Surveying	Lump Sum	105,000	0.0001	11
Total				93

Key:

O&M – operation and maintenance

Marketing the gravel can offset the cost of gravel removal. The 2004 price list from AAA Valley Gravel, Inc. indicates pit run gravel at \$3.00 per ton, or \$4.50 per cubic yard. Annual revenues at \$3.00 per ton would be approximately \$1.5 million, or about \$150 per foot of protected bank. However, there will be added costs associated with preparing the stockpiled material for sale and bringing the gravel to market.

It appears that selling the gravel at fair market value can offset most and probably all of the annual cost of gravel removal. Therefore, in the current value analysis presented in Section

4.2.3, the annual O&M cost for gravel removal operations equals the revenues received from gravel sale, resulting in a no net annual cost.

4.2.2.2 Bank Stabilization

The bank stabilization design concepts evaluated in this cost estimate include major riprap, moderate riprap, and spur dikes. The initial capital and annual O&M cost estimates for bank stabilization utilizing major riprap are presented in Table 4-3.

Table 4-3 Initial Capital and Annual O&M Costs of Bank Stabilization – Major Riprap

Item	Unit	Cost Per Unit (\$)	# Units Per Foot of Protected Bank	Cost Per Foot (\$)
Initial Capital Costs				
Excavation	Cubic Yard	8.0	1.0	8
Place Riprap	Ton	150	7.8	1,167
Place Bedding	Ton	3.5	1.1	4
Geotextile	Square Yard	1.3	4.0	5
Design, Permitting, and Surveying	Lump Sum	120,000	0.0003	40
Mobilization	Lump Sum	36,000	0.0003	12
Total				1,236
Annual O&M Costs				
Maintenance	Annual Cost	73,880	0.0003	25
Total				25

Key:
O&M – operation and maintenance

The initial capital and annual O&M cost estimates for bank stabilization utilizing moderate riprap are presented in Table 4-4.

Table 4-4 Initial Capital and Annual O&M Costs of Bank Stabilization – Moderate Riprap

Item	Unit	Cost Per Unit (\$)	# Units Per Foot of Protected Bank	Cost Per Foot (\$)
Initial Capital Costs				
Excavation of Toe	Cubic Yard	8.0	0.6	5
Place Riprap	Ton	100	4.2	419
Place Bedding	Ton	3.5	0.8	3
Geotextile	Square Yard	1.3	3.0	4
Design, Permitting, and Surveying	Lump Sum	120,000	0.0003	40
Mobilization	Lump Sum	15,000	0.0003	5
Total				483
Annual O&M Costs				
Maintenance	Annual Cost	37,533	0.0003333	13
Total				13

Key:
O&M – operation and maintenance

The initial capital and annual O&M costs for bank stabilization utilizing spur dikes are presented in Table 4-5.

Table 4-5 Initial Capital and Annual O&M Costs of Bank Stabilization – Spur Dikes

Item	Unit	Cost Per Unit (\$)	# Units Per Foot of Protected Bank	Cost Per Foot (\$)
Initial Capital Costs				
Excavation	Cubic Yard	6.0	3.0	18
Place Riprap	Ton	150	4.3	640
Place Bedding	Ton	3.5	5.0	17
Mobilization	Each Spur Dike	3,000	0.0025	8
Engineering, Permitting, and Surveying	Each Spur Dike	9,000	0.0025	23
Total				706
Annual O&M Costs				
Maintenance	Annual Cost	5600	0.0025	14
Total				14

Key:

O&M – operation and maintenance

4.2.2.3 Non-structural Approaches

The non-structural design concepts evaluated in this cost estimate include purchasing developed and undeveloped land. Undeveloped land is valued at \$10,000 per acre. A developed parcel was valued at the average home price in Palmer and Wasilla (\$125,000). This base value was adjusted upward to \$150,000 or \$200,000 per home in order to consider the development of the property in specific subdivisions with known area conditions. The study area was subdivided into reaches of developed or undeveloped land with one of the following characteristics:

- Undeveloped land with a protection zone width of 300 feet.
- Undeveloped land with a protection zone width of 800 feet.
- Developed land in the Circle View/ Stampede area, with a protection zone width of 800 feet.
- Developed land in the Colony Subdivision area, with a protection zone width of 800 feet.
- Developed land in the Nelson Subdivision area, with a protection zone width of 800 feet.
- Developed land in other areas, with a protection zone width of 200 feet.

The initial capital and annual O&M cost estimates are presented in Table 4-6.

Table 4-6 Initial Capital and Annual O&M Costs Of Non-Structural Approach – Developed and Undeveloped Land

Item	Unit	Cost Per Unit (\$)	# Units Per Foot Of Protected Bank	Cost Per Foot (\$)
Initial Capital Costs				
Undeveloped Land (300 feet wide)	Acre	10,000	0.00689	69

Table 4-6 (cont.) Initial Capital and Annual O&M Costs Of Non-Structural Approach – Developed and Undeveloped Land

Item	Unit	Cost Per Unit (\$)	# Units Per Foot Of Protected Bank	Cost Per Foot (\$)
Initial Capital Costs (cont.)				
Undeveloped Land (800 feet wide)	Acres	10,000	0.01837	184
Developed Land: Circle View/Stampede	Home with Land	150,000	0.0013 ¹	200
Colony Subdivision	Home with Land	200,000	0.0027 ¹	533
Nelson Subdivision	Home with Land	150,000	0.0020 ¹	300
Other Developed Area	Home with Land	125,000	0.0010 ¹	125
Total				1,411
Annual O&M Costs				
Land (300 feet wide)	Annual Cost	200	0.00689	1
Land (800 feet wide)	Annual Cost	200	0.01837	4
Developed Land ¹ – Circle View/ Stampede	Annual Cost	3,000	0.0013	4
Colony Subdivision	Annual Cost	4,000	0.0027	11
Nelson Subdivision	Annual Cost	3,000	0.0020	6
Other Developed Area	Annual Cost	2,500	0.0010	3
Total				29

Key:

O&M – operation and maintenance

1 – based on width of protected zone and actual number of homes present in that zone.

4.2.2.4 Combined Actions

The initial capital and annual O&M cost estimates for a combined approach are presented in Table 4-7. The project team assumed that only undeveloped land would be considered for purchase under this action, with 50 percent of the undeveloped land having a 300-foot wide protection zone, and 50 percent having an 800-foot wide protection zone.

Table 4-7 Initial Capital and Annual O&M Costs of Combined Actions

Item	Unit	Cost Per Unit (\$)	# Units Per Foot Of Protected Bank	Cost Per Foot (\$)
Initial Capital Cost				
Gravel Operation	Foot of protected bank	661	0.25	165
Moderate Riprap	Foot of protected bank	483	0.25	121
Major Riprap	Foot of protected bank	1,236	0.25	309
Spur Dike	Foot of protected bank	706	0.25	177
Non-structural Approach – Undeveloped Land (300 ft)	Foot of protected bank	69	0.125	9
Non-structural Approach – Undeveloped Land (800 ft)	Foot of protected bank	184	0.125	23
Total				804

Table 4-7 (cont.) Initial Capital and Annual O&M Costs of Combined Actions

Item	Unit	Cost Per Unit (\$)	# Units Per Foot Of Protected Bank	Cost Per Foot (\$)
Annual O&M Costs				
Gravel Operation	Foot of protected bank	93	0.25	23
Moderate Riprap	Foot of protected bank	13	0.25	3
Major Riprap	Foot of protected bank	25	0.25	6
Spur Dike	Foot of protected bank	14	0.25	4
Non-structural Approach (300-ft width)	Foot of protected bank	1	0.125	<1
Non-structural Approach (800-ft width)	Foot of protected bank	4	0.125	<1
Total				37

Key:

< – less than

ft – feet/foot

O&M – operation and maintenance

4.2.2.5 No Action

There is no initial capital cost associated with the No Action Alternative. The annual O&M cost is essentially the market value of the land, which is the current value of land estimated to be lost over the next 50 years. The project team assumed an average annual loss of 1/3-acre per year over a bank length of 1,500 feet, or 10 feet into the upper terrace. Undeveloped land is valued at \$10,000 per acre. Developed land is valued at \$18,000 per acre based on home values from \$125,000 to \$200,000, and the actual location and densities of development in the study area. Home values in the subdivisions were valued at \$150,000 to \$200,000. With these assumptions, the average annual cost of lost land is \$2 per foot of bank for undeveloped land and \$4 per foot of bank for land with structures (developed land).

4.2.3 Cost and Benefit Comparison

Section 4.2.2 presents the estimated cost of each erosion management alternative as initial capital and annual O&M in dollars per foot of bank protected. This section presents these costs adjusted back to current value of life cycle cost and equivalent annual cost. The current value computations are based on an annual discount rate of 4 percent and a 50-year life. Table 4-8 compares the cost of the action alternatives to the benefit associated with the No Action Alternative 5 cost.

Table 4-8 Comparison of Costs of Alternatives

Alternative	Initial Capital Cost (\$/ft)	Annual O&M Cost (\$/ft)	Current Value of Life Cycle Cost ¹ (\$/ft)	Equivalent Annual Cost (\$/ft/year)
1. Gravel Removal	661	0 ²	661	31
2. Bank Stabilization	1,236 (major riprap)	25	1,773	83
	706 (spur dikes)	14	1,007	47

Table 4-8 (cont.) Comparison of Costs of Alternatives

Alternative	Initial Capital Cost (\$/ft)	Annual O&M Cost (\$/ft)	Current Value of Life Cycle Cost ¹ (\$/ft)	Equivalent Annual Cost (\$/ft/year)
3. Non-structural Approach ³	248 (developed land)	5	355	17
	135 (undeveloped land)	3	199	9
4. Combined Actions	804	37	1,599	74
5. No Action	None	4 (developed land)	86	4
		2 (undeveloped land)	43	2

Key:

1 – Current value at 4 percent over a 50-year period.

2 – Annual cost is offset by revenue from sale of gravel.

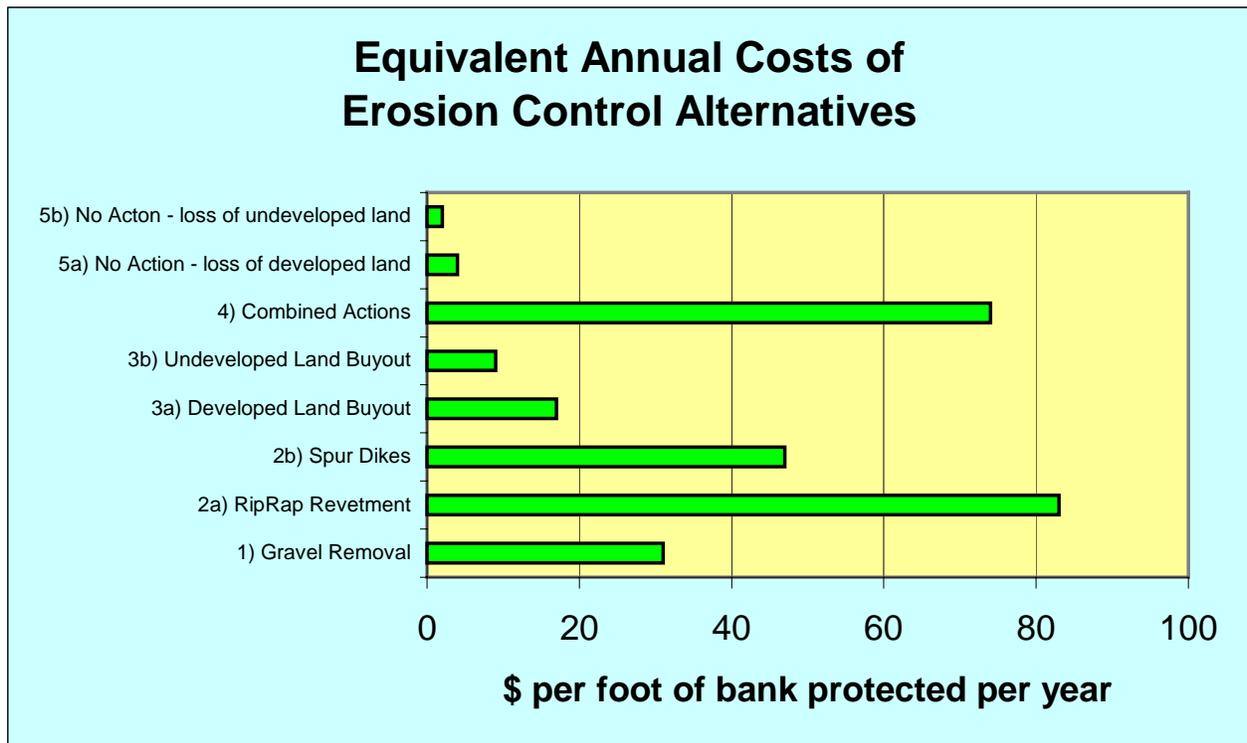
3 – Assumes that this approach is applied to the entire Study Area, costs will vary for specific locations.

\$/ft – dollars per foot

O&M – operation and maintenance

Relative equivalent annual costs of the five erosion control alternatives are illustrated on Figure 4-6. The figure illustrates that the cost of any action alternative exceeds the estimated costs associated with allowing the continued loss of property due to erosion. Buyout of property has the lowest cost of any of the action alternatives, with higher costs associated with gravel removal and structural improvements.

Figure 4-6 Equivalent Annual Costs of Erosion Control Alternatives



4.3 ENVIRONMENTAL CONSEQUENCES

This section provides a comparison of the environmental consequences of each of the five alternatives for erosion management. Table 4-9 provides the project team's definition of significant environmental impact for the physical, biological, and human environments. The baseline condition is equivalent to No Action Alternative 5. This alternative is presented first, since it is the basis on which the project team judged the significance of impacts for the structural and non-structural alternatives.

Erosion control activities are unlikely to significantly alter the character of the Matanuska River and the physical, biological, and social environment of the watershed. Most importantly, the overall flow regime of the river and sediment transport will not be materially affected by any of the alternatives. Stabilization of banks will benefit preservation of the upland riparian outwash terrace and the value of properties potentially affected by continuing erosion. Impacts during construction of erosion control structures may include localized short-term impacts to air and water quality. Such effects are mitigated by permitting through the regulatory authority of the State of Alaska and Federal Government.

Fish habitat has not been quantitatively assessed in the study area. Changes in braided channels induced by gravel excavation or bank stabilization treatments may affect the velocity, depth, and quality of cover associated with the various assemblage of channels at any cross section of the floodplain. However, such effects are expected to be localized and very small compared to the scale of the floodplain and river system.

Table 4-9 Comparison of Environmental Consequences of Alternatives

Topic	Definition of Significant Impact ¹	Alternative 5: No Action Baseline Condition	Alternative 1: Gravel Excavation	Alternative 2: Bank Stabilization	Alternative 3: Non-Structural Approaches	Alternative 4: Combined Bank Stabilization, Gravel Excavation, and Non-structural Approaches
Physical Environment						
Air	A significant impact is one where air emissions from a project result in violation of National Ambient Air Quality Standards or applicable permits.	The area has few vehicle, equipment, or industrial emitters that affect air quality. Air quality is sometimes affected by smoke from forest fires, or dust particles entrained into the air from the Matanuska River floodplain.	Air quality emissions result from heavy equipment use during construction of the gravel-mining infrastructure and ongoing operation. Potential exposure of fine silty material to high winds.	Air quality emissions result from heavy equipment use during construction of the bank protection infrastructure.	No change from baseline condition.	Air quality emissions result from heavy equipment use during construction of the gravel-mining and bank protection infrastructure, and ongoing operation and maintenance.
Topography/ Geology	A significant impact is one where the overall character of the topography or geology is permanently changed.	The broad braided channel of the Matanuska River below the Glenn Highway Bridge is a dominant topographic feature of the landscape, encompassing an area larger than the town of Palmer and nearby suburban development.	Slight change of channel topography due to excavation.	Deepening of some channel reaches at toe of banks.	No change from baseline condition.	Slight change in channel topography due to excavation and deepening at toe of protected banks.
Soil	A significant impact is one where soil is lost from productivity for a long time period.	Soil of the glacial outwash terrace above the Matanuska River floodplain is better developed than the gravel bars and islands existing down on the floodplain. Continued bank failure due to erosion at the margins of the floodplain. Expect loss of 1/3-acre of outwash terrace soil on residential and agricultural land use within the study area on an annual average basis	Containment of flood flows and reduced occurrence of avulsion will allow gradual creation of more complex soil structure over drier portions of the floodplain.	Reduced loss of outwash terrace soil.	No change from baseline condition.	Reduced loss of outwash terrace soil. Containment of flood flows and reduced occurrence of avulsion will allow gradual creation of more complex soil structure over drier portions of the floodplain.
Hydrology	A significant impact is one where surface or ground water flow patterns are disrupted so as to result in down-gradient changes in flood frequency or ground water recharge potential.	Streamflow is a function of climatological patterns within the contributing watershed. Local human actions have no effect on influent flows, except for stream diversions or other consumptive use.	No change from baseline condition.	No change from baseline condition.	No change from baseline condition.	No change from baseline condition.
Water Quantity/ Supply	A significant impact is one that affects ground water recharge to the extent that a measurable shift occurs in water table elevations, lake levels, or streamflow.	Water levels at typical streamflow levels have potential to affect ground water elevations in wells on the adjacent glacial outwash terrace.	Projected changes in stream water levels would not result in a significant change in water tables.	Projected changes in stream water levels would not result in a significant change in water tables.	No change from baseline condition.	Projected changes in stream water levels would not result in a significant change in water tables.
Stream Geomorphology	A significant impact is one where surface flow patterns are disrupted so as to result in down-gradient changes in stream types or groundwater recharge potential.	Stream systems currently are in dynamic equilibrium associated with channel dimensions, patterns, and profile gradient and sediment transport regime. River continues to avulse in response to changes in sediment transport with respect to flow.	River induced into central deepwater channels, diverting channels away from eroding stream bank, but potentially concentrating flow flowing out of constructed channels. Bank will still be subject to attack during avulsion.	Bank protection will likely amplify flow in the channel at the toe, leading to increasing depths and velocities adjacent to the hardening spurs or riprap.	No change from baseline condition.	River induced into central deepwater channels, diverting channels away from eroding stream bank, but potentially concentrating flow flowing out of constructed channels. Bank protection will likely amplify flow in the channel at the toe, leading to increasing depths and velocities adjacent to the hardening spurs or riprap.

Table 4-9 Comparison of Environmental Consequences of Alternatives

Topic	Definition of Significant Impact ¹	Alternative 5: No Action Baseline Condition	Alternative 1: Gravel Excavation	Alternative 2: Bank Stabilization	Alternative 3: Non-Structural Approaches	Alternative 4: Combined Bank Stabilization, Gravel Excavation, and Non-structural Approaches
Physical Environment (cont.)						
Sediment Transport	A significant impact changes the net transport of material carried by the river and affects the character and distribution of sediments in downstream channel environments.	Annual transport of sediment by the river through the Study Area is flow-dependant, but expected to be on the order of 6 million tons per year. Sediment transport remains highly variable, with little predictable behavior of the channel from year-to-year. Bank erosion contributes to downstream sediment load.	Capture of sediment by excavated channels is likely, and will require maintenance and additional gravel removal over time to ensure the continued functionality of gravel mining as an erosion control step.	Hardened bank can lead to more depth and scour at edge of stream. Potential deposition of sediments between spur dikes.	No change from baseline condition.	Capture of sediment by excavated channels is likely, and will require maintenance and additional gravel removal over time to ensure the continued functionality of gravel mining as an erosion control step. Hardened bank can lead to more depth and scour at edge of stream. Potential deposition of sediments between spur dikes.
Water Quality	A significant impact is one that results in a measurable degradation of water quality in violation of State of Alaska Water Quality Standards.	The Matanuska River experiences huge variations in turbidity in conjunction with glacial discharges and associated channel sediment mobilization. Erosion has launched materials potentially contaminated with petroleum products and fertilizer from homesites and farms into the river. Discharge of contaminants is viewed as insignificant in comparison to overall streamflow.	Potential for introduction of contaminants from equipment in the riverbed. Potential increase in turbidity during low flow period due to excavation. Potential for modest reduction in turbidity at margin of river associated with concentration of discharge in channel and concurrent settlement of suspended load. Reduced erosion of potentially contaminated residential, industrial, and farmlands.	Potential for introduction of contaminants from construction equipment in the floodplain. Reduced erosion of potentially contaminated residential, industrial, and farmlands.	Same erosion of potentially contaminated residential, industrial, and farmlands as baseline condition. Reduced future potential due to curtailment of development.	Potential for introduction of contaminants from construction equipment. Potential increase in turbidity during low flow period due to excavation in gravel removal reaches. Reduced erosion of potentially contaminated residential, industrial, and farmlands.
Biological Environment						
Vegetation	A significant impact is one where a shift occurs in the general distribution of vegetation types in the Study Area, or there is a loss of viability of unique populations or uncommon species.	Vegetation on the Matanuska River floodplain is limited. Immigrant populations of alder, willow, and other pioneer species establish within a few years of a channel change resulting from episodic sediment deposition. Continued loss of riparian fringe vegetation. More mature forest types are lost from the glacial outwash terrace as erosion occurs along forested banks.	Potential increased diversity on the river bank through protection of vegetative communities. Limited change on floodplain to vegetation diversity or quantity anticipated.	Limits loss of riparian vegetation in concert with bank protection. May require some vegetation removal to accomplish stabilization. Optionally, may incorporate new vegetative plantings as stabilization method.	Continued loss of riparian fringe vegetation. Potential to preserve natural habitat as a component of land development restriction.	Limits loss of riparian vegetation in concert with bank protection. May require some vegetation removal to accomplish stabilization. Potential increased diversity through establishment of new vegetative communities on the fringe of the floodplain. Optionally, may incorporate new vegetative plantings as stabilization method.
Wetlands	A significant impact is one that results in a change in the relative distribution of wetland types, or loss of unique or uncommon wetland functions in the Study Area. A loss of wetlands is considered to be significant under the Clean Water Act and Executive Order 11990.	U.S. Fish and Wildlife Service has identified wetlands on a regional scale through its National Wetlands Inventory. The three types in the Project Area are riverine, freshwater/shrub wetland, and freshwater emergent wetland.	Requires analysis of potential wetland creation by virtue of excavation in the floodplain.	Some potential for encroachment on riparian wetlands through construction of structural improvements	Potential to preserve wetlands as a component of land development restriction.	Requires analysis of potential wetland creation by virtue of excavation in the floodplain. Some potential for encroachment on riparian wetlands through construction of structural improvements. Potential to preserve wetlands as a component of land development restriction.

Table 4-9 Comparison of Environmental Consequences of Alternatives

Topic	Definition of Significant Impact ¹	Alternative 5: No Action Baseline Condition	Alternative 1: Gravel Excavation	Alternative 2: Bank Stabilization	Alternative 3: Non-Structural Approaches	Alternative 4: Combined Bank Stabilization, Gravel Excavation, and Non-structural Approaches
Biological Environment (cont.)						
Fish	A significant impact is one that results in direct loss of high value anadromous or resident fish habitat (e.g. known spawning, rearing, or over-wintering areas); restriction of fish passage; or direct mortality or measurable sub-lethal effects on the sustainability of regional fish populations.	Fish use of the Matanuska River includes passage to tributary spawning, rearing, and over-wintering areas, and depends on a system of channels providing variety of conditions with respect to cover, depth, velocity, water quality, temperature, and food supply. Hard data on Matanuska River fish resources is limited, so the effect of changes to habitat is largely speculative. Continued high degree of variability of habitat type in time and place, depending on streamflow and degree of channel avulsion and large woody debris transport. Diversity of habitat dependent on streamflow variability and amount of side-channels and sloughs.	Potential excavation in river during fish migration periods. Velocities and depth generally decrease at river margins.	Velocities and depth generally increase at river margins.	No change from baseline condition.	Potential excavation in river during fish migration periods. Some increase and some decrease in velocities and depth at river margins.
Birds	A significant impact is one that results in: loss of high value habitat; measurable effects on distribution, abundance, or movement in the project area; or in direct mortality or measurable sub-lethal effects on the sustainability of regional bird populations.	The broad gravel floodplain of the Matanuska River supports use by many species of raptors, waterfowl, shorebirds, and passerines. The relative abundance and distribution of avian life in braided floodplains versus upland wooded areas is undocumented. Potential loss of nesting in riparian wooded areas due to erosion.	Limited potential for effects to bird use. Some loss of shorebird habitat associated with earthmoving activities on the floodplain. Some potential for reduction of habitat loss due to erosion.	Some loss of shorebird habitat associated with earthmoving activities on the edge of the floodplain. Some potential for reduction of habitat loss due to erosion.	Protecting upland riparian lands from human occupation may improve potential for avian habitat. However, potential remains for reduction of habitat loss due to erosion.	Some loss of shorebird habitat associated with earthmoving activities on the floodplain. Some potential for reduction of habitat loss due to erosion. Protecting upland riparian lands from human occupation may improve potential for avian habitat.
Mammals and Other Wildlife	A significant impact is one that results in: loss of high value habitat; measurable effects on wildlife distribution, abundance, or movements in the project area; or in direct mortality or measurable sublethal effects that affect the sustainability of regional populations.	Upland wooded areas generally support a richer and more diverse system than the barren gravel floodplain. Loss of uplands to erosion has consequential loss of habitat. Two significant mid-river bars provide habitat.	Some loss of habitat associated with earthmoving activities on the floodplain. Potential for reduction loss of upland wooded areas due to erosion.	Some loss of habitat associated with earthmoving activities on the edge of the floodplain. Potential for reduction loss of upland wooded areas due to erosion.	Protecting upland riparian lands from human occupation may improve potential for wildlife habitat. However, potential remains for loss of uplands to erosion and consequential loss of habitat.	Some loss of habitat associated with earthmoving activities on the floodplain. Potential for reduction loss of upland wooded areas due to erosion. Protecting upland riparian lands from human occupation may improve potential for wildlife habitat.
Threatened and Endangered Species	A significant impact is one that results in a taking, including disturbance, or a loss or alteration of critical habitat.	There are no known threatened or endangered species in the Study Area. Therefore, the project cannot result in a disturbance, loss, or alteration of critical habitat. No impact reasonably foreseen.	No impact reasonably foreseen.	No impact reasonably foreseen.	No change from baseline condition.	No impact reasonably foreseen.
Human Environment						
Land Use	A significant impact is one that results in a project being inconsistent with laws and regulations, or approved land use plans or policies.	Loss of 1/3-acre of land of unzoned use on an average annual basis. Erosion may result in loss of powerline in the future.	Reduced land loss.	Reduced land loss. Better protection than Alternative 1.	No change from baseline condition.	Further reduction in potential for loss of upland areas.

Table 4-9 Comparison of Environmental Consequences of Alternatives

Topic	Definition of Significant Impact ¹	Alternative 5: No Action Baseline Condition	Alternative 1: Gravel Excavation	Alternative 2: Bank Stabilization	Alternative 3: Non-Structural Approaches	Alternative 4: Combined Bank Stabilization, Gravel Excavation, and Non-structural Approaches
Human Environment (cont.)						
Socioeconomics	A significant impact is one that results in a measurable shift in the volume of economic activity, or where increased population and demand for services cannot be accommodated by existing infrastructure.	Damage associated with property loss due to erosion amounts to \$3,500 on an average annual basis for undeveloped property and \$70,000 for developed property. Potential loss of powerline.	Introduces new construction jobs and 24 long-term seasonal gravel-mining operation jobs. Provides sand and gravel building materials for large-scale projects. May increase or decrease land values, and associated Borough property tax income, depending on the land location and immediate threat to erosion.	Introduces new construction jobs and periodic maintenance jobs. Protects land values and Borough property tax income.	Potential changes in land development and Borough tax revenue to reserve lands from human occupation. Reduces road and other infrastructure maintenance and upgrade costs.	Introduces new construction jobs, 24 gravel-mining operation jobs annually, and periodic maintenance jobs annually. Provides sand and gravel building materials for large-scale projects. Protects land values and Borough property tax income.
Cultural Resources	A significant impact is one where there would be a loss or degradation of archeological or historic sites.	Reworking of the floodplain by the braided stream channel limits the significance of the Matanuska River as a resource area for archaeological or historic sites.	Unlikely to encounter cultural sites on floodplain.	Bank protection improvements may require cultural resource screening of affected areas.	Potential to identify high-risk bank erosion areas for cultural resource evaluation.	Bank protection improvements may require cultural resource screening of affected areas.
Visual Resources	A significant impact occurs where the nature of the vista accessible to the public is changed by project features or activities.	Public access to viewpoints over the river floodplain is limited. Changes resulting from improvements and ongoing activities are expected to be minimal.	Gravel extraction activities not likely to encourage viewpoint development	Viewpoint development could be associated with bank protection projects, but depends on public accessibility.	Viewpoint development could be associated with land reservation from human occupation.	Viewpoint development could be associated with bank protection projects, but depends on public accessibility.
Noise	A significant impact is one where the duration, frequency, or level of noise is increased over ambient levels so that human or wildlife uses are measurably changed.	Existing noise levels include air traffic, highway traffic, and existing mining operations.	Some noise associated with construction and operations. Not significant compared to other sources.	Some noise associated with construction. Not significant compared to other sources.	No change from baseline condition.	Some noise associated with construction and operations. Not significant compared to other sources.
Recreational Resources	A significant impact is one that results in a measurable shift in the volume or type of recreational use over time, or a measurable change in the quality of the recreational experience for most users.	Little documentation of the amount of recreational floodplain use is available to make comparisons. However, the floodplain is used for recreational purposes.	Long-term gravel extraction activities may interfere with current recreational uses.	Bank protection projects may encourage recreational development or floodplain access.	Good potential to develop recreational use and floodplain access.	Long-term gravel extraction activities may interfere with current recreational uses. Bank protection projects may encourage recreational development or floodplain access. Good potential to develop recreational use and floodplain access on lands reserved from human occupation.
Subsistence Use	A significant impact is one that results in a measurable shift in subsistence resources, use or access.	Little documentation of subsistence use in the Matanuska River floodplain is available to make comparisons.	No effect anticipated.	No effect anticipated.	No change from baseline condition.	No effect anticipated.

Key:

1 – There are no significant impacts to the physical, biological, or human environments from any of the alternatives; however, the character of potential impacts is presented for comparison.

5.0 LIST OF PREPARERS

A list of the personnel, companies, and agencies involved in preparing this Design Study Report is provided below.

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6.0 REFERENCES

(***Bold, italics*** indicates the appendix in this report where the referenced report is located.)

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- MWH. 2004b. Bed Material Sampling Program. Technical Memorandum. Prepared by K. Ivarson, MWH, for the NRCS Matanuska River Erosion Project. March 16. (*Appendix C*)
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- MWH. 2004f. Permitting, Regulatory, and Environmental Constraints. Technical Memorandum. Prepared by K. Ivarson, MWH, for the NRCS Matanuska River Erosion Project. August 25. (*Appendix G*)
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- nhc.** 2004d. Matanuska River Erosion Assessment Progress Report – Bank Erosion Mapping. Prepared for MWH Americas, Inc. for the NRCS Matanuska River Erosion Project. March. (*Appendix F*)
- nhc.** 2004e. MIKE-21 Model of the Matanuska River near Palmer, Alaska. Technical Memorandum. Prepared for MWH Americas, Inc. for the NRCS Matanuska River Erosion Project . September 8. (*Appendix E*)
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- Reason for discharge of fill materials.
- Surface area (in acres) to be affected.
- List of adjoining property owners.
- List of other applications that have been submitted.
- Illustrations with a site vicinity map, a plan view map, and a cross section map.

Following filing of the completed permit, the USACE then has 15 days to publish a public notice of the proposed action. The public must have the opportunity for public hearings, with an unspecified public comment period. In addition, other government agencies may be asked to provide comment, including the U.S. Fish and Wildlife Service (USFWS). Agencies have 120 days to provide comments.

- Formal Consultation (National Marine Fisheries Service [NMFS])

The NMFS, a division of the National Oceanographic and Atmospheric Administration (NOAA) provides the USACE opinions of the proposed issuance of permits under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. The consultation is conducted by the USACE with all information provided through the Section 404 Permit.

- National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) for Discharge of Stormwater from Construction Activities (U.S. Environmental Protection Agency [EPA])

An NPDES permit will be required if there is de-watering or discharge, etc., during the construction and operations stage of a project, in compliance with the CWA. Permit coverage is required from the "commencement of construction activities" until "final stabilization." The permit includes requirements for a notification of intent to construct, stormwater pollution prevention plan (SWPPP) development and implementation, Endangered Species Act review procedures, management activities, reporting, monitoring, operations and maintenance, and notice of termination of activities.

- Endangered Species Act (EPA and U.S. Fish and Wildlife Service [USFWS])

The EPA must conduct a Section 7 consultation with the USFWS regarding any threatened or endangered species that might be affected by the proposed project. The level of required informal or formal consultation will depend on whether listed species occur in the project area, and, if so, whether they likely will be affected by the proposed project. If listed species occur in the area and they likely will be affected, then the EPA and USFWS will undergo the formal consultation process. This is typically an involved process that results in measures designed to minimize the impact of the project on listed species.

The USFWS also provides technical expertise and makes comments and recommendations to federal agencies via the Fish and Wildlife Coordination Act (16 United States Code 661 et. Seq.).

- Title 41 Fish Habitat Permit Application (Alaska Department of Natural Resources [ADNR] Office of Habitat Management and Permitting [OHMP])

Alaska Statute 41.14.840 (Fishways Act) requires that authorization is obtained from ADNR for activities within or across a stream used by fish if the department determines that such

activities could represent an impediment to the efficient passage of fish. ADNR approval is required for the placement or removal of any material or structure below ordinary high water.

Alaska Statute 41.14.870 (Anadromous Fish Act) requires that an individual or governmental agency provide prior notification and obtain approval from ADNR "to construct a hydraulic project or use, divert, obstruct, pollute, or change the natural flow or bed" of a specified anadromous waterbody. The Statute also requires approval "to use wheeled, tracked, or excavating equipment or log-dragging equipment in the bed" of a specified anadromous waterbody. All activities within or across a specified anadromous waterbody, and all instream activities affecting a specified anadromous waterbody require approval from the ADNR. These activities including construction; road crossings; gravel removal; placer mining; water withdrawals; the use of vehicles or equipment in the waterway; stream realignment or diversion; bank stabilization; blasting; and the placement, excavation, deposition, disposal, or removal of any material.

The permit application must include the type of project, location, timing of operations, description of construction methods, a site rehabilitation and restoration plan, the waterbody characteristics and a hydraulic evaluation. The description of the project and proposed construction methods should include a description of the alternatives considered. In addition, detailed project plans need to be included that describe the protective measures, equipment to be used and the extent of the project work.

- Alaska Coastal Management Program Consistency Determination (ADNR Office of Project Management and Permitting [OPMP] Alaska Coastal Management Program [ACMP])

The federal Coastal Zone Management Act of 1972 was established to promote the orderly development and protection of coastal resources. In response to the federal legislation, the State of Alaska established the Alaska Coastal Management Plan (ACMP). The ACMP requires that projects in Alaska's coastal zone be reviewed by coastal resource management professionals and found consistent with the statewide standards of the ACMP. These standards and the enforceable policies of an affected coastal district ensure that development interests observe the vision set out for the future by the state and coastal communities. Using the statewide standards (6 Alaska Administrative Code [AAC] 80) and local enforceable policies, the ACMP evaluates the effects a project will have on the coastal resources and uses.

In addition to the federal and state requirements, the Matanuska-Susitna Borough has developed the Matanuska-Susitna Borough Coastal Zone Management Program. Due to regulation at various levels of government, the coastal zone is managed at each of the levels of government. The ACMP at the state level, however, consolidates several of these authorities and directs the permittee to the appropriate authority for review of an operation plan.

The Consistency Review process steps are outlined as follows:

- The applicant completes the Coastal Project Questionnaire.
- A determination is made by the State regarding the applicability of the consistency determination to the project.

- A determination is made regarding the completeness of the application. The ACMP has 21 days to make this determination.
 - The scope of the project is reviewed. This is limited to activities of the project that are subject to ADNR or ADF&G authorization, or federal consistency determination.
 - Public notice is prepared and submitted.
 - 30 day comment period
 - The applicant distributes and considers comments, then works to resolve issues that are identified.
 - The ACMP issues a proposed determination and the applicant is allowed to make revisions as needed, and otherwise respond to the agency. This may include an elevation of the process to the commissioner of the ADNR.
 - The final determination is made within 90 days.
- Compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulations at 36 CFR 800 and AS 41.35 (Office of History and Archeology [OHA], ADNR)

Section 106 of the National Historic Preservation Act requires review of any project funded, licensed, permitted, or assisted by the federal government for impact on significant historic properties. Both federal and state authorities regulate this section. The agencies must allow the State Historic Preservation Officer and the Advisory Council on Historic Preservation, 15 days for comment on a project. The Alaska Historic Preservation Act contains a provision similar to Section 106 which mandates that any project with state involvement be reviewed in a similar manner.

The OHA will provide information on the location of sites and on cultural resources surveys previously done in an area. If the potential to discover unknown sites is high, a survey may be recommended. When there are sites in a project area, OHA consults with the agency on National Register eligibility, on how the project will affect sites, and on ways to lessen unavoidable damage.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969

NEPA requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. The "NEPA process" must be followed when a Federal Agency proposes a management activity and/or provided funding to an activity. This process outlines specific procedures for determining the potential effects and mitigation measures for an action.

To meet this requirement, federal agencies prepare a detailed statement. This can be either an Environmental Assessment, for small projects, or an Environmental Impact Statement (EIS). Both statements require public scoping, interdisciplinary input, public comment, and specific timing.

NEPA documents, such as an EIS, include a detailed analysis of the potential effects on different parts of the environment. This is in addition to analysis of economics and the human environment. The EIS "shall provide full and fair discussion of significant

environmental impacts and shall inform decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment" (Council on Environmental Quality [CEQ] Regulations Sec. 1502.1). The EIS must "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated" (CEQ Regulations Sec. 1502.14(a)). The EIS "shall serve as the means of assessing the environmental impact of proposed agency actions, rather than justifying decisions already made" (CEQ Regulations Sec. 1502.2(g)). The EIS should "devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits."

The standard format is as follows:

- Cover sheet
- Summary
- Table of contents.
- Purpose of and need for action
- Alternatives including proposed action
- Affected environment
- Environmental consequences
- List of preparers
- List of Agencies, Organizations, and persons to whom copies of the statement are sent
- Index
- Appendices (if any).

Known Fisheries Issues:

- Identify anadromous fish of concern. Matanuska River contains habitats suitable for all five species of pacific salmon as well as rainbow trout and dolly varden char.
- ADF&G may require the Applicant to demonstrate no impact to fish or fish habitat.
- NOAA Fisheries National Gravel Extraction Policy states that "gravel extraction should not be allowed within, upstream, or downstream of anadromous fish spawning grounds," it also indicates that individual operations must be judged from a watershed management perspective.
- ADNR requires plans to be submitted and approved for any activity below the ordinary high water level and may limit work to specific time periods.
- ADNR may require a survey of the river to describe habitat use by fish in affected reach.
- Matanuska Susitna Borough's Coastal Zone Management Program Enforceable and Administrative Policies.

The General Policies prohibit the dredging and filling of tide flats, wetlands, submerged land and water bodies important to migration, spawning, and/or rearing of anadromous and resident fish unless no reasonable and prudent alternative exists. The discharge of any dredged material into water must comply with standards in Parts 320-33-, Title 33, CFR Vol. 47, No. 141, July 22

1982. Policies specific for gravel mining will allow gravel extraction within the floodplain if no reasonable or prudent alternative to coastal extraction exists. These policies also require that the operation is conducted such that there is no significant adverse impact to fish productivity and that impacts to fish and wildlife habitats are minimized.

Secondary Considerations:

- Spill Prevention Control and Countermeasure (SPCC) Plan (EPA)

For operations where storage of 1200 gallons or more of fuel is planned, a SPCC plan for fuel storage will be required under Section 40, Part 112 of the Code of Federal Regulations (40 CFR 112). Different sections of the SPCC rule apply depending on the type of facility and operation being conducted. Construction is regulated under this rule. The SPCC plan must outline procedures for oil storage, oil containment and handling, spill prevention, corrosion prevention, training, inspections and reporting, among others.

- Notice of Proposed Construction or Alteration, Form 7460-1 (Federal Aviation Administration [FAA])

To comply with 14 CFR 77 pursuant to 49 United States Code (USC) Section 44718, the FAA Form 7460-1 must be filed for every construction project ranging from grading terrain to erecting of buildings or towers within 5 miles of an active airport. The study reach is within five miles of the Palmer Airport. The notification must be submitted 30 days prior to the proposed start of construction. The applicant must provide information on the location, duration, work schedule, lighting or marking of the site, the overall height of any structure, site elevation, nearest public use airport, direction and distance to that airport. A complete description of the proposed work must be included, with an attached U.S. Geological Survey (USGS) 7.5-minute quadrangle map marked with the precise site location and any certified survey.

- State Water Quality Certification – for compliance with Clean Water Act (CWA) Section 401 (Alaska Department of Environmental Conservation [ADEC])

Pursuant to Section 401 of the CWA, the State of Alaska certifies permits issued by the EPA under the NPDES program. Known as a Section 401 Certification, the state is required to make the determination that the state water quality standards will not be violated by the issuance of the subject permit. As per 18 AAC 72.600, engineering plans should be submitted to ADEC for review and approval. To obtain a "letter of non-objection" an applicant must submit:

1. Short project description containing information of:
 - a. Project name
 - b. Contact name, address, phone and fax numbers and e-mail address
 - c. Project area (total and "soil disturbed")
 - d. Receiving water body and estimated distance from the project site
 - e. Methods of runoff flow and treatment (down to the discharge point)
 - f. Treatment system's maintenance procedures
 - g. Snow storage/disposal

2. Runoff flow calculation based on 2 years 6 hours rain event (before and after project is completed)
 3. Treatment system sizing estimation (e.g. swale: length, cross section, bank and longitudinal slopes, flow velocity, detention time etc.)
 4. One set of drainage plans clearly showing drainage boundaries and flow directions (please highlight them with a marker if your plans do not identify drainage boundaries and/or flow direction)
 5. All engineering design and calculations will need to be stamped by Alaska licensed engineer as required by 18 AAC 72.600 and 18 AAC 72.990.(29).
 6. Check payable to State of Alaska - DEC in amount determined by 18 AAC 72.955 Table D Plan Review Fees (5)(A)
- Storm Water Pollution Prevention Plan (SWPPP [ADEC])

A SWPPP is required as a major component of the EPA NPDES permitting process, for compliance with the CWA, and must be prepared prior to submission of a Notice of Intent (NOI) to conduct construction activities. The SWPPP must be developed for each construction project covered by the Construction General Permit (CGP) issued by EPA during the NPDES permit process. The SWPPP must be prepared in accordance with good engineering practices and identify all potential sources of pollution, which may reasonably be expected to affect the quality of storm water discharges from the construction site. The SWPPP must describe practices to be used to reduce pollutants in storm water discharges from the construction site and assure compliance with the terms and conditions of the CGP.

The requirements vary slightly depending on the type of operator. However, the general requirements include as site and activity description and controls to reduce pollutants. The SWPPP must include a description of all pollution control measures (i.e., Best Management Plans) that will be implemented as part of the construction activity to control pollutants in storm water discharges. A description of interim and permanent stabilization practices for the site, including a schedule of when the practices will be implemented must be included. The SWPPP must also include documentation supporting a determination of permit eligibility with regard to Endangered Species. Other requirements of the SWPPP are outlined in the CGP.

- Excavation Dewatering Wastewater Disposal Permits (ADEC)

This permit is required for excavation dewatering under 18 AAC 72.050. Information required to complete this application includes the project description and contact information, dates of discharge, discharge flow rates and locations. A description of the discharge area must be included which describes: the overland distances and drainage routes to major water bodies, contaminated sites within 3 miles, sensitive areas that may be affected by the discharge, drinking water wells or surface water sources within 1 mile of the proposed discharge. In addition, the proposed treatment, disposal and monitoring must be included. The permit must be obtained in conjunction with an EPA NPDES permit.

- Water Use Permit (ADNR)

A water right is a legal right to use surface or ground water under the Alaska Water Use Act (Alaska Statute [AS] 46.15). A water right allows a specific amount of water from a specific

water source to be diverted, impounded, or withdrawn for a specific use. An application for water rights must be accompanied by the filing fee of:

- \$50 for the use of 5,000 gallons per day (gpd) or less;
- \$100 for the use of more than 5,000 gpd but less than 30,000 gpd;
- \$200 for the use of 30,000 gpd or more but less than 100,000 gpd;
- \$300 for the use of 100,000 gpd or more but less than 500,000 gpd;
- \$500 for the use of 500,000 gpd or more but less than 1,000,000 gpd;
- \$1,000 for the use of 1,000,000 gpd or more except \$1,500 for the use of 1,000,000 gpd or more outside the hydrologic unit from which it was removed (hydrologic units are based on the most current U.S.G.S. Hydrologic Unit Map of Alaska).

To ensure that the public is notified of proposed water uses, you may be required to pay the cost of a legal advertisement in at least one issue of a local newspaper in the area of the proposed water use. Public notice is required if the appropriation is over 5,000 gallons per day; if it comes from an anadromous fish stream; or if the water source has a high level of competition among water users. In addition, permit and certificate (including temporary water use permit) holders are subject to an annual \$50 water right administrative service fee for any non-domestic use of more than 500 gpd. Domestic water users of less than 1,500 gallons per day are exempt from the fee.

A temporary water use permit may be needed if the amount of water to be used is a significant amount, the use continues for less than five consecutive years, and the water to be used is not already appropriated. This permit does not establish a water right but will avoid conflicts with fisheries and existing water right holders. The application fee for a temporary water use permit is the same as for a water right.

A significant amount of water is defined by 11 AAC 93.970(14) as:

- The use of more than 5,000 gallons of water in a single day from a single water source; or,
- The regular daily or recurring seasonal use of more than 500 gallons of water per day for 10 days or more per year from a single water source; or
- The non-consumptive use of more than 30,000 gallons of water per day (0.05 cubic feet per second) from a single water source; or,
- Any water use that might adversely affect the water rights of other appropriators or the public interest.

- **Air Quality Control Permits, Title V (ADEC)**

18 AAC 50 provides authorization for air quality monitoring and permitting to the ADEC. Regulations that establish the minimum standards for the state are specified in federal regulations 40 CFR part 70. The determination to require a permit is based on the source location, total emissions and changes in emissions for sources specified in 18 AAC 50.300(a). Generally, air quality must be maintained at the lowest practical concentrations of contaminants specified in the Ambient Air Quality Standards of 18 AAC 50.020(a) (suspended particulates, sulfur oxides, carbon monoxide, ozone, nitrogen dioxide, reduced sulfur compounds, and lead). The applicant for a Title V permit must submit an application and supplemental information as required by 18 AAC 50.3000(b). Air Quality Permits are

required for construction and operation activities that produce air contaminant emissions. Permits are issued for a maximum 5-year period, and are renewable by the same procedure.

The construction, modification, and operation of facilities that produce air contaminant emissions require a state Air Quality Control Permit to Construct, and a separate Air Quality Control Permit to Operate. An air quality permit to construct will be required prior to beginning pre-production activities to ready the site. Information required for the permit application include: sources of air emissions, inventory of air emissions, and assessment of the impacts on ambient air quality, usually obtained through modeling.

The application should contain information on pre-production site work (e.g., construction of roads, etc.) and full-scale production. The permit, once it is granted will cover the pre-production site work and may include the initial operation phase. Within 12 months of commencement of construction, an Application for an Air Quality Control Permit to Operate must be submitted. During review and negotiation of an Air Quality Control Permit to Operate application submitted within this timeframe, the Air Quality Control Permit to Construct remains in effect and is the mechanism that allows operations during this time period.

In addition to these two air quality control permits, open burning of cleared vegetation would require a separate permitting process. This would include obtaining a Burn Permit from ADNR, which would focus on fire control, and an Air Quality Control Permit to Open Burn from ADEC, which would focus on air quality impacts.

Therefore, the permits required for construction and operation of a facility that produce emissions, and for open burning include:

- Air Quality Control Permit to Construct
- Air Quality Control Permit to Operate
- Burn Permit
- Air Quality Permit to Open Burn

A completed Coastal Project Questionnaire Certification Form must be submitted to ADEC Air Permits with the application for an Air Quality Permit. The specific forms required for the Air Quality Permit are dependent on the project classification, determined by:

- Equipment Type and Size
- Emissions
- Location
- Owner Requested Limits

The ADEC provides specific guidance documents for preparation of the required forms based on the regulations specified in 18 AAC 50.

- **Material Sale Permit (ADNR)**

Under the authorization of 11 AAC 80 and AS 38.35, a material sales permit is required for the removal of rock, crushed rock or gravel from State Lands. This applies in cases where there is more than 200 cubic yards removed and a fee usually applies.

- **Flood Plain Development Permit (Matanuska – Susitna Borough)**

A development permit shall be obtained before construction or development begins within any area of special flood hazard established in MSB 17.29.060, which includes the Matanuska River bottom. The permit shall be for all structures, including manufactured homes, as set forth in the definitions, and for all development including fill and other activities.

A fee established by the assembly must accompany development permit application. The application may include, but not be limited to plans in duplicate drawn to scale showing the nature, location, dimensions and elevations of the area in question; and existing or proposed structures, fill, storage of materials, drainage facilities, and the location of the foregoing. The following information is required:

- Elevation in relation to mean sea level of the lowest floor (including basement) of all structures;
- Elevation in relation to mean sea level to which any structure has been flood-proofed;
- Certification by a registered professional engineer or architect that the flood-proofing methods for any nonresidential structure meet the flood-proofing criteria in MSB 17.29.170.
- Description of the extent to which a watercourse will be altered or relocated as a result of proposed development.

- **Conditional Use Permits (Matanuska – Susitna Borough)**

A conditional use permit shall be obtained for activities that include the construction of towers or tall structures, noise, and traffic. The requirement for towers or tall structures applies to certain structure locations and heights and is regulated under MSB 17.60.030. Permits are required for tall structures exceeding the maximum allowable height for structures within a special land use district or, exceeding 100 feet above average grade in locations where no maximum height for structures is designated by borough code; tower farms containing two or more tall towers regulated under this section; tower line routes and tower service area grids, containing two or more towers regulated under section MSB 17.60.030; and electrical lighting towers in excess of 185 feet located within the road rights-of-way along major arterial corridors.

The standards are specified for noise in MSB 17.61.080 and for traffic under MSB 17.61.090. These standards are based on the location, level of noise and traffic, and the timing of operation.

- **Shoreline Setback Exception (Matanuska – Susitna Borough)**

MSB 17.55.020 regulates the setback of activities from the shoreline. In general, no structure or footing shall be located closer than 75 feet from the high water mark of a watercourse or body of water. An exception may be applied for to exempt the structure from this code.

- **Building Codes (Matanuska – Susitna Borough)**

The borough has adopted by reference the following codes of technical regulation for buildings and structures which are constructed, improved, or modified by the borough:

- Uniform Mechanical Code, 1997 Edition (including appendices thereto);

- Uniform Building Code, 1997 Edition (including appendices thereto);
- Uniform Plumbing Code, 1997 Edition (including appendices thereto);
- National Electrical Code, 1997 Edition (including appendices thereto); and
- Uniform Fire Code, 1997 Edition (including appendices thereto).

Application of these codes will be dependent on the type of project proposed.

Kris Ivarson
Hydrogeologist