Elim Subsistence Harbor Feasibility Study
Appendix D: Economics
Elim, Alaska

November 2020

US Army Corps of Engineers
Alaska District

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Prepared By:
U.S. Army Corps of Engineers
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1. OVERVIEW

This appendix presents the economic analysis of six alternative plans (numbered 2–7, with Alternative 1 designated as the no-action plan) for navigation improvements at Elim, Alaska. The alternative plans were evaluated using the four accounts established in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*: national economic development (NED), regional economic development (RED), environmental quality (EQ), and other social effects (OSE).

A NED analysis performed under the authority of the Water Resources Development Act of 2007 (WRDA 2007, as amended) Section 2006 (Remote and Subsistence Harbors) demonstrated that none of the alternative plans had a benefit-cost ratio (BCR) greater than 1.0. Since no plan was identified as preferred by the NED analysis (a NED plan), a cost effectiveness and incremental cost analysis (CE/ICA) was used to support plan selection. The non-monetary metric used in the CE/ICA—opportunity days gained for safe access and moorage days for the Elim vessel fleet—refers to the improved opportunity each alternative offers the community to participate in subsistence and commercial fisheries activities and improve barge deliveries.

The results of the NED analysis and CE/ICA are summarized in Table 1 and Table 2. Alternatives 6 and 7 were included in the NED analysis but screened out prior to conducting the CE/ICA. The NED analysis indicated that these two alternatives are not cost effective given the high project costs relative to the level of benefits accrued. Alternative 2 has the highest average annual net benefits, but its BCR is below 1.0. Alternatives 2 and 5 were identified as best-buy plans through the CE/ICA, meaning they provide the greatest increase in output for the least increase in cost. These analyses inform plan selection as detailed in the main report of the *Integrated Feasibility Report and Environmental Assessment* (IFR/EA).

Table 1. NED Summary

Description	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Present Value NED Benefits	$29,370,000	$30,630,000	$30,630,000	$31,260,000	$26,320,000	$28,940,000
Present Value NED Costs	$76,040,000	$99,840,000	$101,500,000	$106,010,000	$102,260,000	$153,300,000
Average Annual Cost	$2,610,000	$3,520,000	$3,580,000	$3,740,000	$3,610,000	$5,410,000
Average Annual Benefits	$1,040,000	$1,080,000	$1,080,000	$1,100,000	$930,000	$1,020,000
Average Annual Net Benefits	-$1,570,000	-$2,440,000	-$2,500,000	-$2,640,000	-$2,680,000	-$4,390,000
BCR	**0.40**	**0.30**	**0.30**	**0.29**	**0.26**	**0.19**

Table 2. CE/ICA Summary

Alternative	Access Days Gained	Average Annual NED Cost	Annual Cost Per Unit of Output (Opportunity Days)	CE/ICA Result
No Action	0	0	0	Best Buy
Alt 2	4,438	$2,610,000	$588	Best Buy
Alt 3	5,067	$3,520,000	$695	Cost Effective
Alt 4	5,243	$3,580,000	$683	Cost Effective
Alt 5	5,544	$3,740,000	$675	Best Buy

2. INTRODUCTION

Limited marine infrastructure and available draft in Elim result in operational inefficiencies, vessel damage, and decreased safety. These limitations threaten the long-term viability of Elim and the region. This economic appendix evaluates the proposed navigation improvements at Elim through the NED analysis and CE/ICA. It discusses the economic and social factors that inform the two analyses.

The NED analysis defines benefits as a change in the value of goods and services that the nation accrues due to the project construction. NED costs are the total economic costs of building and maintaining the project. The project's average annual economic benefits are compared to the average annual economic costs to provide an estimated BCR. A project with a BCR greater than 1.0 is considered economically justified.

When considering a community's long-term viability, NED benefits and a corresponding BCR may not be the most complete and reflective measure of benefits. The CE/ICA evaluates the effects of proposed plans beyond the confines of monetary NED benefits;

specifically, the non-monetary benefits associated with OSE. This economic appendix discusses the economic and social factors that inform the two separate analyses.

This appendix followed guidance in the U.S. Army Corps of Engineers (USACE) *Planning Guidance Notebook* (Engineering Regulation 1105-2-100; specifically in the appendices on economic and social considerations), the USACE Civil Works program, and recent Economic Guidance Memoranda issued by Headquarters USACE. Additional guidance for the CE/ICA is found in the Institute of Water Resources (IWR) *Planning Suite II Guide* (2017) and *Planning Manual on Risk-Informed Planning* (2017).

The planning objectives of this study are as follows:

- Provide safe, reliable, and efficient waterborne transportation systems for the movement of commerce (including commercial fishing) and subsistence in Elim.
- Support the long-term viability of Elim.

2.1 Study Authority

This study utilizes the project justification allowed under WRDA 2007 Section 2006, as modified by Section 2104 of the Water Resources Reform and Development Act of 2014 and further modified by Section 1105 of WRDA 2016. The authority states that, in conducting a study of harbor and navigation improvements, the Assistant Secretary of the Army for Civil Works (Secretary) may recommend a project without demonstrating that the improvements are justified solely by NED benefits if the Secretary determines that the improvements meet the following criteria:

1. The community to be served by the project is at least 70 miles from the nearest surface accessible commercial port and has no direct rail or highway link to another community served by a surface accessible port or harbor; or the project would be located in the State of Hawaii or Alaska, the Commonwealth of Puerto Rico, Guam, the Commonwealth of the Northern Mariana Islands, the United States Virgin Islands; or American Samoa.

2. The harbor is economically critical such that over 80% of the goods transported through the harbor would be consumed within the region served by the harbor and navigation improvement as determined by the Secretary, including consideration of information provided by the non-Federal interest.

3. The long-term viability of the community in which the project is located, or the long-term viability of a community located in the region that is served by the project and that will rely on the project, would be threatened without the harbor and navigation improvement.

2.2 Meeting the Authority

The proposed navigation improvements at Elim meet the criteria of the Remote and Subsistence Harbors authority for the following reasons:

1. The project is in Alaska.
2. Based upon weight, over 80% of the goods transported through the harbor in the future with-project condition (after construction) would be consumed within the region. The region that is to be served by the navigation improvements is the village of Elim. Using available data from the Waterborne Commerce Statistics Center, and on the basis of consumption in metric tons, Elim consumes 84–92% of the goods transported through the proposed harbor. Alternatives supporting commercial fishery exports from Elim provide economic opportunities in Elim that are consistent with the authority and study objectives. These exports are projected to weigh less than 20% of the total tonnage going through the harbor when considering market and institutional factors such as Community Development Quotas (CDQ) and associated export prices. Imports include fuel, freight, and construction materials. Exports include raw fish and are estimated to range from 8 to 16% of the total weight of goods transported through the harbor. These estimates are conservative, given that the analysis accounts for projected growth in exports but assumes that the imports will remain the same.
3. Remote Alaska communities face challenges that are complex and multifaceted. Rural economies in Alaska, including that which exists in Elim, can be characterized as a mixed, subsistence-cash economy. The subsistence and cash sectors are interdependent and mutually supportive. Access to resources and the opportunity to earn some form of cash income are foundational for continued viability. Without a safe and functioning harbor, limited access to subsistence resources, coupled with limited economic opportunities, compounds the threats to community viability. The cultural identity of Alaska Native Tribes is highly dependent upon subsistence activities tied to specific locations and in-depth historical knowledge of the land and marine subsistence resources. Given subsistence activities' social and cultural value to tribal identities, the inaccessibility of subsistence resources can threaten communities. In addition, the costs of basic essential goods required to support a subsistence lifestyle would remain prohibitively high. Reductions in the costs of basic essential goods are necessary for community viability. While population estimates suggest that Elim’s population is stable, the population alone is not an indicator of a viable community. The viability of a community is based on its ability to survive and thrive. When wage-paying employment is limited, coupled with average wages lower than the state average, a stable population in a remote community is

severely threatened. More information on these socio-economic factors is presented in the following sections.

The authority states that, while determining whether to recommend a project under the criteria above, the Secretary will consider the following benefits of the project:

- Public health and safety of the local community and communities that are located in the region to be served by the project and that will rely on the project, including access to facilities designed to protect public health and safety;
- Access to natural resources for subsistence purposes;
- Local and regional economic opportunities;
- The welfare of the local population; and
- Social and cultural value to the local community and communities located in the region to be served by the project and that will rely on the project.

The benefits listed above are associated with a project's effects on social well-being, which extend beyond the NED benefits. Social well-being effects reflect a complex set of relationships and interactions between a proposed plan and the social and cultural setting in which these are received and acted upon (USACE 2000).

These benefits are considered from both a quantitative and qualitative perspective. In particular, the analysis uses the CE/ICA metric of opportunity days gained, which emphasizes the occurrence of beneficial effects to quantify in non-monetary terms the contributions of a navigation project to social and economic opportunities (listed above). These social well-being effects are also expanded upon in Section 14 under the four-accounts evaluations.

3. BACKGROUND

3.1 Location and Climate

Elim is a second-class city on the northwest shore of Norton Bay on the Seward Peninsula, 96 miles east of Nome and 460 miles northwest of Anchorage (Figure 1). Elim lies at 64.6 degrees north latitude, -162.3 degrees west longitude. The area encompasses 2.4 square miles of land.

Elim has a subarctic climate with maritime influences. Norton Sound is generally ice-free between mid-June and mid-November. Summers are cool and moist; winters are cold and dry. Summer temperatures average between 46–62 degrees Fahrenheit; winter temperatures average from -8 to 8 degrees Fahrenheit. Annual precipitation averages 19 inches, with about 80 inches of snow (Department of Commerce, Community and Economic Development, Division of Community and Regional Affairs 2019).

Figure 1. Location of Elim in Alaska

3.2 History

Elim was formerly the Malemiut Inupiat Eskimo village of Nuviakchak. The Alaska Native culture was well developed and well adapted to the environment, and each tribe possessed a well-defined subsistence harvest territory. The area became a Federal reindeer reserve in 1911. In 1914, Reverend L.E. Ost founded a Covenant mission and school called Elim Mission Roadhouse. The City of Elim was incorporated in 1970 and remains an Inupiat Eskimo village with a predominantly fishing and subsistence lifestyle (USACE Alaska District 2013). Residents rely upon subsistence harvests of fish, crab, seal, walrus, beluga whale, caribou, moose, greens, and berries. Elim's detailed history is described in Section 1 of the IFR/EA main report.

3.3 Government Entities

The City of Elim was incorporated in 1970 as a second-class city. As a second-class city in the unorganized borough, the City of Elim has discretionary powers under state law for planning, platting, and land use regulation within municipal boundaries. The local city government consists of an elected mayor and city council. The Federally recognized governing tribal body, the Native Village of Elim, shares some of these responsibilities and powers. The Native Village of Elim also works closely with Kawerak Inc., the regional non-profit Native Corporation. The village corporation established under the Alaska Native Claims Settlement Act of 1971 (ANSCA) is Elim Native Corporation.

3.4 Infrastructure

Elim is not connected to any other communities by road and must be accessed by plane or boat or by snow machine in winter. The only existing road connects Elim to Moses Point, which is approximately 10 miles northeast of Elim.

3.4.1 Marine Facilities

Elim has no dock or barge ramp infrastructure. A cargo ship brings freight from Nome annually to the beach fronting the community. Because there are no marine facilities, supplies must be self-lightered to shore, further described in Section 6.1.3. There are two barge landing areas at Elim. Fuel barges anchor offshore near the fuel header location at the southwest end of the community. Freight barges land east of a small stream outfall along the beach where cargo is offloaded.

Moses Point is the sandy mouth of the Kwiniuk River, used as a make-shift harbor, but there is no boat launch or mooring infrastructure. It is relatively protected but shallow, and only small boats use Moses Point for moorage. Moorage in the area is not always possible because of active river dynamics that cause the river mouth to migrate. During the commercial salmon fishing season, skiffs lighter fish totes from the fish-buying station at Moses Point out to fish tenders offshore that cannot access the harbor due to depth constraints.

3.4.2 Airport

Elim's remote location leads to a reliance on air transportation. Until the outbreak of the coronavirus pandemic, two airlines operated small passenger and cargo flights to Elim daily. There is a 3,401-foot-long, 60-foot-wide state-owned gravel runway. One of the airlines filed for bankruptcy in April 2020, ceasing flights to Elim and other communities. This airline reports that it plans to re-launch as a new company in the near future. (Ravn Alaska 2020).

The Elim Native Corporation also owns a private 3,000-foot-long by 60-foot-wide airstrip at Moses Point that is not operational. The airstrip at Moses Point is unattended and not maintained during the winter. According to the Federal Aviation Administration, Moses Point is eroding in spots. The corporation-owned airstrip is near where commercial fish are landed and sold during the summer. The eastern end of the runway is reported to attract birds (Federal Aviation Administration 2008). The daily flights into Elim primarily use the state-owned runway.

3.4.3 Public Services and Utilities

3.4.3.1 Health Services

Primary health services and infrastructure in Elim are provided by the Norton Sound Health Corporation, which operates the Norton Sound Regional Hospital in Nome and 15 village clinics in surrounding communities. According to the *Bering Strait Community Needs Assessment* (McDowell Group 2019), Elim hosts one of the larger clinics, named Yukuniaraq Yunqcarvik Village Clinic, which staffs a physician assistant or nurse practitioner and may provide limited pharmacy and radiology services (McDowell Group 2019). The Yukuniaraq Yungcarvik Village Clinic is shown in Figure 2.

Norton Sound Health Corporation manages community health services including village health, behavioral health, and health aide training. Its programs include rotating provider teams of ancillary services such as optometry, physical therapy, and audiology to the service villages. At the time of this report, the corporation is building a Wellness Center in Nome that will house behavioral health, chemical dependency detox, and substance abuse treatment services. The Nome Public Health Center is another healthcare provider in the region and offers infectious disease surveillance and tuberculosis screening and treatment.

Figure 2. Yukuniaraq Yunqcarvik Village Clinic in Elim

Depending on treatment needed, Elim residents are either treated at the local clinic or travel to the Norton Sound Regional Hospital by plane. Every month an average of 10 residents leave to seek medical treatment or medical appointments in Nome (Kawerak Inc. 2013).

3.4.3.2 Energy and Water Services

A diesel power plant owned and operated by the Alaska Village Electric Cooperative primarily generates Elim's electricity (Kawerak Inc. 2013). The power plant and tank farm are located west of town. Electric generation by diesel results in high electricity costs. Elim participates in the Power Cost Equalization program, which provides economic assistance to rural Alaska communities and residents. The cost of electricity can be substantially higher than for customers in more urban areas of the state. The Power Cost Equalization program subsidizes electricity cost to be near the cost of power in Anchorage, Fairbanks, and Juneau (Alaska Energy Authority 2020). The majority of homes are heated by oil or kerosene, but 27% of Elim homes use wood for heating (McDowell Group 2019).

Elim participates in the consolidated bulk fuel program coordinated by the Norton Sound Economic Development Corporation (NSEDC). Through this program, which began in 2006, NSEDC groups fuel orders and negotiates purchases for participants in member communities, which allows for lower fuel prices for residents in the Norton Sound region (NSEDC 2020). NSEDC acts as an agent on behalf of participant communities to coordinate fuel orders and deliveries based on fuel suppliers' proposals. NSEDC issues requests for proposals, awards a fuel contract, and acts as the point of contact for the fuel supplier and program participants. This program benefits local entities or communities, as the bulk fuel orders and the competitive contract bids from fuel companies lower fuel and delivery costs.

According to the Alaska Department of Community and Regional Affairs, Elim's main fuel tanks are owned by multiple owners, as shown in Table 3. Elim's total fuel capacity is nearly 350,000 gallons (DCCED 2019).

Table 3. Fuel Tank Capacities in Elim

Fuel Tank Owners	Capacity (gallons)
City of Elim	142,430
Alaska Village Electric Cooperative	70,850
Elim Native Store	68,130
Bering Straits Schools	57,410
Army National Guard	4,500
Alaska Department of Transportation/Airport	3,000
Total Fuel Tank Capacity	**346,320**

Water and sewer systems built in 1974, along with housing provided by the Bureau of Indian Affairs and the Department of Housing and Urban Development, give the residents piped water and sewer, indoor water heaters and plumbing, and in-home washers and dryers. Waste flows to a sewage treatment plant with ocean outfall.

According to the *Bering Strait Community Needs Assessment*, Elim is one of three communities in the Bering Strait region aside from Nome with complete piped water and sewer systems (McDowell Group 2019).

The McDowell Group (2019) reports that the water system's adequacy in the community is limited. On a site visit in April 2019, the USACE study team observed holes and slices on the community water tank toward the lower half of the exterior, cutting at least the tank's insulation and possibly further into the tank. During the site visit, it was observed that the community did not have water due to the damaged water system. Necessary facilities such as bathrooms and kitchen sinks did not have a water supply. For the series of community meetings, water from a neighboring village was transported via a snow machine.

4. SOCIOECONOMIC CONDITIONS

4.1 Population

The Department of Labor and Workforce Development (DLWD) Research and Analysis group estimates that the Elim population fluctuated from 330 to 370 during the 2010–2018 period. Still, the city saw an overall increase over the 9 years, as shown in Figure 3 (DLWD 2016). The DLWD estimated 368 people living in Elim in 2018.

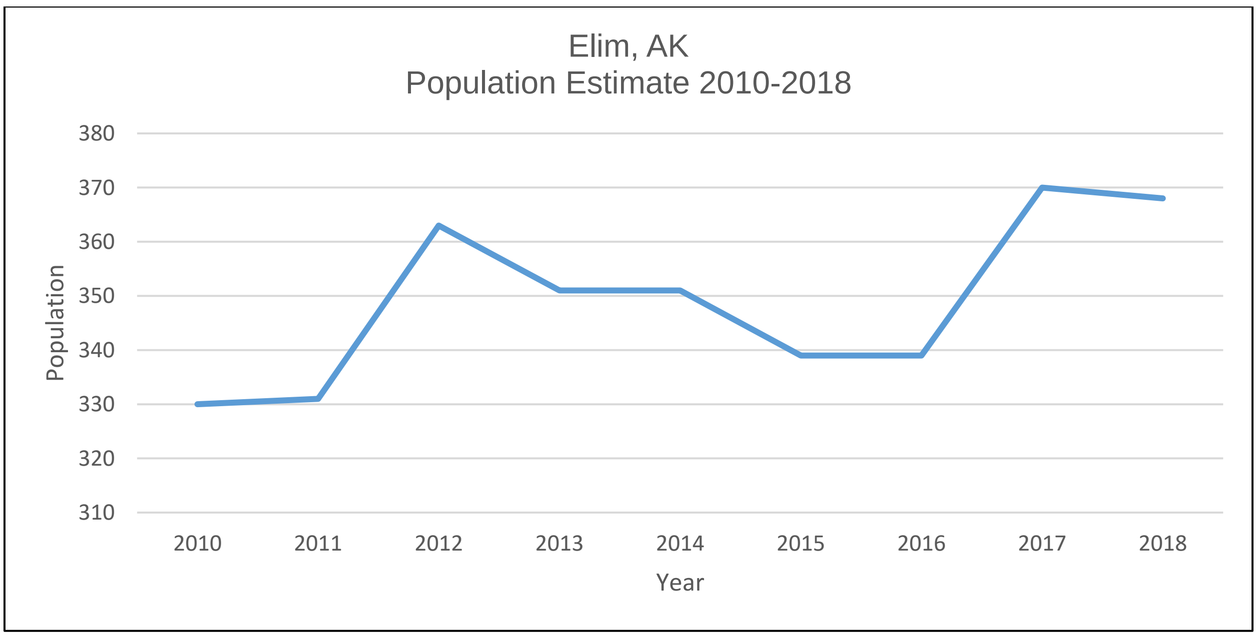

Figure 3. Elim Population Estimates, 2010–2018.

The U.S. Census Bureau's American Community Survey for the 5-year period of 2013–2017 estimates 98% of Elim's population are Alaska Natives, compared to 15.4% for the State of Alaska (U.S. Census Bureau 2017). Sixty percent of the Elim population are male, and 40% are female. Elim residents' median age is relatively young at 25 years, compared to the state's median age of 34 years. While the population trend in Elim is relatively stable, 26% of the residents live below the poverty line. Further discussion on the population's economic status is provided in Section 4.3.

4.2 School Enrollment

The Aniguiin School in Elim operates under the Bering Strait School District and serves grades pre-kindergarten (Pre-K) through 12. Total enrollment from 2010–2018/19 increased from 90 to 122, a 36% increase (Department of Education and Early Childhood Development 2019). The stable enrollment trend shown in Figure 4 points to a positive sign that the school at present does not face a threat of closing. However, a stable enrollment does not translate to a robust, complete education. For Alaska Natives, education extends to learning from community members and elders. This learning is often knowledge shared by participating together in subsistence activities connected to specific places.

Pre-K to grade five make up more than half of total enrollment, between 58 and 66% from 2010 to 2019; grades 6–12 account for 37–42% of total enrollment for the period. This indicates the prominent presence of children ages 4–11 in Elim. This age group is also the crucial formative years for instilling cultural values and identity.

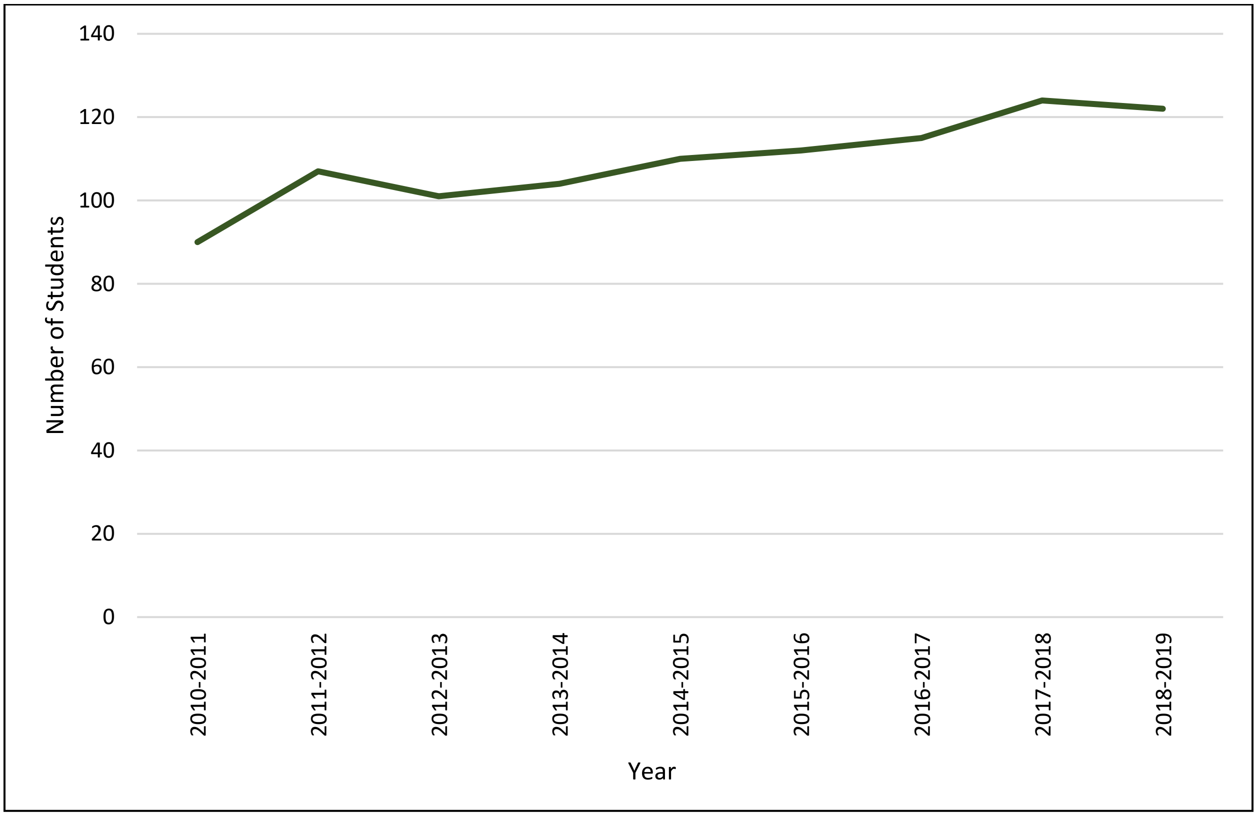

Figure 4. Aniguiin School Enrollment for Grades Pre-K through 12, 2010–2019

4.3 Employment, Income, and Cost of Living

4.3.1 Employment

Employment opportunities in rural Elim are limited and often depend on the presence and extent of local industries. For example, some residents are employed in the oil and gas industry, which is dependent on resource and industry movements. The DLWD (2016) reports worker characteristics for Elim over the period of 2012–2016. In the 5-year period, the percentage of residents employed showed fluctuation, with a decrease in the percent of employed residents in the last 2 years, from 72 to 65% (Figure 5).

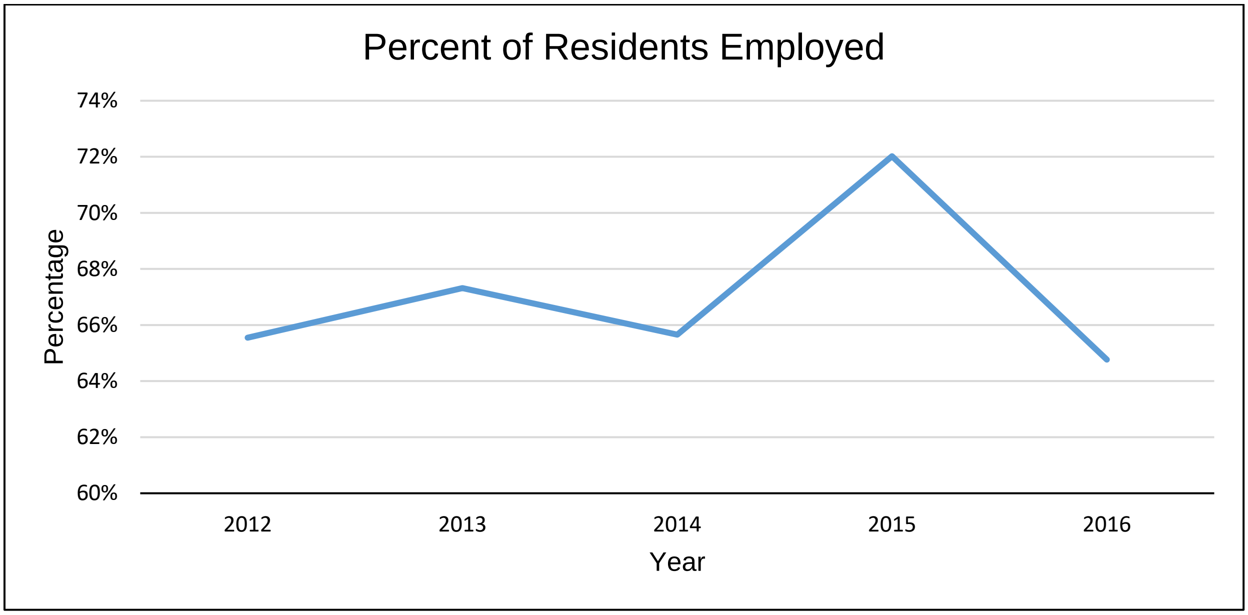

Figure 5. Percent of Elim Residents Employed, 2012–2016. Adapted from Alaska DLWD

The percent of working residents represents the number of employed residents relative to the workforce population of people 16 and older, as shown in Table 4. The local government sector accounts for more than 60% of total resident employment for the 5-year period. The private sector employs 30%, and state government employs about 2% of employed residents.

Table 4. Employed Residents in Elim

Employed Residents	2012	2013	2014	2015	2016	Five Year Average
Residents age 16 and over	209	205	198	193	193	166
Residents employed	137	138	130	139	125	112
Percent of Residents Employed	**66%**	**67%**	**66%**	**72%**	**65%**	**67%**

Based on DLWD data, the following are the top occupations in Elim for 2016, the most recent year available:

- Laborers and freight, stock and material movers
- Teacher assistants
- Elementary school teachers
- Secretaries and administrative assistants
- Construction laborers
- Janitors and cleaners
- Highway maintenance workers
- Water and wastewater treatment plant and system operators

The oil and gas industry drives several employment opportunities in Elim: laborers and freight, stock and material movers; construction laborers; and water and wastewater treatment plant and system operators. In 2012 and 2013, fish cutters and trimmers were ranked second in Elim’s top occupation list, but this occupation has since dropped off the list (DLWD 2016). The change suggests that Elim's commercial fishing operations were previously a major employer for residents but have downsized in recent years. This occupation category is discussed further in subsequent sections of this appendix.

Commercial fishing is a key income source in Elim during the commercial salmon fishing season; however, it is not reported by DLWD in its worker characteristics (USACE 2018). Many commercial fish are tracked by NSEDC via commercial fishing permits owned by Elim fishermen, but this does not show the number of crew members employed by each commercial vessel. Section 0 describes the characteristics of the commercial fisheries' resources in Elim. While commercial fishing is not recorded as an occupation by DLWD, community members in Elim work in commercial fishing. These residents own vessels and dedicate labor and resources to maintaining their boats. Some community members have a formal full time or part-time job and work in commercial fisheries intermittently.

4.3.2 Unemployment

The percent of residents employed in Elim averages 67%, reflecting an average of about 30% unemployed. Given the upward population trend and the limited growth of future economic opportunities in remote Elim, it is likely that unemployment will remain at 30% or increase. More people are expected to compete for the same number of jobs in the future. Coupled with high costs for fuel and dry goods, this may increase impoverished residents from 26% reported by the American Community Survey.

4.3.3 Income and Cost of Living

Income and the cost of living influence the community’s livelihood and viability. Data from remote Alaska is limited; the latest available data (2016) is used in this discussion to represent Elim's current and future conditions. More than 20% of the working residents in Elim earned less than $5,000 in 2016. Wage ranges earned by Elim residents, compared to those earned statewide, are shown in Figure 6.

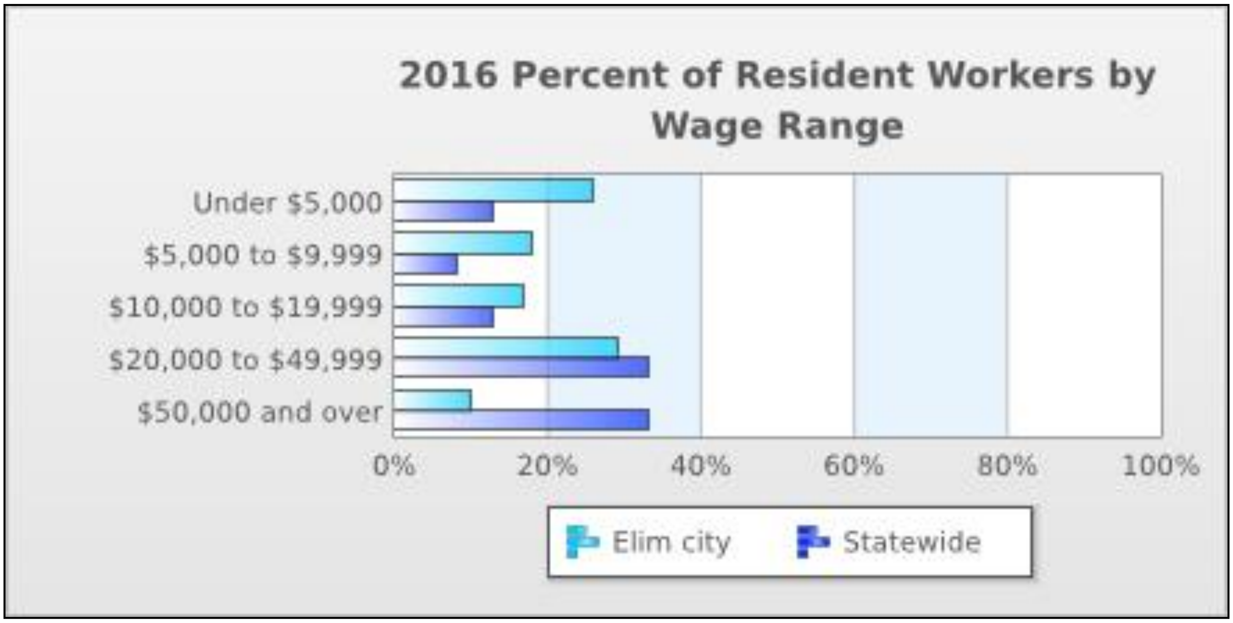

Figure 6. Percent of Elim Workers by Wage Range in 2016. Reprinted from Alaska DLWD

As the wage ranges increase in dollar value, the percent of Elim residents earning those wages decreases. The opposite is observed at the statewide level; fewer residents earned the low wage ranges, and more workers earned higher wage ranges. About 21% of residents statewide earned less than $10,000, but this percent is more than doubled, to 44%, in Elim. About 33% of statewide residents earned $50,000 or more, while only 10% of Elim residents earned this wage range. Elim's median household income is $39,375, which is almost half of the Alaska state median household income of $76,114 (U.S. Census Bureau 2017).

The University of Alaska's Alaska Food Cost Survey, conducted 4 times per year, compares weekly food costs for a basket of goods in various areas of Alaska with U.S. Department of Agriculture information for the United States. The food cost survey does not include Elim, but does include Nome, which can be considered a proxy for Elim's cost due to its geographic proximity. Since Elim is even more remote and has less infrastructure and transportation services than Nome, it is reasonable to assume that Elim's cost of living is even higher. On average, a family of four with children aged 6–11 can expect to spend $154 a week on food in the United States. The average cost for Alaska is $180 per week in Alaska, an increase of 17%. For Nome, the average cost increases to $376 a week[1]—more than double that of the state and almost 2.5 times that of the United States.

[1] Most recent data for Nome is in 2017 dollars. These values are updated to 2019 dollars

If the average cost of living in Nome is nearly 2.5 times the U.S. average, then the average cost of living in Elim is substantially higher than the U.S. average. Elim residents expect to have to pay a higher cost than the Nome average for the same amount of goods. The median household income in Nome is $81,389, and Elim's household income is half of that in Nome; close to half of employed Elim residents earn less than $10,000 per year in wages. All these income and cost of living conditions mean that Elim households are more exposed to systemic problems attributable to interruptions to the transportation system. While a set of factors and thresholds come into play when defining poverty, these comparisons aid in understanding the challenges faced by the 26% of Elim residents who are below the poverty line (U.S. Census Bureau 2017).

4.4 Housing Facilities

Having a safe and reliable shelter is important to public safety and the viability of a community. The *Bering Strait Community Needs Assessment* identified a host of housing challenges in the region (McDowell Group 2019). These include aging housing stock, overcrowding, affordability, and air quality. According to the report, these issues add to current social, health, and homelessness concerns. Moreover, potential employers identify housing availability as a critical concern to employee recruitment.

Local housing units in Elim are aging, with almost 50% of all housing units built before 1980 and 38% built between 1980 and 1999. Only 12% of all housing units in Elim have been built since 1999 (McDowell Group 2019). Existing housing units either need structural repairs or have inadequate facilities that contribute to poor air quality, compromising residents' health. Housing is expensive in the region, and 36% of households live in overcrowded conditions. The U.S. Department of Housing and Urban Development refers to overcrowding as more than one person per room in a house. A quarter (26%) of the homeowners in the region with a mortgage pay 30% or more of their household income for housing. The local median household income in Elim is under $40,000, and the cost of living is more than 2.5 times the national average. For homeowners with mortgages, this $40,000 income barely covers housing and cost of living.

5. MARINE RESOURCES ASSESSMENT

Marine resources play a critical role in the economies and cultural practices of remote and rural communities in western Alaska, such as Elim. Subsistence activities and commercial fisheries depend on access to these marine resources and the viability of fisheries and resources in the region. This section describes marine resources' characteristics and management institutions in the Norton Sound region and Elim. Elim residents rely on marine resources listed in this section, such as fisheries, marine mammals, and terrestrial game.

5.1 Physical Characteristics

Norton Sound is fed by several sub-arctic streams, rivers, and estuarine lagoons meeting the Bering Sea. These hydro-geographically complex systems support subsistence and commercial fisheries for salmon. The Norton Sound region, of which Elim is one of 15 communities, stretches from Cape Douglas, northwest of the Sinuk River's mouth, to Point Romanof, south of Stebbins (Menard et al. 2017). The Norton Sound region in Western Alaska is shown in Figure 7. The Kwiniuk River and the Tubutulik River drain out at Moses Point, 9 miles northeast of Elim, which is where the community fishes for salmon.

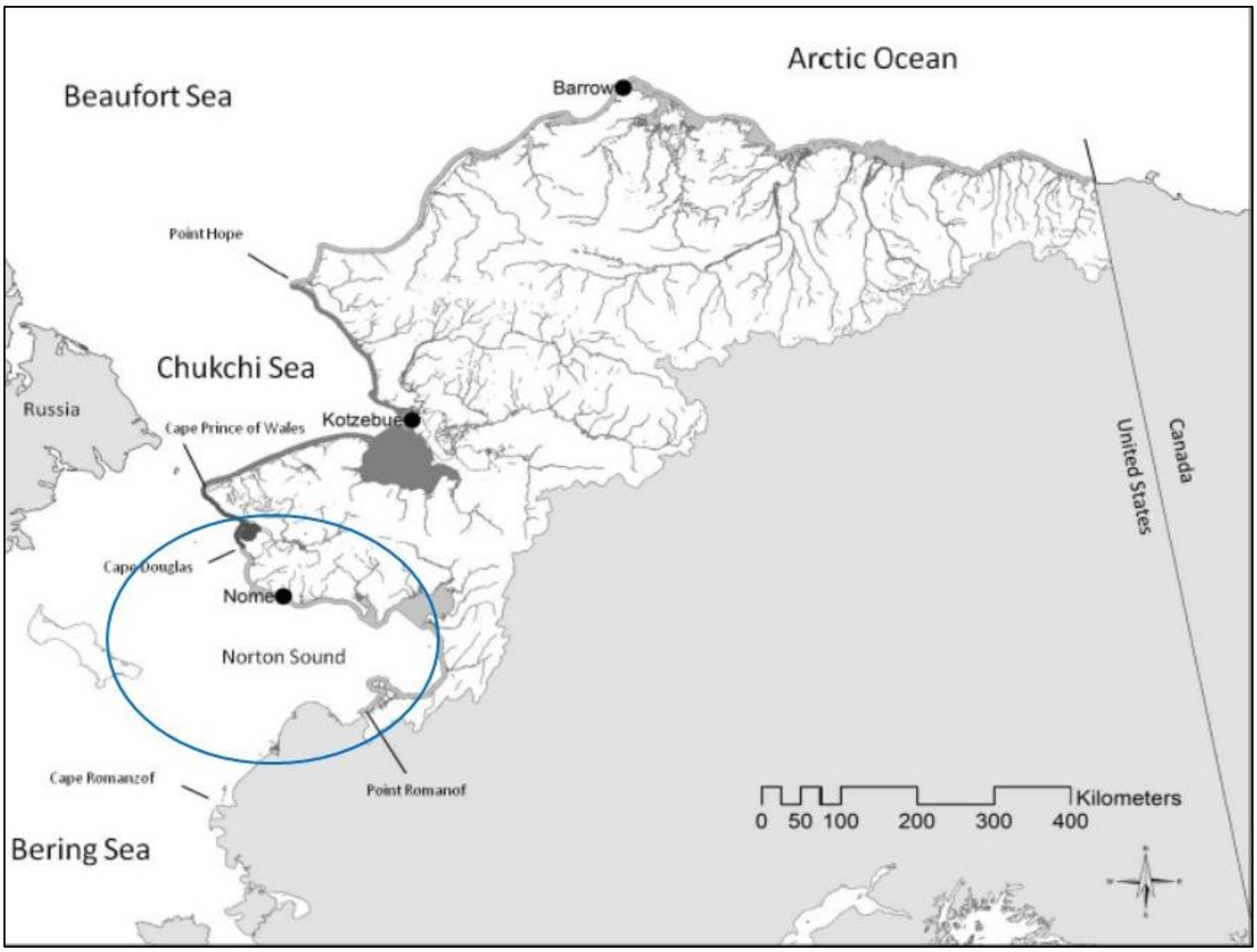

Figure 7. Norton Sound Region. Adapted from Alaska Department of Fish and Game

5.2 Fisheries Management

Management authority for Alaska fisheries is based on species or groups of species. It falls under the purview of various state, Federal, and fisheries-specific agencies, depending on the species and related legislation affecting its management. Fisheries management in Alaska includes the following:

- Alaska Board of Fisheries
- Alaska Department of Fish & Game (ADF&G)
- Commercial Fisheries Entry Commission (CFEC)
- National Marine Fisheries Service (NMFS)
- North Pacific Fishery Management Council
- The Pacific States Marine Fisheries Commission
- International Pacific Halibut Commission
- Federal Subsistence Management Program

Jurisdiction for fisheries management is primarily split between the ADF&G and NMFS. Per the Magnuson Fishery Conservation and Management Act of 1976, ADF&G generally has purview over fisheries within 3 miles of shore. NMFS manages fisheries from 3 to 200 miles off U.S. coasts. Some species may have shared jurisdiction or may be under the jurisdiction of another institution. For example, NMFS manages the groundfish and halibut CDQ fisheries; NMFS and ADF&G manage the CDQ crab fisheries; and ADF&G manages salmon fisheries to meet spawning escapement goals established for major river systems.

5.2.1 Community Development Quota Program

The Federally managed fisheries of the Bering Sea and Aleutian Islands include the CDQ program. The CDQ program was initiated to provide 65 western Alaska communities with the opportunity to participate and invest in Bering Sea and Aleutian Islands fisheries and support economic development. Figure 8 shows the CDQ group boundaries and communities on a map of Alaska. Through the 1976 Magnuson Act, a portion of the annual catch limit for each directed fishery of the Bering Sea and Aleutian Islands management area is allocated among the 6 non-profit corporations representing the 65 western Alaska villages:

- Aleutian Pribilof Island Community Development Association,
- Bristol Bay Economic Development Corporation,
- Central Bering Sea Fishermen’s Association,
- Coastal Villages Region Fund,
- NSEDC, and
- Yukon Delta Fisheries Development Association.

5.2.2 Norton Sound Economic Development Corporation

The NSEDC region is the northernmost CDQ area, bordered by the international dateline on the northwest and the Yukon Delta Fisheries Development Association south of St. Lawrence Island. NSEDC facilitates the harvest of CDQ species in the Norton Sound region, including groundfish, crab, and halibut. The annual CDQ target fisheries for red king crab in the Norton Sound and halibut in International Pacific Halibut Commission Area 4D/E are predominantly reserved for local fishermen residing in NSEDC member communities. The annual CDQ of most other groundfish species and the greater Bering Sea CDQ fisheries are harvested and processed in cooperation with NSEDC's industry partners (NSEDC 2018).

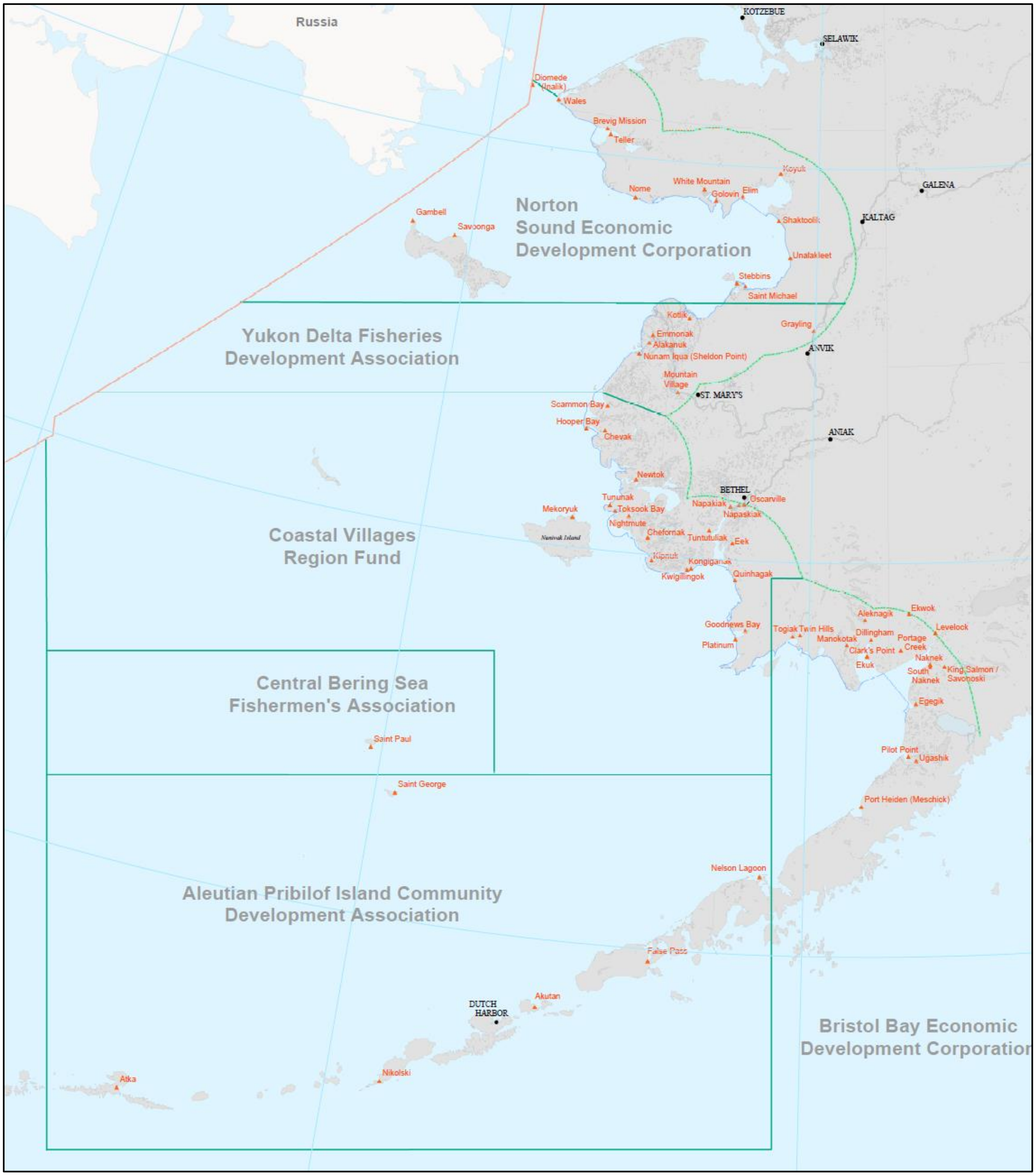

Figure 8. CDQ Communities and Group Boundaries (reprinted from National Oceanic and Atmospheric Administration website)

5.3 Fisheries Resources

The Norton Sound region participates in the following fisheries: salmon, halibut, king crab, Pacific herring, and miscellaneous finfish. In Elim, salmon is the major fishery. Therefore, this assessment focuses on the commercial and subsistence salmon fisheries.

5.3.1 Salmon

There are five salmon species of importance to commercial and subsistence fisheries in Elim and the Norton Sound region: chum salmon, pink salmon, coho salmon, a small number of Chinook salmon throughout the region, and sockeye salmon in the region's western portion at the Sinuk and Pilgrim Rivers; which is important to the local subsistence fishery. Sport fishery targets all five species but makes up a very small portion of the fisheries compared to commercial and subsistence. (Menard et al. 2009).

5.3.1.1 District Boundaries

The Norton Sound District salmon fishery consists of all waters between Cape Douglas in the north and Point Romanoff in the south (Figure 9). The district is divided into six subdistricts and corresponding statistical areas to facilitate the management of individual salmon stocks:

- Subdistrict 1: Nome (333-10)
- Subdistrict 2: Golovin (333-20)
- Subdistrict 3: Elim (333-31, 32, 33)
- Subdistrict 4: Norton Bay (Koyuk) (333-40)
- Subdistrict 5: Shaktoolik (333-50)
- Subdistrict 6: Unalakleet (333-60)

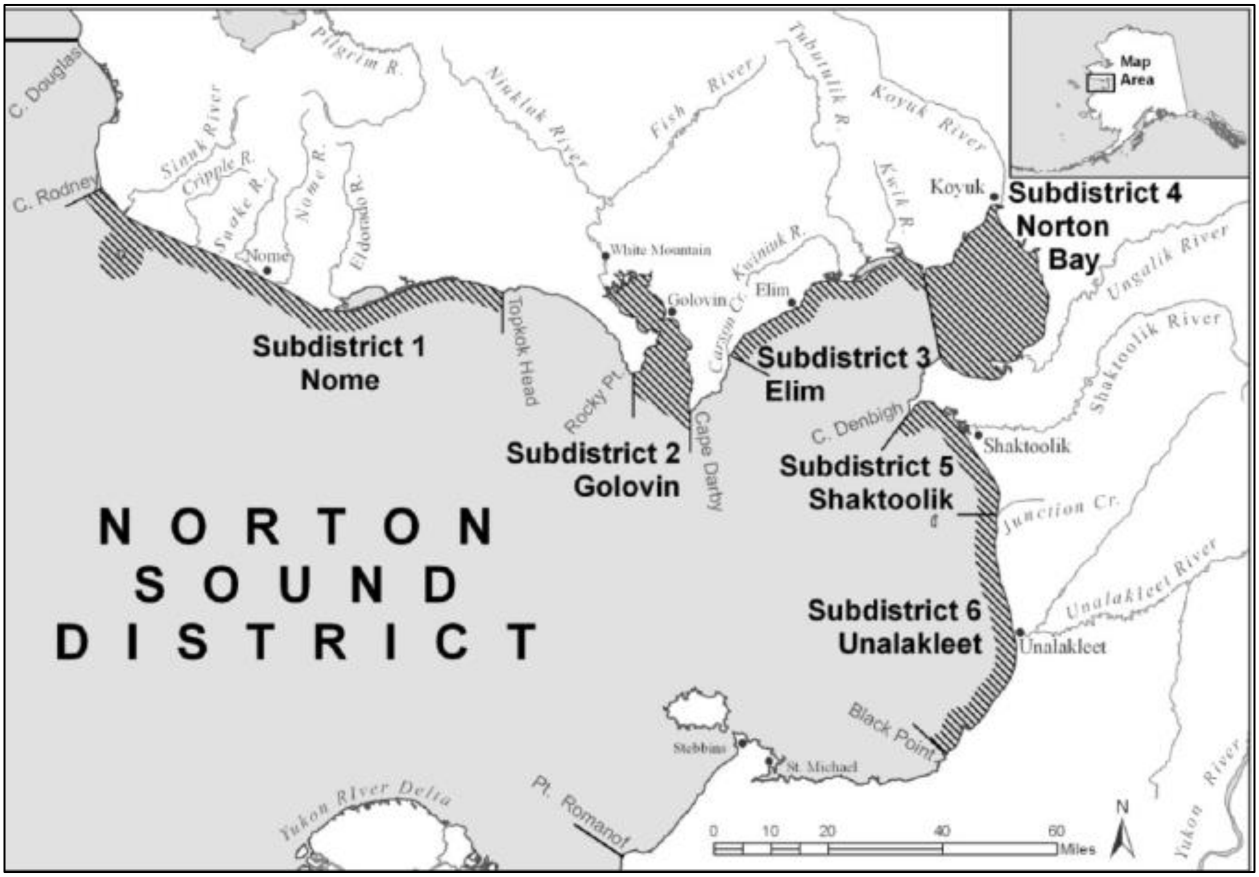

Figure 9. Norton Sound District Salmon Subdistricts

5.3.1.2 Fishery Management Techniques

Salmon fisheries are managed by ADF&G such that escapement goals are met. When salmon abundance exceeds or is predicted to exceed the established escapement goals, ADF&G permits the harvest of salmon by subsistence, commercial, and sport fisheries. Subsistence harvests take priority over commercial and sport fisheries when salmon runs are low in abundance.

Commercial fishing gear for salmon is restricted to gillnets in the Norton Sound region except for the Shaktoolik and Unalakleet (Subdistricts 5 and 6, respectively), where regulations allow for the use of seine gear. ADF&G enforces restrictions on mesh sizes to try to direct harvest toward a specific species of salmon. For example, gillnet mesh size restrictions to 6.0-inch or smaller are used to target chum and coho salmon. In the Unalakleet and Shaktoolik subdistricts, if there are Chinook salmon fishing periods in June through early July, 8.25-inch stretched mesh gillnets are commonly used (Menard et al. 2018).

5.3.1.3 Harvest Timelines and Fishing Seasons

Announcements on commercial and sport fishery openings, closings, fishing areas, and times are referred to as emergency orders. ADF&G considers a combination of factors before issuing emergency orders each year. These factors include comparative commercial catch data, escapements, and weather conditions, which affect the management of fishing periods, allowable mesh size, and fishing areas. Figure 10 summarizes approximate season dates for salmon fisheries in Norton Sound.

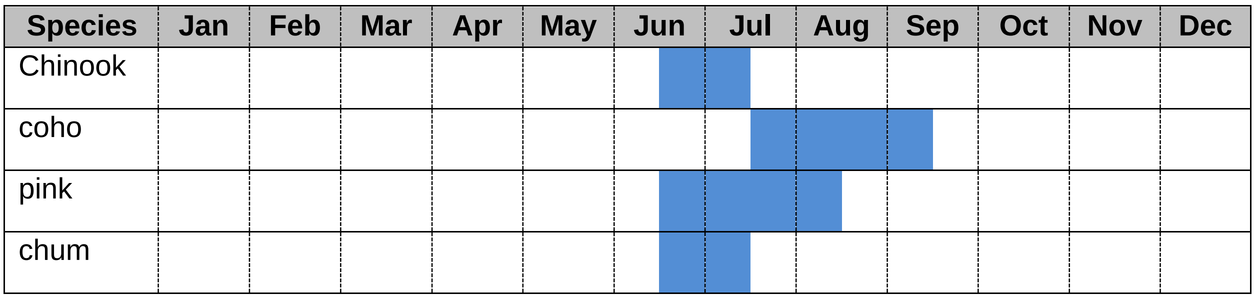

Figure 10. Norton Sound Area Commercial Salmon Fishing Season by Species

Note: This summary is intended as a general guide only and is non-binding. Season lengths indicated in this summary are subject to closure by emergency order as guideline harvest objectives are met or as deemed necessary by conservation concerns.

The commercial salmon fishing season usually opens by emergency order between 08 June and 01 July but depends on run timing within each subdistrict. The season closes by regulation on 31 August in Subdistricts 1, 2, and 3 and on 07 September in Subdistricts 4, 5, and 6. Emergency orders set possible extensions. In the past, however, processors have often terminated their operations before the regulatory closure dates.

The district commercial fishing season typically begins in June, targeting Chinook salmon if a sufficient run exists. Emphasis switches to chum salmon in July, and the coho salmon fishery begins the fourth week of July and closes in September. Pink salmon are much more abundant in even-numbered year returns. A directed pink salmon fishery may coincide with or be scheduled to alternate periods with historical chum salmon fishery. At the Elim subdistrict specifically, chum salmon is targeted in June and most of July, pink salmon in June and July during even-numbered years, and coho salmon in late July and August. Golovin, the subdistrict west of Elim, has the same targets.

5.3.1.4 Commercial Salmon Fishery Overview

Two factors influence the commercial salmon fishery in the Norton Sound District: the abundance of the salmon run each year and the presence of buyer interest. Commercial salmon fishing in the Norton Sound District began in Shaktoolik and Unalakleet in 1961. Chinook and coho salmon were the two species of interest that were flown to

Anchorage for further processing. Chum and pink salmon were purchased and processed by one U.S. freezer ship during 1961. The following year, two floating cannery ships operated in the district, and commercial fishing was extended to Golovin, Elim (Moses Point), and the Norton Bay (Koyuk). Salmon canning operations peaked in 1963. After that, markets were sporadic through the 1980s. Some subdistricts were unable to attract buyers for entire seasons. The Nome Subdistrict closed commercial fishing periods from 1997 to 2012 due to regulatory restrictions on chum salmon, lack of buyer interest, and weak runs. Limited commercial fishing began for chum and pink salmon in 2013 and for coho salmon in 2016. Of all the subdistricts, Unalakleet and Shaktoolik have the most consistent markets. NSEDC established Norton Sound Seafood Products (NSSP) in 1995 (Menard et al. 2018). NSSP buys and processes salmon from the district’s commercial fishermen from the NSEDC communities. NSSP operates processing plants in Nome, Unalakleet, and Savoonga.

In Elim, salmon fishing takes place at Moses Point near the Kwiniuk and Tubutulik river drainages. Historically, Subdistrict 3 was not immune to the challenges associated with a lack of buyer interest and weak salmon runs. Weak salmon runs from 2002 to 2006 resulted in ADF&G’s enforcement of subsistence fishery priority over commercial fishing. For five consecutive seasons, commercial salmon fishing did not occur. Salmon runs rebounded in 2007, resuming commercial salmon fisheries for coho, pink, and chum salmon and minimally for Chinook and sockeye. By the late 2000s, continued improving salmon runs sparked renewed buyer interest in the northern subdistricts (Menard et al. 2017). In 2017, the Norton Sound District reported well above average runs of chum, pink, sockeye, and coho. The sockeye salmon harvest, although a small portion of the overall harvest, was the second highest in history at nearly 3,000 fish. The pink salmon run was one of the highest runs for an odd-numbered year; however, the only buyer had minimal interest in pink salmon.

In 2018, NSEDC reported a record harvest of more than 3.6 million pounds for these salmon species with an ex-vessel value of more than $4 million, an increase from the ex-vessel value of $2.8 million in 2017. An overall steady increase of harvest sold to NSSP by the district in recent years is shown in Table 5. The commercial salmon harvest saw a 107% increase for chum and more than 300% increase for coho and pink salmon, respectively, between 2013 and 2018. Sockeye salmon increased the most.

Table 5. Salmon Harvest by Pound for NSEDC Communities, 2013–2018

Species	2013	2014	2015	2016	2017	2018	Percent Change
Chum	820,615	737,906	1,017,160	344,613	1,162,302	1,695,616	107%
Coho	410,936	810,560	1,226,157	701,450	1,308,875	1,844,718	349%
Pink	24,802	572,461	215,714	748,576	71,746	116,194	368%
Sockeye	1,145	2,102	25,656	16,057	16,568	18,978	1557%
Chinook	0	0	0	0	2,299	0	
Source: NSEDC Annual Reports 2013–2017							

The commercial salmon harvest in the Elim subdistrict made up 8–40% of the total commercial salmon harvest sold to NSSP between 2013 and 2018. The rest of the NSSP salmon catch was harvested by NSEDC communities in the other subdistricts. The harvest (in pounds) by Elim fishermen over this period is shown in Figure 11.

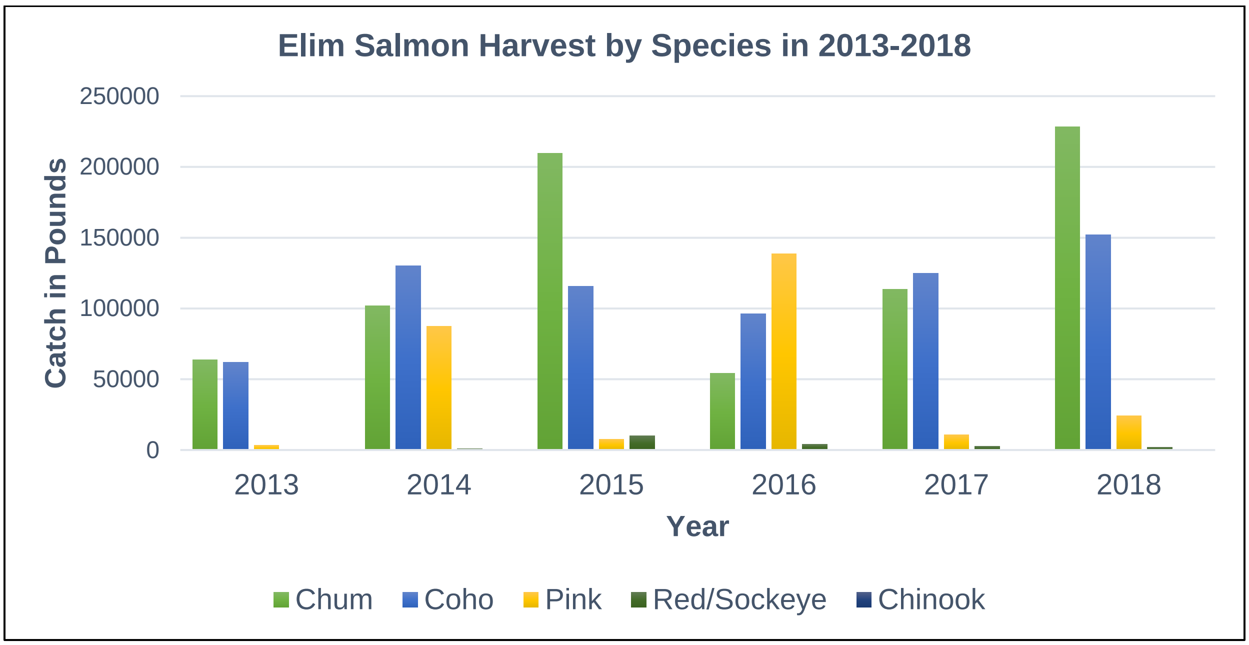

Figure 11. Elim Salmon Harvest in Pounds, 2013–2018

In 2017, NSSP was the only salmon buyer that operated in Norton Sound. NSSP operates a fish plant in Unalakleet, where salmon was tendered from Subdistricts 2–5. Fishermen in Subdistricts 1–3 could deliver their catch to the NSSP-operated fish plant in Nome. However, the option for a fisherman to deliver a catch from Elim to Nome depends on the commercial vessel's capability to traverse to Nome and weather conditions. The average dock prices per pound for salmon from 2013 to 2017 in the Norton Sound District are shown in Table 6.

Table 6. Salmon Average Dock Prices per Pound in Norton Sound District, 2013–2017

Year	Chinook	Sockeye	Pink	Chum	Coho
2013		$1.49	$0.22	$0.55	$1.77
2014	$2.00	$0.63	$0.29	$0.60	$1.60
2015	$2.25	$0.60	$0.14	$0.50	$1.10
2016	$2.45	$0.90	$0.10	$0.48	$1.39
2017	$3.00	$1.40	$0.03	$0.79	$1.40
Five Year Average	**$2.43**	**$1.00**	**$0.16**	**$0.58**	**$1.45**
Source: (Menard et al. 2017)					

The harvest (in pounds) for each species is multiplied by the corresponding mean price for each year to calculate the value of commercial salmon harvest by the NSEDC communities (Table 6). It is then adjusted to current dollars using the Urban Alaska (formerly Municipality of Anchorage) Consumer Price Index. The commercial salmon fishery saw a steady increase throughout this period, with the 2017 fishing season realizing the highest harvest value of close to $3 million, as shown in Table 7. On average, fishermen from the 15 communities in the Norton Sound region earn more than $2 million each salmon fishing season.

Table 7. Value of Salmon Harvest in NSEDC Communities, 2013–2018

Year	Total	2019 Dollars
2013	$1,186,000	$1,287,000
2014	$1,907,000	$2,022,000
2015	$1,903,000	$2,008,000
2016	$1,230,000	$1,292,000
2017	$2,783,000	$2,910,000
2018	$3,706,000	$3,760,000
Average Harvest	**$2,119,000**	**$2,213,000**
Note: 2019 values are rounded		

For the 2013–2018 period, the combined commercial salmon value harvested by Elim fishermen was an estimated $300,000 (rounded) each season—about $10,800 per fisherman (total value divided by 28 average commercial fishermen in Elim). The rest of the salmon harvest was caught by the rest of the NSEDC communities in other subdistricts and sold to NSSP.

5.3.2 Permit Holders

Based on ADF&G reports (Menard et al. 2017), there are 131 commercial salmon permit holders on average that participate in the Norton Sound District salmon fishery. Of this total, about 28 are Elim commercial fishermen, making up 20% of the district's commercial salmon permit holders. Close to 50% of the commercial salmon fishermen homeport in Unalakleet, where there is a natural small boat harbor. Excluding the small boat harbor in Nome, Unalakleet is the only community in the region with a boat harbor. It serves more than 100 residents and non-resident commercial vessels that participate in salmon, herring, and crab fisheries (Kawerak Inc. 2013).

5.3.3 Vessel Types

Commercial salmon fishermen in the Norton Sound District operate set gillnets from outboard-powered skiffs. The Commercial Fisheries Entry Commission (CFEC) maintains a database of commercial permit holders and registered vessels in the state. However, not all vessels for some areas in western Alaska are captured in the CFEC database. The exclusion of some vessels from the CFEC database is due to a vessel license exemption enacted into law by the Alaska State Legislature that exempts skiffs used in salmon fisheries from registration with CFEC (AS § 16.05.490). The exemption was intended to reduce the financial burden of participation in the commercial salmon fishery on western Alaska communities. In the Norton Sound region, exemption requirements are often met, as most fishermen do not participate in other commercial fisheries. Only fishermen in the Norton Sound District who want to participate in other non-salmon fisheries would be motivated to register their vessel with the CFEC. The description based on CFEC information of the vessel types in this fishery is not holistically representative of the vessel fleet in the region. Nevertheless, the records by CFEC show some important information about the fleet in the Norton Sound District, particularly that the commercial fleet is aging.

There are 100 commercial fishing vessels in the region. The number of fishing vessels in the Norton Sound District registered with CFEC in 2018 is shown in Table 8. The average lengths of vessels at each subdistrict range from 22 to 33 ft (ft). Two of the commercial vessels have steel or iron hulls, 98 have aluminum hulls. More than 60% of the commercial fishing vessels are at least 30 years old. Newer vessels that were built in the 2000s make up 10% of the commercial fishing vessels.

Table 8. Norton Sound District Commercial Vessel Characteristics, 2018

Subdistrict	Number of Vessels	Average Length Overall (ft)
Elim	7	25
Golovin	4	25
Koyuk	4	22
Nome	13	33
Shaktoolik	23	25
Unalakleet	49	25
Total	100	
Year Built	**Percentage**	
1966–1979	6%	
1980–1989	59%	
1990–1999	25%	
2000–2018	10%	
Gear Type	**Percentage**	
Gill Net - Drift	1%	
Gill Net - Herring	64%	
Gill Net - Set	77%	
Pot Gear	31%	
Longline	11%	

Commercial vessels may participate in multiple fisheries and use several gear types. Close to 80 commercial vessels use set gillnets, 64 participate in gillnetting for herring, 30 use crab pot gear, 11 use longline gear, and only 1 uses drift gillnet gear. The commercial fishing vessels in Elim are further discussed in subsequent sections of this report about the fleet.

5.3.4 Subsistence Salmon Overview

According to Fall et al. (2019), subsistence fishing is an important element of Alaska's social and cultural heritage, as well as a crucial component of the subsistence sector of the state's economy. In the Norton Sound region, nearly all residents depend on fish and game resources. The dependency on each resource varies by the community, based on the community's location and the migratory behaviors of wildlife resources (Braem and Kostick 2014). Subsistence fishermen operate gillnets or seines in the main rivers and, to a lesser extent, harvest salmon in coastal marine waters (Menard et al. 2018). As previously discussed, the salmon fisheries are managed on a sustained yield basis. Priority is given to subsistence users over commercial and sport fishermen, as required by Alaska law.

ADF&G monitors subsistence harvests through permits issued to users made available in Nome. Subsistence use permits are also distributed by field staff deployed throughout the communities prior to fish openings. The permits identify gear restrictions and require subsistence users to record gear type used, areas fished, and catch quantities by species for each day fished. Most subsistence fishing is conducted during the summer, and the catch is air dried or smoked for consumption by residents or occasionally by their dogs (Fall et al. 2019).

From 2012 to 2016, subsistence users in the Norton Sound District harvested an average of 64,000 salmon. Since 2013, regulations have allowed for cash sales of subsistence-taken finfish for up to $500 per household per year in the Norton Sound District.

5.4 Marine and Terrestrial Mammals

Marine resources are accessed primarily by vessels, while marine-related terrestrial resources are those land-based subsistence resources which residents access by vessels. Subsistence use is central to the customs and traditions of remote Native Alaska communities such as Elim. This subsection provides an overview of the primary wildlife resources that require access by boat.

5.4.1 Subsistence Hunting and Fishing Management

Subsistence fishing and hunting in Alaska is regulated in a dual management system, with overlapping state and Federal jurisdictions in many areas. Depending upon where the harvest occurs, subsistence fishing and hunting are regulated by the ADF&G and the Federal government. The following agencies manage and regulate subsistence hunting and fishing in Alaska:

- Alaska Board of Fisheries
- Alaska Board of Game
- ADF&G
- U.S. Fish and Wildlife Service
- NMFS
- Federal Subsistence Management Program

The Alaska Board of Fisheries is responsible for developing regulations that conserve and develop the fishery resources of the state. These regulations include the setting of seasons, methods, and mean of subsistence and commercial fisheries. Members of the public can submit their proposals to the Board of Fisheries, where the proposals are considered and decisions are voted on. Regulations are then drafted and legally reviewed before they are made official (ADF&G 2020). The Alaska Board of Game is responsible for establishing open and closed seasons, areas for taking game and regulating methods and means.

The Federal government manages marine mammal hunting through NMFS (seals, sea lions, and whales) or the U.S. Fish and Wildlife Service (polar bears, sea otters, and walruses). An exemption in the Federal Marine Mammal Protection Act allows for the traditional harvest and use of marine mammals by coastal Alaska Natives. The U.S. Fish and Wildlife Service also manages subsistence hunting of migratory waterfowl.

Subsistence resources are harvested during different seasons. Most of the subsistence wildlife resources Elim harvests are harvested inland and require traveling up the Kwiniuk River. Moose and caribou are examples of such resources. During the resource harvests in the warm ice-free seasons, residents often organize camping trips, consisting of traveling up the Kwiniuk River by boat to hunt and to collect berries, eggs, and other resources. This assessment focuses on three mammals the community harvests on a subsistence basis by boat: beluga whale, caribou, and moose.

5.4.2 Beluga Whale

Beluga whales are an important subsistence resource for coastal residents of Alaska. (Frost K.J, Alaska Beluga Whale Committee 1998). Residents use the meat, skin, and blubber for food, clothing items, and equipment. It is also shared with friends and relatives in other communities. The eastern Bering Sea (Norton Sound/Yukon Delta) is one of the five summering concentrations in Alaska where beluga whales are found. The others are Cook Inlet, Bristol Bay, eastern Chukchi Sea (Kotzebue Sound and Kasegaluk Lagoon), and the eastern Beaufort Sea.

Representatives from the communities in these groups (except Cook Inlet) make up the Alaska Beluga Whale Commission, established in 1988. The role of commission includes the co-management of beluga whales with NMFS to maintain a healthy beluga whale resource for subsistence and public enjoyment by future generations (North Slope Borough Alaska Beluga Whale Committee 2020).

Local management organizations at the community level coordinate hunts and support the Alaska Beluga Whale Commission. Elim-Shaktoolik-Koyuk Marine Mammal Commission is one of these local organizations, with representatives from the three communities. The significance of beluga whales to coastal Alaska Native communities is noted by the elders' traditional ecological knowledge. A part of this traditional ecological knowledge is documented by Huntington et al. (1998), specifically: migratory and local movements, feeding, calving, and ecological interactions. The insights shared by the elders the study contacted are consistent with past biological studies of beluga whales. The beluga whale movements follow the tide and the fish in both the spring and the fall. The movements of beluga whales in Norton Bay during the spring and fall, as documented by Huntington et al. during interviews with Elim, Shaktoolik, and Koyuk community members, are shown in Figure 12.

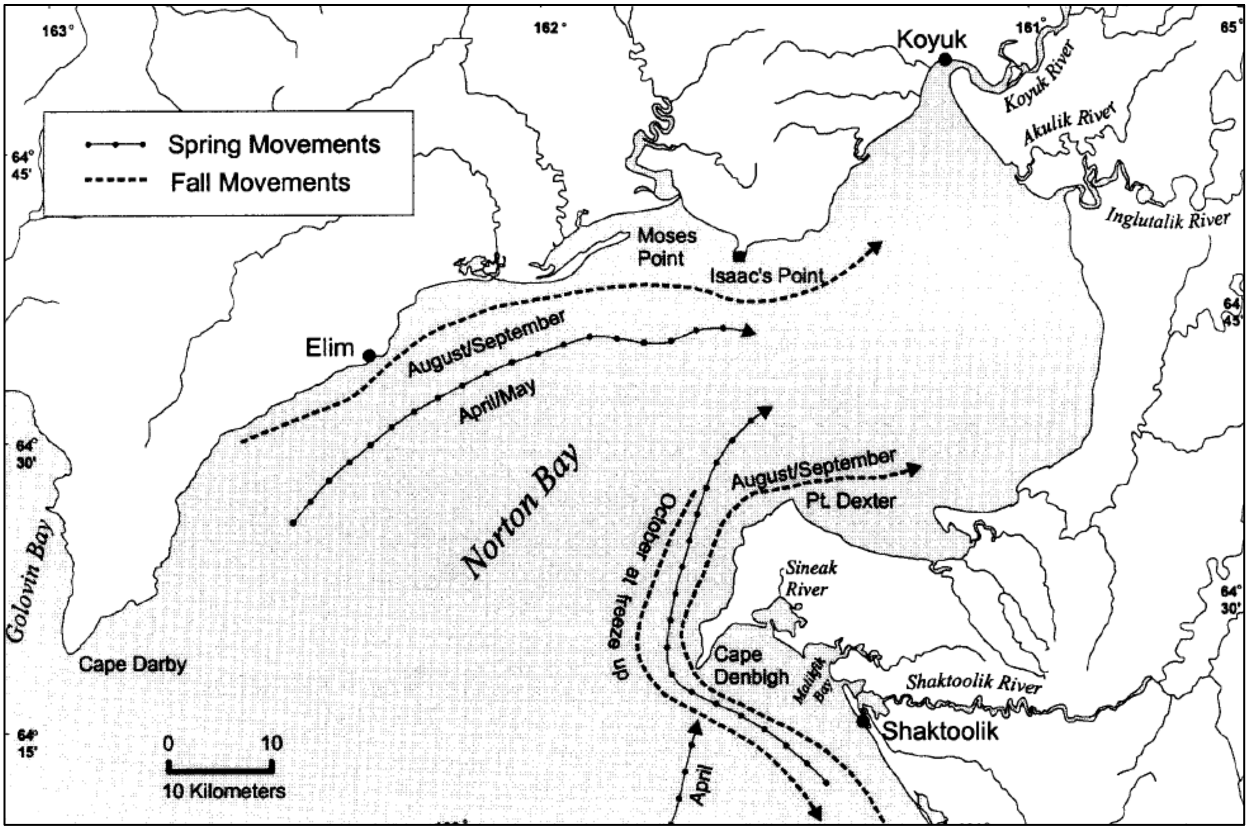

Figure 12. Beluga Whale Migratory and Local Movements during Spring and Fall in Norton Bay (Braem and Kostick 2014)

Beluga whale harvest in the spring occurs from April to May when the belugas arrive in Norton Bay from the south, along the coast past Besboro Island and Shaktoolik, or southwest past Cape Darby and Elim. Hunters from Elim and Shaktoolik hunt from the ice edge near their villages using harpoons and nets. In the fall, beluga harvest occurs from August to September and sometimes October. All three communities often hunt cooperatively inside the Norton Bay. Beluga whale hunting in the fall uses vessels, nets, harpoons.

A comprehensive survey conducted in 2006 on subsistence use in the Bering Strait region by Ahmasuk et al. (2008) estimated that beluga whale harvest was 188 pounds per capita at Elim. At Koyuk, the survey findings estimated 10 pounds per capita. The comprehensive survey further reported 40% of Elim households shared a portion of the beluga whale harvest they obtained.

5.4.3 Caribou

The role of caribou in the nutritional, cultural, and economic health of northwestern Alaskan communities varies (Braem & Kostick 2014). Like beluga whales, caribou herds are migratory. The ADF&G categorizes the caribou herd that roams the region around Elim as the Western Arctic caribou herd. This herd roams throughout 140,000 square miles and is the largest caribou herd in the state.

Elim residents harvest caribou from fall through winter (October to April). According to a community member, hunting camps traverse the river to reach the hunting area during the fall. In winter, snow machines are often used. ADF&G surveyed Elim households in 2011 and reported 34.6 pounds of caribou harvest per capita. The harvest per capita at Elim is low compared to its neighbor Koyuk, which reported 84.4 pounds per capita. Braem and Kostick reasoned that a village's location is one factor that influences a community's caribou harvest each year. Residents may have only occasional access to the Western Arctic caribou herd.

5.4.4 Moose

Elim residents hunt moose during summer (July to September) from the same region the caribou roam. ADF&G's household survey in 2011 found that moose harvest for Elim was 18.4 pounds per capita. Koyuk harvested nearly twice as much as Elim: 34 pounds per capita. Braem and Kostick noted community concerns that there were fewer moose and that they were too far away from the community compared to the past. Moose harvest is influenced by the same factors that influence the caribou harvest, including migratory behavior and location of the community.

5.5 Marine Resource Outlook

Subsistence and commercial salmon fisheries are expected to continue to support the demand for a harbor in Elim over the period of analysis. Despite weak salmon runs from the early to mid-2000's, commercial salmon fisheries in Norton Sound rebounded steadily from 2007. In Elim specifically, commercial salmon harvest increased significantly between 2013 and 2018. NSEDC's future plans and NSSP's operations in the Norton Sound region indicate a continued buyer presence and a market for salmon fisheries. The salmon management by the previously mentioned entities in Alaska supports sustaining the fisheries for Alaska and the Norton Sound region.

Similarly, marine and terrestrial wildlife resources are regulated to support sustainable resources and subsistence use. Subsistence harvests of terrestrial and marine resources in Elim and the region are expected to continue to support its mixed economy and sustain cultural and social practices.

5.5.1 Climate Change, Resiliency, and Adaptation

The National Oceanic and Atmospheric Administration (NOAA) began publishing an annual, peer-reviewed Arctic Report Card in 2006. The Report Card is a “source for clear, reliable, and concise environmental information on the current state of different components of the Arctic environmental system relative to historical records” (Osborne, Richter-Menge, & Jeffries 2018). The 2019 Arctic Report Card states that winter sea ice in the Bering Sea was declining as ocean temperature rises (NOAA Arctic Program 2019). Elders from the Bering Sea communities note that their access to subsistence resources is more challenging and hazardous in the warming Arctic. Also, the Bering Sea fisheries, according to the report card, are experiencing a northward shift in the distribution of subarctic and Arctic fish species, linked to the loss of sea ice and changes in bottom water temperature.

While climate events such as a warming arctic impact the access to subsistence resources in Bering Sea communities, these resources' reliability remains increasingly important. As such, multi-level government and non-government organizations listed at the beginning of this section continue to work collaboratively to support local communities' resiliency and adaptation to the changing climate.

6. EXISTING CONDITIONS

This section describes Elim’s current conditions. Existing conditions serve as the baseline for projecting the future with or without the proposed project. Elim has limited transportation infrastructure and relies on air and maritime transportation. This section discusses vessel operations, Elim’s proximity to other harbors, and the existing fleet. Existing conditions in Elim are informed by the USACE *Continuing Authorities Program (CAP) 107 Elim* study in 2013; community insights shared at a study charette in the fall of 2018 and focus groups in April 2019; and available information by the Department of Commerce, Community and Economic Development (2019).

6.1 Vessel Operations

Elim has no permanent boat launch, moorage, or barge ramp infrastructure. There are two areas in Elim used for launching commercial and subsistence vessels: the beach in front of the community and Moses Point. This report refers to the beach site located in the community as Elim Beach (Figure 13). At Elim Beach, most boats are anchored just offshore or pulled onto the beach for storage when not in use. When strong waves or storms are approaching, a loader is used to pull boats up from shore onto Front Street (highlighted in orange on the map). A fisherman requiring a loader to pull his skiff from the water due to rough waves in October 2018 is shown in Figure 14.

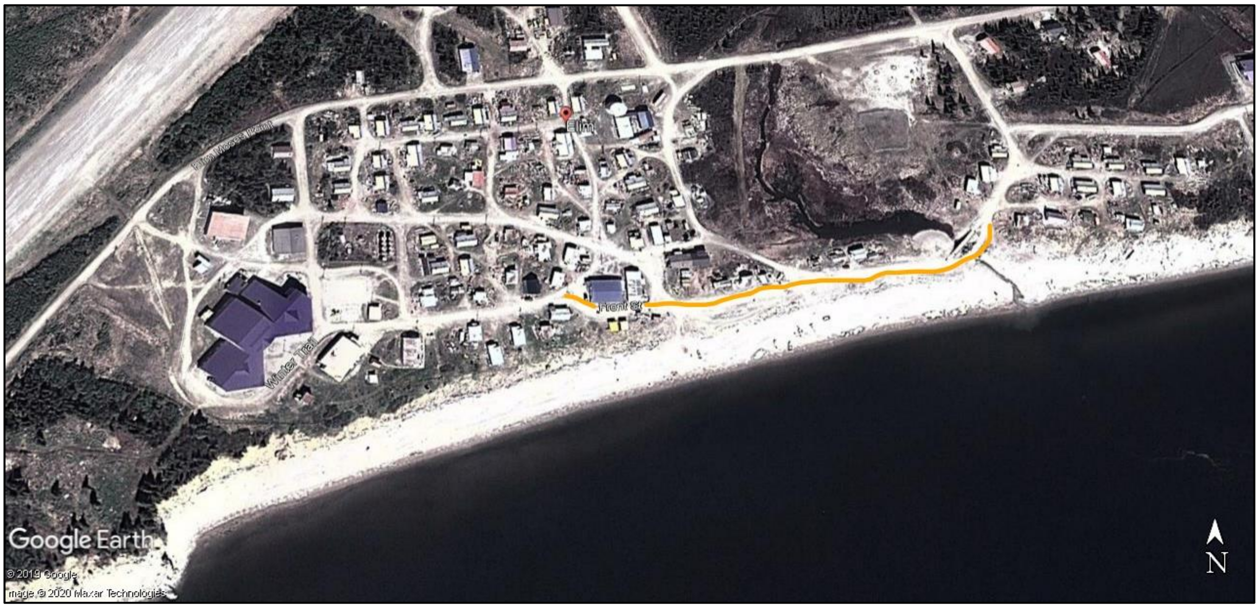

Figure 13. Elim Town and Beachfront

Figure 14. Loader Pulls a Salmon Skiff from Rough Water at Elim Beach (October 2018)
(Photo courtesy of a local community member: C. Nagaruk, April 2019)

Moses Point is the sandy spit at the mouth of the Kwiniuk River. Kwiniuk River is used as a make-shift moorage area and is located about 10 miles northeast of Elim's center. The location of Moses Point, relative to Elim, is shown in Figure 15. Elim and Moses Point are connected by a gravel road, which takes approximately 20 minutes to travel one-way by vehicle.

Figure 15. Location of Moses Point Relative to Elim

Vessel access to Kwiniuk River is dependent on wave and water level conditions. Residents have reported increased shoaling at the Kwiniuk River's mouth, making access to the safe moorage less predictable. During large storm surges, residents pull their boats higher onshore. If there is short notice of a storm, vessels can get swamped due to the distance between Elim and Moses Point and the limited number of residents with trucks and trailers. Many vessels, even the larger commercial fishing vessels, are pulled onto shore at Moses Point when not in use. Due to the shallow depth along the

Kwiniuk River slough and river mouth, larger vessels with drafts of approximately 5 ft or more cannot access Moses Point.

The mouth of the Kwiniuk River is active and dynamic. During storm surges, flooding occurs at Moses Point and extends along the road. When the road floods, residents cannot drive to Moses Point to check on their boats. Flooding can also erode the road and further prohibit access. Winds of 40 knots from the southwest shift the sand bar that protects the river mouth. Without protection, boat access from the ocean to Moses Point during high water becomes challenging and unsafe. The community reported that several boats have turned over and lost motors during flood events. Dragging boats onto the shore causes boat damage and reduces the life of the vessel. Vessels anchored offshore are subject to swamping, which cause serious damage to the engines. The current conditions at Moses Point are such that, while it provides some safe moorage for small subsistence skiffs to the larger commercial vessels, safe access from the ocean and the town via the road depends on the weather.

6.1.1 Subsistence Activities

Elim residents rely upon the harvest of subsistence resources for food, clothing, tools, and medicinal uses. The community's reliance on subsistence is especially significant, given Elim's relative isolation and limited connections to other communities. While imported foods are appropriate supplements, they are not substitutes to subsistence foods that are part of the community's traditional diet.

Subsistence resources are harvested by season and typically require access by boat. For example, when hunting caribou, hunters travel up the Koyuk River and set up camp. However, when they return with game weighing over 1,000 pounds, Moses Point can become inaccessible due to the shallow water depths. The alternative access point is Elim Beach, but due to rough water conditions, safely approaching the shore is difficult. Community members often prepare to wait out the wave conditions offshore and time when they attempt to approach the shore. When the community anticipates these conditions during a harvest season, they sometimes choose not to subsistence harvest at all.

6.1.2 Commercial Fishing

During the fishing season, NSEDC sets up a fish-buying station at Moses Point. The fish-buying station consists of a small portable crane, a Connex, totes for fish, and several skiffs used to transport fish to a tender moored offshore (Figure 16). Fishermen deliver their catch to the buying station by boat or by four-wheeler, depending on where nets are set. Fish are placed in iced totes, loaded onto skiffs, and delivered to the offshore tender.

Figure 16. Fish-Buying Station at Moses Point

Fish delivery skiffs are tied next to the tender vessel, and the crane on the tender transfers the totes, each weighing approximately 1,500 pounds. The skiffs make 5–10 trips daily during the fish openings to deliver fish totes to a tender. The tide and wave conditions at the mouth of Kwiniuk River dictate deliveries to the offshore tender, which helps dictate the amount of fish that can be caught and sold. During rough wave activity, this operation becomes complex and unsafe. The tender then delivers the fish totes to the NSSP plant at Unalakleet.

The fish-buying station's operability is impacted when low tides and north winds cause low water and limit navigational access to the site. Access through offshore sand bars is also variable. Some fishermen choose not to fish during openings if they anticipate that the buying station will not be accessible due to low water levels. Due to flooding events and low tides that restrict access, the fish-buying station is periodically relocated to Iron Creek, approximately 5 miles northeast of Elim. An employee at the fish-buying station reported that when water levels are too shallow at Iron Creek for boat access, fish totes are transported by four-wheeler to town. From the beach, a telehandler forklift (referred to as a Zoom Boom loader) transfers the fish totes onto a skiff in the water for delivery to the tender anchored offshore. Disruption to fish-buying operations that require relocations to either Iron Creek or Elim Beach occurs 8–10 times per fishing season.

6.1.3 Freight Barge

Elim has no barge landing infrastructure. Freight barges land on the east end of Elim Beach, just east of Elim Creek's mouth, where fewer rocks obstruct beach access. The location of the landing is shown in Figure 17. Barge deliveries to Elim use a beach landing craft that is 150 ft long with a 52-foot (ft) beam. The landing craft is pushed onto the beach, and freight is offloaded using a loader. Cargo barges make deliveries to Elim twice each summer but will deliver more often if necessary.

Figure 17. Elim, Alaska

Due to the depth at the freight barge landing site, freight barges must land at high tide. They also must launch at high tide when departing from Elim after delivery, which means that the barges must either offload quickly or wait for appropriate tidal conditions to launch. In some cases, the barges accelerate from offshore and ride a wave to the beach. Operators do this when high tide does not provide enough water depth for the barge's keel. The barge operators wait for a breaking wave and must time with precision when to speed up to catch the wave from the halfway point to the barge's front. The barge surfs the wave to shore and risks a rough landing on the gravel beach with a heavy load. This practice poses risks to the safety of barge operators and crew.

Sometimes when the tide does not provide deep enough water depth to get the barge all the way to shore to offload cargo, self-lightering is required. Self-lightering is when the loaders and equipment are walked through the water to shore to lighten the load, which causes additional wear and tear on the equipment and leaves sheen behind in the water.

An exposed sewer outfall line near the middle of the shoreline that fronts the community poses a navigational hazard to barge landings. The approximate location of the sewer outfall is labeled in Figure 17. There is a limited staging area at the existing freight landing site, which further reduces deliveries' efficiency. Elim's bridge over which equipment must cross to deliver some freight is reported as “substandard” and cannot accommodate large trucks.

6.1.4 Fuel Barges

Fuel delivery to Elim occurs 2–3 times per year using a tug and barge combination. Under existing conditions, the fuel barge anchors offshore and floats a hose to shore to deliver fuel to the community. Barge operators do not land on the beach in Elim because of the rock outcrops along the beach's west area that may damage the barge. The fuel tank farm serving Elim is near the south end of the airport runway shown in Figure 17. The fuel tank farm is 150 ft above sea level. The fuel header is located on the west side of the community near the school (Figure 18). The fuel header and tank farm are connected by two 4-inch pipes (one for gasoline and one for diesel/fuel oil) approximately 0.75 miles long.

Figure 18. Fuel Header in Elim

To deliver fuel to the community, barges double anchor 60–70 ft offshore of Elim Beach near the fuel header and float a 4-inch hose to shore. The hose is dragged across the beach and up the bluffs by hand to the fuel header where it is connected. Usually, the fuel vendor tests the line to be used before the connection. Upon successful completion of testing, the fuel is pumped from the barge to the tank farm. The delivery rate is slow and requires 24 hours of offloading; this is believed to be due to the tank farm's elevation above the barge.

After fuel delivery, some of the fuel remaining in the pipelines will be forced into the tanks by high-pressure air from the barge. Some of the fuel remains in the pipelines. The fuel header valves are closed, the hose is disconnected, and caps are placed on both header and the hose. Retrieval is again done by human resources from the header back to the beach and floated back to the barge. Fuel remaining in the hose is drained back into the barge. There are many occasions through delivery where small spills can occur. This practice of anchoring offshore and floating a hose to shore poses a risk of fuel spills during offloading from the barge to the fuel header.

6.2 Proximity to Other Harbors

If local Elim boaters choose not to store their vessels in Elim, there are few options for alternative ports. Communities nearest to Elim that have harbor facilities are shown in Table 9. The nearest communities to Elim are Golovin and Koyuk, which lie approximately 23 miles west and 40 miles east of Elim, respectively. However, there are no marine facilities at either location. There are no road connections between Golovin, Koyuk, and Elim, further limiting alternate boat storage potential.

Table 9. Distances between Elim and Nearby Communities with Harbor Facilities

Distances from Elim to:	Nautical Miles
Nome	102
Unalakleet	60
Source: Distances Between U.S. Ports, NOAA 2009 & Google Earth 2012	

Elim is not connected by road to any communities with marine facilities. The closest community to Elim that contains marine facilities is Unalakleet, 60 nautical miles south of Elim. Assuming an average travel speed of 10 knots, it would take about 6 hours to travel between Elim and Unalakleet by boat.

Most of the vessels in Elim are 18–24-ft skiffs, which are not conducive to a 6-hour trip across Norton Sound. Elim residents use their vessels mostly for subsistence harvesting and some commercial fishing and need their boats available for quick launching. Boat storage in Unalakleet would reduce their vessels' availability and, therefore, the ability to participate in commercial and subsistence harvests. Given the isolation of Elim, the usage patterns of local vessels, and the distance to any alternate ports, the benefit to Elim residents of storing their vessels at alternate port facilities would be outweighed by the costs of air travel and reduced harvest opportunity.

6.3 Search and Rescue for Vessels in Distress

When there is a vessel in distress, existing conditions make it difficult to safely mobilize search and rescue efforts. Response vessels often wait for better weather and wave conditions to launch from Moses Point or Elim Beach (USACE 2018). Dangerous conditions include unknown sand bar movement at Moses Point and shallow depths at both Moses Point and Elim Beach. If the water depth conditions at Moses Point are favorable for boat launch, response community members still have to drive from Elim to Moses Point, provided the road is not flooded. The longer the delay in launching response vessels, the greater the potential risks for the vessel's distress.

6.4 Existing Vessel Fleet

Four vessel classes make up the vessel fleet in Elim:

- Subsistence vessels, which are skiffs with outboard motors used for subsistence fishing, hunting, and gathering.
- Commercial fishing vessels that participate in commercial salmon and herring fisheries. Due to Elim's remote location and the lack of moorage infrastructure, there are no commercial fishing vessels from other communities.
- Commercial fish tenders that deliver fish from the community to Unalakleet's processing plant.
- Fuel and freight barges. The fuel barge combines a tugboat and barge.

The characteristics of the existing fleet are summarized in Table 10.

Table 10. Characteristics of Vessel Fleet in Elim

Vessel Class	Number	Length (ft)	Width (ft)	Draft (ft)
Subsistence	25	18–24	7	2
Commercial	25	20–32	12	5
Tender	2	33–66	16–24	6
Freight Barge	1	150–180	52	7
Fuel Barge	1	150–159	52	7
Tug*	1	70–86	28.5	8

Note: The tug is combined with the fuel barge and is discussed as a single unit vessel throughout the analysis.

During a site visit to Elim in September 2011, there were about 50 vessels in the community. The community members reconfirmed this number at public meetings held in Elim in August 2018. The local fleet includes small skiffs (18–24 ft length overall) and larger seine vessels (20–32 ft length overall) used for subsistence and commercial fishing. NSEDC reports that 23–25 Elim fishermen hold permits and participate in commercial fisheries. This analysis assumes that 25 vessels participate in both commercial and subsistence fishing, and another 25 vessels participate in subsistence harvesting.

The tenders that call on Elim support the commercial fishery by delivering Elim's catch to NSSP's fish processing plant in Unalakleet. NSEDC operates six tenders in the communities it serves. The overall lengths of tenders range from 33 to 66 ft, with drafts between 4 and 24 ft. The tenders dispatched to the communities are dependent on the expected size of the catch and water depths at the fish-buying station sites.

Available data from the Waterborne Commerce Statistics Center shows the typical fuel and freight barges that call into Elim. Only one barge calls to Elim at a time. A freight and fuel barge would not be offloaded at the same time. The freight barges are landing crafts with overall lengths between 150 and 180 ft and draft up to 8 ft when loaded. The fuel barges are typically the following: deck barge, double and single-hull tanker barges with tugs up to 86 ft long. Barges that deliver construction materials or rock for the road range between 150 and 180 ft combined with a tug and draft up to 7 ft loaded. A barge up to 240 ft long was recorded to call into Elim to deliver construction materials during the school's construction in 2004. For this specific project, the community built a ramp out to the barge to offload materials. Barge operators reported that this was a rare occurrence.

7. MOORAGE DEMAND ANALYSIS

The assessment of moorage demand in Elim is based on personal interviews or phone calls with fuel and freight barge operators, the NSSP fish processing plant manager, and community members who participate in a subsistence and commercial fishing activities. During these meetings, information gathered was compared with the moorage demand analysis from the previous CAP 107 Elim study. Existing demand for moorage is similar to demand detailed in the 2013 CAP study. Given that no moorage infrastructure has been put in place since then, the demand for such infrastructure remains unmet.

There are approximately 50 vessels owned by community members in Elim, used for commercial fishing or subsistence. About 25 vessels are used for subsistence harvesting, and 25 vessels are used for commercial fishing activities in addition to subsistence harvesting. These vessels are exposed to vessel swamping and inclement weather, whether they are moored at Moses Point or offshore at Elim Beach.

There is no moorage for tenders at Elim Beach or Moses Point. During the fishing season, two tenders alternate deliveries from Elim to the Unalakleet processing plant. The tender moors offshore and receives fish totes from a skiff. The efficiencies of this operation could be improved with a dredged channel and protected tender dock. NSEDC plans to set up a pre-processing plant in Elim for the commercial fishery (Johnson 2019). The plant will be a head and guts facility within Elim. There are already utilities and access to an ice machine intended to pre-process fish before it reaches

Unalakleet's plant. The pre-processing plant will alleviate the amount of fish delivered to the Unalakleet plant simultaneously. It is a reasonable projection that with NSEDC's future plans, up to two tenders may call into Elim at the same time. The moorage demand for tenders is safe moorage for two tenders.

The barges and landing craft that serve Elim deliver fuel and cargo during the ice-free months of June through October. Deliveries occur 1–3 times each season. The depth restrictions at Elim continue to result in delays for cargo delivery and fuel offloading. Safe moorage demand for barges requires accommodating a barge up to 160 ft in length and 50 ft in width.

8. FUTURE WITHOUT-PROJECT CONDITIONS

This section analyzes the adverse impacts on subsistence and commercial harvests and vessel damage that could be avoided with navigation improvements at Elim. Vessel damage is assigned monetary values where possible; otherwise it is discussed in qualitative terms. The future without-project (FWOP) condition provides a benchmark for comparison of the proposed alternative plans. This analysis uses the Federal fiscal year (FY) 2020 discount rate of 2.750% and a 50-year period of analysis.

This section also provides the expected future conditions under which Elim residents will operate compared to the existing conditions. This analysis uses several key assumptions about the operating conditions of Elim boaters to define the FWOP condition:

- A small fish processing plant will be built in Elim to maintain fish quality and reduce delays associated with plant capacity at Unalakleet
- The fish-buying station will be relocated to wherever the commercial fishermen can land their catch, be it at Elim Beach, Iron Creek, or Moses Point

The potential benefits described in this section are specific to the vessel fleet operating in Elim. Where necessary, assumptions are developed based on similar USACE studies or communities in Alaska.

8.1 Subsistence Harvest Analysis

Subsistence is one of the two sectors of Elim's mixed economy. Elim residents rely upon the harvest of subsistence resources for food, clothing, tools, and medicinal uses. The community's reliance on subsistence is especially significant, given Elim's relative isolation and limited connections to other communities. Airfreight and cargo barges are the only methods to deliver goods to Elim. Weather conditions and lack of a protected landing area mean that barges are sometimes delayed, and residents may have to go without supplies. In addition, the lack of moorage infrastructure and sufficient water depths for navigation hampers subsistence activities and results in potential harvests not being met.

This analysis estimated the potential unmet harvests of the major subsistence goods acquired by subsistence vessels: fish (salmon and non-salmon), beluga whale, caribou, and moose. The method used in the subsistence analysis was as follows.

- The total pounds of harvest for the selected goods by the community were determined.
- Subsistence harvests were assigned dollar values based on assumed replacement and production cost values for these resources.
- An estimate was developed of the subsistence harvest Elim residents forego due to existing navigational inefficiencies.

8.1.1 Estimated Total Pounds of Subsistence Harvest

The subsistence analysis used data from the *Bering Strait Region Local and Traditional Knowledge Pilot Project*, a comprehensive study on subsistence harvest in the Bering Strait Region (Ahmasuk et al. 2008). The comprehensive study reported estimated pounds harvested of fish, beluga whale, caribou, and moose by Elim during the 2006 and 2010 seasons.

8.1.2 Sources for Estimating Dollar Value of Subsistence Harvest

A study on subsistence in Alaska by the ADF&G Division of Subsistence reported a replacement cost value of subsistence resources ranging from $5.00 to $10.00 per pound in 2017 dollars or $5.23 to $10.47 in current dollars (2019). The USACE Alaska District conducted a study on subsistence harvests in the rural community of Little Diomede and found the maximum harvest value of subsistence resources to be $26.15 per pound in current dollars (USACE Alaska District 2011). The latter study considered the cost of production for acquiring subsistence resources, whereas the former study considered the cost of purchasing proteins as replacements for subsistence resources. When the cost of acquiring subsistence resources is considered, the value of subsistence is higher. It is also more representative of the activities in rural communities.

The values calculated for Little Diomede are specific to that community and do not necessarily represent the costs to harvest subsistence resources in Elim. However, including this cost in the distribution of possible subsistence valuations is appropriate for this analysis to address the range of valuing subsistence methodologies. The method used for the Little Diomede feasibility study is a production cost method that assumes that subsistence resources are worth at least as much as the harvesters invest in them through expenditures of cash and labor. The production cost method is a more comprehensive approach than simply considering the grocery store (or equivalent) replacement value of these resources.

The subsistence data presented in the Little Diomede feasibility study is based on comprehensive surveys to estimate subsistence production time and costs. The level of data needed to conduct a detailed update of this method is not available for Elim. Updating the value from the Little Diomede study using an economic index is an appropriate method to utilize this data for Elim. This value is used as one point on distributing subsistence values to represent the uncertainty in quantifying these resources.

Subsistence harvest values for this analysis were based on the ADF&G and USACE studies mentioned above using @Risk, a Microsoft Excel add-in. This analysis used an @Risk triangular distribution with the following parameters: $5.33 (minimum), $13.95 (most likely), and $25.94 (maximum) to address variation and uncertainty in harvest values. Given the uncertainty and lack of historical data about production costs for subsistence resources in Alaska, a triangular distribution with these parameters was considered appropriate for this analysis. This analysis used the mean value of $13.95 per pound from the distribution for further calculations. The @Risk simulation of subsistence harvest value is presented in Figure 19.

8.1.3 Estimated Harvest Foregone Due to Navigational Inefficiencies

Once the subsistence value per pound was determined, the next step was to estimate the subsistence harvest Elim residents forego due to the navigational inefficiencies previously described. USACE Alaska District hydraulics and hydrology (H&H) engineers conducted a wave analysis for Elim to evaluate accessibility improvements with a project. The H&H analysis considered hindcast wave conditions by month and the wave criteria requirements of each vessel class. Based on the wave and water level analysis, subsistence vessels' access conditions were estimated to increase by a certain percentage with navigational improvements. The wave analysis is further described in Section 14.

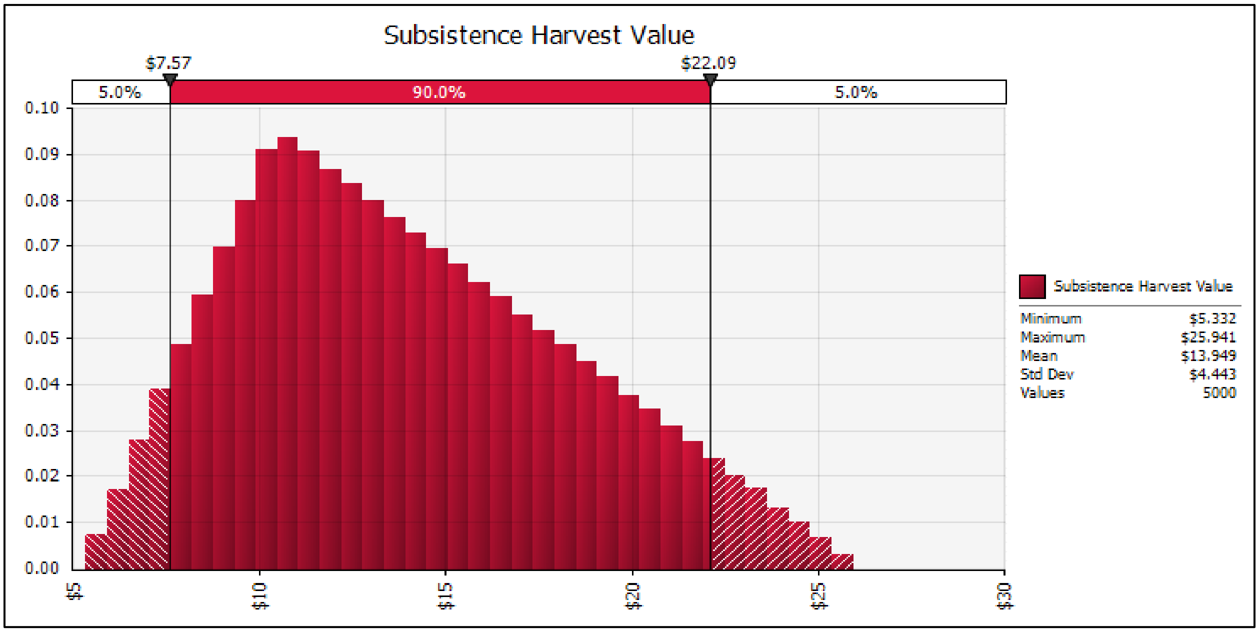

Figure 19. Subsistence Harvest Value @Risk Simulation

The subsistence analysis further assumed that in the FWOP condition, limited access for subsistence vessels would continue to result in subsistence harvest foregone. Subsistence harvests are seasonal, with fish harvested in summer and beluga whales harvested in fall and sometimes spring. The estimated percent increase of harvest for each resource based on the projected accessibility during the harvest periods is shown in Table 11. The estimated harvest increase represents foregone subsistence harvest absent Federal intervention. It is assumed that each subsistence resource harvest would increase by the same percent as the wave analysis estimate of increased access during the harvest season. In the FWOP, this is the harvest foregone due to lack of access.

Table 11. Estimated Percent of Harvest Foregone by Resource

Harvest Period	Subsistence Resource	Potential Increase in Harvest with Access
June-September	Fish (salmon and non-salmon)	12%
August-September	Beluga	5%
October-November	Caribou	10%
July-September	Moose	10%

The total pounds of harvest for fish, beluga, caribou, and moose reported by the North Pacific Research Board (NPRB) comprehensive study was multiplied by 12%, 5%, and 10%, respectively, to estimate the subsistence harvest forgone. The estimated increase in total pounds for Elim was about 15,900 pounds. The pounds foregone was then multiplied by the mean price value of $13.95 per pound, giving an estimated subsistence harvest foregone of $221,823 annually. The estimated harvest increase by the resource is presented in Table 12. Input data to estimate the value of subsistence harvest foregone is summarized in Table 13. Dollar values are rounded to the nearest thousand dollars.

Table 12. Estimated Annual Subsistence Harvest Value Increase by Resource

Resource	Reported Total Harvest in Pounds	Percent of Expected Harvest Increase	Estimated Harvest Increase in Pounds	Value of Harvest Increase
Fish	65,006	12%	7,801	$109,000
Beluga Whale	50,209	5%	6,025	$84,000
Caribou	11,294	10%	1,355	$19,000
Moose	6,001	10%	720	$10,000
Total	**132,511**		**15,901**	**$222,000**

Table 13. Annual Subsistence Harvest Value Foregone

Variable Description	Value
Estimated Total Harvest Increase in Pounds	15,901
Average Mean Price Per Pound	$13.95
Annual Forgone Subsistence Value	$221,823
Annual Average Equivalent Value	**$222,000**

8.2 Commercial Harvest Foregone

Depth constraints, coupled with the migrating Kwiniuk River mouth at Moses Point, lead to inefficiencies for commercial fishery operations. Elim's commercial fishermen lose out on some commercial harvesting opportunities. Disruption to commercial fishing operations occurs 8–10 times each fishing season. The resulting cascading effect is that fishermen are not accessible by the fish-buying station and may choose to sit out the fishing day. The alternative option for the delivery of fish is in town at Elim Beach. Depth constraints also affect the amount of time that tenders can access Elim to pick up fish and therefore the amount of catch for which local fishermen can receive payment. NSEDC estimates that 10% of Elim's total commercial harvest is foregone due to these inefficiencies.

When there are high amounts of commercial catch that the processing plant at Unalakleet cannot take in, the plant shuts down to catch up with processing and commercial fishermen are advised to stop fishing. In the past, plant closures occurred during coho openings, which is the main salmon harvested commercially by Elim residents. Commercial fishermen have had to forego potential coho harvests on the days the plant closes. NSEDC estimates that 25% of the coho salmon harvest is foregone due to fishing closures when the Unalakleet plant shuts down temporarily. In the FWOP conditions, NSEDC plans to install a pre-processing plant in Elim to reduce the excessive influx of fish at the Unalakleet plant. However, even if this smaller scale plant opens, 10% of the overall salmon harvest and an additional 25% of coho are still foregone without improving navigational access for commercial and tender vessels.

The commercial harvest analysis makes two assumptions based on the existing conditions:

- 10% of the potential harvest is not caught because of delivery inefficiencies to and from the fish-buying station.
- There is an estimated 25% of coho foregone due to plant closures at Unalakleet. In the FWOP condition, the pre-processing plant in Elim would still experience fish closures without efficient access for the fish tenders to deliver fish to the pre-processing plant.

The analysis uses Elim's salmon harvests reported in NSEDC's annual reports (from 2013 to 2018) and estimated mean prices paid to commercial fishermen (ex-vessel prices) reported by ADF&G. Elim fishermen commercially harvest five salmon species. The annual harvest in pounds is multiplied by each salmon species' ex-vessel prices for the associated year to the value of Elim's salmon harvest. The estimated value of Elim's salmon harvest for the 6-year period is $1.5 million, with an average of $300,000 per year.

The assumed 10% reduction in the overall salmon harvest and additional 25% reduction in coho represents a maximum commercial harvest foregone of $70,304 each year[2]. The present value of commercial harvest foregone is approximately $2 million using the Federal discount rate of 2.50% over a 50-year period of analysis. In the FWOP, Elim fishermen will continue to forego a harvest value each fishing season as shown in Table 14.

Table 14. Commercial Harvest Key Data Inputs

Key Data Inputs	Value
Value of Elim Salmon Harvest 2013–2018	$1,487,000
Average Value of Elim Salmon Harvest 2013–2018	$297,000
Increase in Salmon Harvest Value	$30,000
Increase in Coho Harvest	$41,000
Total Harvest Forgone Annually	$70,000
Present Value	**$1,900,000**
Average Annual Equivalent (rounded)	**$70,000**

The benefits associated with increased commercial fishing harvests represent the change in net income: the value of the increased revenue minus the value of the

[2] Estimated foregone harvest equals the sum of $29,000 (10% of $297,000) plus $40,600 (25% x $162,416).

increased vessel operating costs. However, this analysis assumes that this additional commercial harvest would occur during the existing operating times for local commercial fishermen and will not significantly increase the operating costs of Elim fishermen. This assumption is reasonable given the relatively small incremental increase in fisheries harvest resulting from navigation improvements.

8.3 Transportation Costs

In addition to foregone commercial harvests, there are transportation inefficiencies associated with vehicle trips between Elim Beach and Moses Point and skiff delivery trips from shore to tenders moored offshore. These inefficiencies represent transportation cost savings that could be realized with navigation improvements.

8.3.1 Vehicle Trips

The one-way distance between Elim and Moses Point by road is an estimated 10 miles. The 2019 Internal Revenue Service mileage reimbursement rate of $0.58 was used to calculate the cost of each trip. NSEDC staff estimated five vehicle trips per day between Elim Beach and Moses Point to deliver iced fish totes, equal to 600 vehicle trips in a season. The potential vehicle transportation cost savings accrued by the commercial fish-buying operations for the whole 60-day season amounts to cost savings of approximately $7,000 annually.

8.3.2 Skiff Trips

As described in Section 6, skiffs must deliver fish totes weighing up to 1,500 pounds from the fish-buying station to a fish tender offshore due to the lack of moorage infrastructure for fish tenders. According to the fish-buying station staff, skiffs average eight trips daily to deliver fish to the tender, which anchors 0.5–5 miles offshore, depending on sandbar movements. Each trip and transfer lasts about an hour. This operation inefficiency results in additional vessel operating costs in the FWOP condition.

Vessel operating costs for the Elim fleet were used to calculate FWOP transportation costs and, subsequently, benefits resulting from navigation improvements. Previous USACE Alaska District small boat harbor studies provided the basis for the methodology and assumptions used to develop these estimates. This approach has been used in Alaska District feasibility studies for Petersburg, Craig, Whittier, Valdez, Homer, and Port Lions. The basic framework used in those studies applies to Elim, with changes to input data as appropriate.

Vessel costs consist of both fixed and variable costs. Fixed costs are induced upon the owner of the vessel regardless of productive use. Variable costs occur while the vessel is in operation, including the costs for vessel repair and maintenance, the cost of fuel and lubricating oil, and other such costs. This analysis assumed that fixed expenses for any given vessel operating out of Elim would be unchanged with improved navigation conditions; variable expenses for vessel operators, specifically the fish shuttling skiffs, could change due to navigation improvements.

Vessel characteristics were used as a starting point to determine operating costs. Certain vessel costs are calculated as a portion of vessel investment cost. For this analysis, vessel investment costs were based on the 2014 Craig feasibility study's values, updated to current dollars. These were considered representative of operating costs for the subsistence and commercial fishing vessels in Elim. The skiffs used to shuttle fish totes offshore to the fish tender were assumed to incur operating costs similar to subsistence vessels.

The vessel operating cost used in this analysis was derived from fuel usage by skiffs. The model developed for the Craig feasibility study determined a low, medium, and high fuel use rate. Potential transportation cost savings under FWOP conditions are summarized in Table 15.

Table 15. Transportation Cost Savings Summary

Alternative	Vehicle Trip Savings	Skiff Trip Savings	Total
Present Value	$204,000	$633,000	$837,000
Annual Average Equivalent	$7,000	$22,000	$29,000
Note: Values are rounded and do not reflect exact calculated values.			

8.4 Opportunity Cost of Time

The opportunity cost of time (OCT) is the value of time that would otherwise be spent pursuing additional work or leisure. The methodology used to value the time saved is based on descriptions in the *Planning Guidance Notebook*. The OCT rates for commercial and subsistence fishermen are calculated based on Connelly and Brown (2006) data and updated to current dollars, as shown in Table 16.

Table 16. Hourly Wage Rates for Commercial and Subsistence Fishermen

Description	Current Dollars
Hourly Wage Rate	
Commercial Fishing Captain	$171.84
Commercial Fishing Crew	$59.13
Hourly Leisure Rate	
Commercial Fishing Captain	$57.28
Commercial Fishing Crew	$19.71

In the FWOP condition, wave conditions and depth constraints would continue to result in vessel delays and idling on the open water or onshore. Community members reported that in a 60-day commercial fishing season, 10 fishing days are affected by shallow waters and/or wave conditions on average. Based on Connelly and Brown's report, the average length of commercial fishing hours in a day is 12.5 hours. The total hours of vessel delay and idling in a season is estimated by the average length of hours spent fishing, the number of days affected per season, the total percentage of exceedance of accessible and moorable conditions during the season (from the wave analysis as described in Section 8.1.3), and the number of vessels affected. The total number of hours of delay and/or idling that could be spent fishing or doing other work for commercial and subsistence vessels is 75 hours.

Connelly and Brown's study found that if commercial fishermen were not delayed in most cases, they would choose to engage in additional fishing activities. This analysis assumed that commercial fishermen would also enjoy additional leisure time. The estimated hourly leisure rate for commercial vessels is equal to one-third of the labor rates of the hourly wage rate for commercial fishing. It is unlikely that all vessels would accrue 75 hours idling. Therefore, an assumption was made that 25% of the commercial and subsistence fleet would experience delays in a given season.

The resulting estimated annual OCT accrued by crews of commercial and subsistence vessels is $170,000 annually. The percentage of depth exceedance for commercial and subsistence vessels for the season of operation in the existing condition formed the basis of the assumed delay. It was assumed that 40% of the subsistence harvest season would result in delays to subsistence vessels. For the 60-day commercial fishing season, it was assumed that some commercial vessels would experience some delays 60% of the time. The estimated OCT for the commercial and subsistence vessels is presented in Table 17.

Table 17. Estimated Opportunity Cost of Time

Vessel Class	OCT Description	Estimated Percent of Exceedance per Season	25% of Fleet Affected per Season	Estimated OCT
Subsistence Vessel	Hourly Wage Rate	40%	6	$104,000
Commercial Vessel	Hourly Wage Rate	60%	6	$27,000
Commercial Vessel	Hourly Leisure Rate	40%	6	$35,000
Annual Average Equivalent				**$164,000**
Present Value				**$4,637,000**

Any OCT associated with barge deliveries was assumed to be included in the barge operating expense and was not quantified for this category. Similarly, no avoided vessel operating expenses were quantified for commercial, subsistence, or tender vessels at Elim. No corresponding opportunity cost of time calculations was made.

8.5 Barge Delays

Barges that deliver to Elim experience operational delays resulting from shallow water depths and lack of landing infrastructure. Particularly in the case of landing crafts, which deliver cargo to Elim, the shallow, sandy beach affects deliveries' efficiency.

The analysis of barge delays was developed in the previous CAP 107 study. The barge conditions remain unchanged. The assumptions used in this analysis remain the same. Based on the information provided by Crowley Maritime, cargo landing craft delays of 12–24 hours happen at least twice per year. The delay time is spent waiting for appropriate tidal conditions, and without navigation improvements, the costs associated with these barge delays will persist. Downtime due to delays is the additional time expended by barge companies waiting at Elim, which could otherwise be spent delivering to other communities.

Daily barge operating costs were obtained from USACE studies for barge operators that historically and currently deliver to Elim. Based on estimated vessel operating costs and the length and frequency of delays, the annual cost of cargo delivery delays at Elim ranges from $15,000 to $30,000.[3] These delays have a total present value of $621,000 over the analysis period, with an average annual value of $23,000.

8.6 Fuel Offloading

The current landing configuration in Elim causes inefficiencies in fuel delivery operations. Fuel is offloaded to the fuel header located at the top of the bluffs near the beach fronting the community. The inefficiencies of fuel loading and offloading described in Section 6.1.4 are expected to continue in the FWOP conditions. Moving the hose from the barge to the fuel header and back is intensive manual labor on the barge crew. It also provides a prime opportunity for the occurrence of mistakes and accidents, although it is not possible to quantify that under the NED perspective.

Elim's fuel tanks are in a tank farm near the south end of the airport runway at 150 ft above sea level. Given the fuel tanks' elevation and the need to float the hose from offshore, inefficiencies associated with a slow offloading rate would continue using existing equipment. Figure 20 shows the locations of the fuel header and tank farm.

[3] $621 per hour x 12 hours x 2 occurrences per year = $14,904. $621 per hour x 24 hours x 2 occurrences per year = $29,808.

Figure 20. Fuel Tank Farm Relative to Fuel Header

The bulk fuel agreements utilized by NSEDC and other organizations such as the Alaska Village Electric Cooperative and the Bristol Bay School District serve to keep fuel prices competitive. Since fuel suppliers must bid for the contracts to provide service to groups of communities, there is an incentive for them to make the lowest bid to receive the contract. As a result, fuel delivery prices are set at a competitive level, and fuel barge operators often state that the fees charged for fuel delivery would not change due to navigation improvements at a single community. However, operational efficiencies described in this section are still calculated as a reduction in overall operating expenses, which are considered benefits to the nation.

8.7 Vessel Damage

8.7.1 Vessel Swamping

Due to a lack of mooring or landing infrastructure at Elim, vessel damage is common. Residents report that vessels sometimes get swamped while attempting to land on the beach in front of Elim, while anchored offshore of Elim, or accessing Moses Point during poor conditions. Also, dragging vessels onto the beach in front of the community or at Moses Point results in damage to vessel hulls, engines and reduced vessel lives.

Residents report that vessel swamping incidents happen 4–5 times each year. These incidents typically do not cause a full vessel loss but do require engine repairs or replacement. Typical outboard motors used in Elim range in price from $11,500 to $13,300. The costs for injectors are assumed to 5% or 25% of the low and high engines' cost, respectively. Therefore, the engine injector costs range from $574 to $3,328, and residents report that injectors must be replaced after each swamping.

This analysis assumes that one vessel engine must be replaced per year, while engine injectors must be replaced after each vessel swamping incident. Vessel swamping incidents will continue in the FWOP condition, given that residents will continue to have to land at an unprotected site and will still be subject to engine damage. Using the assumptions above, the potential vessel damage resulting from vessel swamping ranges from $14,000 to $30,000.[4]

8.7.2 Hull and Engine Damage

Elim vessels are damaged by being dragged onto the beach for storage when not in use. This damage to hull and engines from dragging along the beach would be avoided with a boat launch and local upland facilities. This analysis assumes that in the FWOP, the community would not construct a boat launch and uplands area without other navigation improvements. As such, avoided damage would only be realized with navigation improvements. In the FWOP condition, damage to the boat hull and engine from excessive dragging along the beach would continue.

The potential benefits of reducing vessel damage were estimated based on vessel replacement costs and the frequency of replacement. The existing practice shortens the lifespan of the vessel. Using assumptions developed in previous Alaska District studies, commercial and subsistence vessels in Elim are assumed to last an average of 12.5 years. Damage to vessel hulls and engines reduces vessel lifespan to 5 years. The estimated cost of potential damage was determined as follows:

1. Calculate replacement costs for commercial and subsistence vessels.
2. Determine the cost of replacing the Elim fleet (25 commercial and 25 subsistence vessels) every five years.
3. Calculate the annual replacement cost of Elim's fleet every 12.5 years, the potential lifespan of vessels if hull and engine damage were reduced.

[4] $11,486 engine replacement + [$574 for injectors x 4 vessel swampings]) = $13,783 per year.
$13,314 engine replacement + [$3,328 for injectors x 5 vessel swampings) = $29,957 per year.

4. Subtract the annual replacement cost of vessels at their potential lifespan from the replacement cost under FWOP (more frequently replaced).

The investment costs for vessels from the 2014 Craig feasibility study updated to current dollars were used to calculate the replacement cost. The replacement cost for a commercial vessel is $119,400 ($107,000 investment cost + $12,400 average engine cost). Subsistence vessel replacement cost was estimated to be $60,400 ($48,000 investment cost + $12,400 average engine cost). Under FWOP conditions the total vessel replacement cost per year for all 50 vessels would be $899,000 ([25 commercial x 119,400] + [25 subsistence x $60,400] divided by 5 years).

8.7.3 Cost of Foregone Fishing Days Due to Damaged Vessel

Elim residents report that an entire fishing season can be lost when a commercial vessel is damaged while awaiting the delivery of a new motor. There are two vessel classes in Elim: subsistence vessels and combination commercial and subsistence vessels. The annual value of the fishery for each vessel is dependent upon the type of vessel damaged. There are approximately 25 subsistence vessels and 25 combination vessels in Elim. This analysis assumed that one vessel per year would be damaged enough to result in loss of fish harvesting for that year, based on previous data. There is a 50% chance that a combination vessel will have to sit out the season and a 50% chance that a subsistence-only vessel will be affected in a given year.

On average, there are 28 commercial salmon permits held by Elim fishermen. The average annual commercial value per permit fished by Elim residents is approximately $10,800 ($300,000 average value of Elim harvest divided by 28 commercial permits). This $10,800 value represents the commercial harvest foregone when a commercial vessel is damaged and sits out the fishing season.

According to the NPRB comprehensive subsistence use survey, the annual subsistence harvest of fish (including salmon and non-salmon species), caribou, beluga whale, and moose is 1,997 pounds per household. These are the subsistence resources acquired by the vessel during ice-free months and are included in the analysis. The survey analysis uses harvest pound by household rather than per capita because a subsistence vessel is typically used to acquire items for a subgroup of people or family rather than individuals. Utilizing the subsistence production values from Section 8.1 of $13.95 per pound, the annual value of the subsistence harvest was estimated to be $28,000 per household ($13.95 x 1,995 pounds).

If a combination vessel is damaged, the total cost of the lost fishing opportunity per vessel is approximately $19,300 (($10,800 foregone commercial catch + $27,900 subsistence value) x 0.5 probability of damage). The loss of a subsistence harvest season when a subsistence vessel sits out the season is approximately $14,000

($27,855 x 0.5 probability of damage). Absent Federal investment, the annual damage associated with lost fishing opportunity due to an out-of-commission vessel would be about $33,000 annually ($19,400 + $14,000).

8.7.4 Vessel Damage Summary

The three vessel-damage categories are summarized in Table 18. Vessel damage costs in the FWOP condition make up more than 60% of the potential NED benefits. Also, the vessel damage calculations are informed by a series of assumptions and various data sets. Given these variations and the significance of this benefit category to the overall analysis, uncertainty and risk were incorporated by applying a range similar to that used in the subsistence analysis. The low range was 70% of the total benefit values calculated for each vessel damage subcategory.

Table 18. Average Annual Vessel Damages

Vessel Damage Type	**Low Benefit Range (70%)**	**High Benefit Range (100%)**
Vessel Damage Subcategory	**Annual Average Equivalent**	**Annual Average Equivalent**
Vessel Swamping	$15,000	$22,000
Hull and Engine Damages	$378,000	$539,000
Lost Harvest Value	$23,000	$33,000
Total	**$416,000**	**$595,000**

During focus groups and discussions with local fishermen, community members further noted that sometimes residents could evacuate their vessels before a flooding event or storm occurs. Based on this preventative action, it was assumed that 30% of the time, vessel owners evacuate their vessels before an oncoming storm or flooding, thereby successfully avoiding vessel swamping or damage to hulls. Under this 30% preventative scenario, only 70% of vessel damage would occur. In other words, the damage would be avoided but not attributed to the project and, therefore, not included. The vessel damage in the FWOP is expected to range between $416,000 and $595,000 annually, as summarized in Table 18.

8.8 Summary of Future Without-Project Conditions

Absent Federal action to provide navigation improvements at Elim, transportation inefficiencies, vessel delays, vessel damage, and forgone subsistence and commercial harvest opportunities are expected to continue throughout the analysis. These adverse impacts would be incurred as a result of current and expected future conditions. They have a total present value of approximately $26 million over the analysis period, with an average annual value of $963,000. The values shown in Table 19 are the sum of the values estimated for each potential benefit category.

Table 19. Future Without-Project Summary

Potential Benefit Categories	Present Value	Average Annual
Total Subsistence	$6,300,000	$222,000
Commercial Harvest	$1,990,000	$70,000
Transportation Cost Savings Commercial Fishery Operations	$837,000	$30,000
Opportunity Cost of Time (OCT)	$4,637,000	$164,000
Barge Delays	$635,000	$22,000
Vessel Damages	$16,862,000	$595,000
Total	**$31,262,000**	**$1,103,000**

If Elim's population's long-term upward trend persists, impoverished residents estimated at 26% are likely to remain the same or increase. Fuel consumption and demand for dry goods delivered via barge are likely to increase with the population. However, with limited economic opportunities for employment, coupled with prohibitively high costs for fuel and goods, residents would be less capable of transitioning out of poverty. Additionally, replacing critical infrastructure such as residential housing in the FWOP is expected to lag in meeting population needs due to the lack of navigational improvements at Elim.

Beyond the quantified transportation inefficiencies, vessel delays, vessel damage, and foregone harvests are social conditions that are expected to continue in the future without navigation improvements. Social conditions affected by the lack of an adequate harbor include public health and safety of the local community and social and cultural values tied to subsistence activities. These are elaborated upon in Section 13.4.

9. FUTURE WITHOUT-PROJECT CONDITIONS AND COMMUNITY VIABILITY

This section describes the threats to community viability faced by Elim in the FWOP conditions. A review of vessel operations identifies linkages between threats to viability in the FWOP condition and the navigation improvement project planning objectives:

- Provide safe, reliable, and efficient waterborne transportation systems for the movement of commerce (including commercial fishing) and subsistence in Elim.
- Support the long-term viability of Elim.

Assessment of community viability informs the rationale for the CE/ICA metric used in this study (opportunity days gained for access and moorage days; further discussed in Section 14).

9.1 Access and Moorage for Subsistence and Commercial Vessels

Subsistence activities are a fundamental component of Elim's mixed cash-subsistence economy. Most vessel owners in Elim use their boats for both subsistence and commercial fishing. Employment opportunities in the community are limited and often seasonal. The cost of living is relatively high. The weekly cost of food for a household of four is estimated to be 2.5 times the national average. Elim residents rely upon the harvest of subsistence resources for food, clothing, tools, and medicinal uses. The community's reliance on subsistence is especially significant, given Elim's relative isolation and limited connections to other communities. These factors further emphasize the interdependency of the subsistence and cash sectors in Elim's economy. Different subsistence activities occur at different times of the year and are interconnected to one another. Crucial to productive subsistence activities is the equipment used to acquire subsistence resources, such as boats, four-wheelers, and snow machines. When the vessels used for subsistence activities are damaged, the ramifications include disruption to acquiring these resources that are vital to Elim's welfare**.**

Subsistence activities are intricately tied to cultural values, historical knowledge, and specific places. The continued participation and transfer of these values and knowledge are important to the viability of the community. Subsistence activities bring the community together, cultivating a sense of identity. As access to subsistence resources becomes more difficult, participation in these activities declines, and the fostering of cultural values and identity is threatened. Lack of safe navigational access impedes participation in subsistence activities and continues to threaten community viability.

9.2 Access and Moorage for Tenders

Navigational inefficiencies cause disruptions to commercial fishing operations 8–10 times per season on average. The existing and FWOP conditions are such that skiffs shuttle fish totes from the fish-buying station at Moses Point to the tender offshore. These deliveries are dictated by the tides and become complex and unsafe during rough wave activity. Moreover, in recent years, Elim's commercial harvest indicates a steady increase, but the Unalakleet processing plant occasionally shuts down because it cannot take any more fish. This impacts commercial fishermen through fishing days foregone, and some harvest is lost. The planned head and guts facility in Elim is expected to improve the Unalakleet plant's efficiency and reduce fishing day closures due to plant shutdowns. However, without access and moorage for commercial vessels to deliver the catch to the pre-processing plant in Elim and for fish tenders to receive pre-processed fish, inefficiencies would still lead to plant closures and fishing days foregone.

The commercial fishery plays a key role in Elim's mixed cash-subsistence economy. Commercial fishing is a means to earn cash, which can be used for basic goods and repair or upgrade equipment used in subsistence activities. Other means of cash-earning are limited in Elim, and access to the cash economy often requires individuals to leave their community and culture for extended periods of time. Moreover, Elim is a fishing community where the skills and practice are passed down by generation. The transfer of these skills is important to the community's ability to survive and thrive. In the FWOP conditions, Elim's commercial fishery would continue to experience disruptions resulting in loss of commercial harvests and residents who leave for better-paying opportunities. Without navigational improvements, the transfer of fishing skills necessary for the continuity of commercial fishing would be hampered and may pose risks to the safety of fishermen.

9.3 Access and Moorage for Freight and Fuel Barge

In the FWOP conditions, freight barge deliveries would continue to experience delays and operate in less than optimal conditions. An example of such conditions is when a freight barge surfs a wave to shore and risks rough landing on the gravel beach with a heavy load. This practice poses risks to the safety of barge operators and crew.

Navigational inefficiencies would continue to hamper the delivery of critical infrastructure materials and impact Elim's capability to replace aging or threatened infrastructure. Almost 50% of housing units in Elim were built before 1980 (McDowell Group 2019). Improving the efficiency of delivery can lead to improved housing and combat social and health issues associated with housing conditions such as overcrowding and poor air quality. In addition, the ability to upgrade or repair equipment needed for subsistence activities relies on the barge delivery.

Similarly, the access to fuel for subsistence vessels and vehicles used to harvest is dependent on the fuel barge delivery. Without addressing these foundational needs, the viability of a community will continue to be threatened.

Without improved access and moorage for fuel delivery, the fuel barge would continue to anchor offshore and float the hose to shore. Under FWOP conditions, this practice would continue to pose a risk of fuel spills during offloading from the barge to the fuel header. These fuel spills can impact the marine subsistence resources the community relies upon.

10. FUTURE WITH PROJECT CONDITIONS

The following section describes anticipated conditions at Elim if navigation improvements are constructed. Anticipated changes in the operations of the vessel fleet with the proposed navigation improvement are the basis for the economic analysis.

10.1 Assumptions

A navigation improvement project at Elim would enhance access to subsistence resources and commercial fisheries and improve efficiencies of fuel and freight deliveries. The NED benefits of navigation improvements at Elim would result from reduced vessel damage and increased subsistence and commercial harvests. In addition, transportation cost savings would accrue to the local commercial fisheries operations. Efficiencies to freight and fuel barge deliveries would reduce delays and, consequently, operating costs.

The period of the analysis is 50 years—from the base year of 2027, the project effective date, to 2077. The FY21 Federal discount rate of 2.50% was used to discount benefits and costs per the Economic Guidance Memorandum (October 2020). The analysis used a methodology for small boat harbor navigation analysis described in the *Planning Guidance Notebook* appendices on economic and social considerations. Procedures stated in the IWR *Planning Suite II User Guide* for conducting CE/ICA were also used in this analysis.

10.2 Proposed Alternatives

Structural and non-structural navigation improvement measures were initially proposed at four sites: Elim Beach, Airport Point, Iron Creek, and Moses Point. A map of the sites can be found in the *Integrated Feasibility Report and Environmental Assessment* main report and Appendix C. Subsequent screening led to the selection of Elim Beach and Airport Point as the optimal sites. Iron Creek and Moses Point were screened out due to the distance from the community center, lack of utilities, inaccessibility for barges, and possible contamination. Six alternative plans were developed in addition to the FWOP or no-action plan. This section describes each alternative plan and the vessel fleet it accommodates. The main report provides figures of the alternatives.

10.2.1 Alt 1: No Action

Existing conditions in Elim would remain the same without the development of navigation improvements. Fishermen would continue to incur losses due to vessel damage and missed opportunities for subsistence and commercial fishing. Delays in offloading cargo and fuel would continue to result in high costs and pose the danger of a fuel spill that could cause environmental consequences. Response times to boats in distress would still be hampered by the need to travel to Moses Point prior to launching response vessels. Vessels would continue to experience damage during large storm surges due to the inaccessibility of Moses Point on short notice, causing some vessels to get swamped.

10.2.2 Alt 2: Elim Beach: Commercial and Subsistence Fleet

Alternative 2 would be a harbor located at the beach in front of the school in Elim. The harbor would be sized to provide access and moorage for 50 subsistence and commercial vessels varying in length from 18 to 32 ft. Two rubble mound breakwaters would provide moorage and turning basins with a total area of 3.9 acres. The moorage and turning basins and entrance channel would require dredging to a depth of -8.0 ft mean lower low water (MLLW) with an over-dredge depth of -10.0 ft MLLW. The west breakwater would be 985 ft long and the east breakwater 457 ft long. Local service facilities required would include a single boat launch, uplands with an area of 3.2 acres for parking and turn-around at the boat launch, and a road connecting the uplands to Front Street and the harbor uplands. The road would be 0.15 miles (800 ft) long and relatively flat.

Alternative 2 assumes that the fish-buying station would be relocated to Elim and that commercial vessels would moor in the harbor and transport their fish uplands to the fish-buying station then to the pre-processing plant in Elim. Tenders cannot approach Elim Beach to pick up commercial harvests, which means that the pre-processed fish would still have to be delivered to Moses Point in fish totes by vehicle. Commercial fishery openings per year are 60 days. The fish tender may still attempt to approach Elim Beach instead of anchoring off Moses Point if conditions were conducive to this operation. The analysis of this alternative assumed that on 30 days out of the 60-day commercial fishery season the fish tender would approach Elim Beach and have a skiff lighter the pre-processed fish. On remaining 30 days, the commercial boats would land their fish at Elim Beach and deliver pre-processed fish by vehicle from Elim to an offshore tender at Moses Point.

Improved navigational access would provide benefits to local subsistence and commercial harvests. Some transportation cost savings to the commercial fishery operations would be realized. Avoided vessel damage to the local fleet is also expected.

10.2.3 Alt 3: Elim Beach: Commercial and Subsistence Fleet with One Tender

Alternative 3 would be a harbor in the same location as in Alternative 2 but sized to provide access and moorage for a 66-ft tender and 50 commercial and subsistence vessels varying in size from 18 ft to 32 ft. The plan would also include a tender dock with a length of 87 ft. Two rubble mound breakwaters would provide moorage and turning basins with a total area of 4.6 acres. The moorage basin would have a required dredge depth of -8.0 ft MLLW with an over-dredge depth of -10.0 ft MLLW. The turning basin, tender dock access, and entrance channel would have a required dredge depth of -9.0 ft MLLW with an over-dredge depth of -11.0 ft. The west breakwater would be 1,068 ft long and the east breakwater 463 ft long. Local service facilities required would include a single boat launch, uplands with an area of 3.9 acres for parking and turn-around at the boat launch, a tender dock, and a road connecting the uplands to Front Street and the harbor uplands. The road would be 0.15 miles (800 ft) long and relatively flat.

The improved efficiencies of the commercial fishery operations would render transportation cost savings. The Alternative 3 plan assumes that the fish-buying station and the pre-processing plant would be in Elim. Commercial fishermen would deliver their catch to the fish-buying station then to the pre-processing plant. When the fish are ready for delivery to the Unalakleet plant, the fish totes would be transported to the tender dock in a loader where the tender would pick up the fish totes using an onboard crane. With a tender dock in Elim, vehicle trips to transport fish to Moses Point would be eliminated for the whole season.

10.2.4 Alt 4: Elim Beach: Commercial and Subsistence Fleet with Two Tenders

Alternative 4 would be the same as Alternative 3 but could accommodate two tenders. Two rubble mound breakwaters would provide mooring and turning basins with a total area of 5.1 acres. The moorage and turning basins and tender dock access would have a required dredge depth of -9.0 ft MLLW with an over-dredge depth of -11.0 ft MLLW. The west breakwater would be 1,099 ft long and the east breakwater 463 ft long. Local service facilities required would include a single boat launch, uplands with an area of 3.9 acres for parking and turn-around at the boat launch, a tender dock, and a road connecting the uplands to Front Street and the harbor uplands. The road would be 0.15 miles (800 ft) long and relatively flat.

The Alternative 4 plan assumes that the fish-buying station and the pre-processing plant would be in Elim. These operations are assumed to bring an additional tender to Elim to support operations. More transportation cost-saving benefits and support to commercial harvest are expected as a result of the additional tender. However, quantifying these benefits is difficult, given the lack of detailed information. As such, the NED benefits of Alternative 4 are assumed to be the same as Alternative 3.

10.2.5 Alt 5: Elim Beach: Commercial and Subsistence Fleet with Two Tenders and Fuel and Freight Barge Access

Alternative 5 would be the same as Alternative 4 with additional harbor accommodation for one 160-ft barge and associated 86-ft tug. Two rubble mound breakwaters would provide mooring and turning basins with a total area of 6.2 acres. The moorage basin would have a required dredge depth of -9.0 ft MLLW with an over-dredge depth of -11.0 ft MLLW. The turning basin, tender dock access, barge landing access, and entrance channel would have a required depth of -12.0 ft MLLW with an over-dredge of -14 ft MLLW. The west breakwater would be 1,082 ft long and the east breakwater 468 ft long. Local service facilities required would include extension of the existing fuel header at the top of the bluffs near the school to a protected storage or service pad on Elim Beach; a single boat launch; developed uplands with an area of 3.9 acres that will accommodate parking and turn-around at the boat launch; a tender dock; a barge landing and two mooring points; and a road connecting the developed uplands to Front Street. The road would be 0.15 miles (800 ft) long and relatively flat.

In addition to the benefits provided by Alternative 4, this alternative would reduce freight barge delays, resulting in operating cost savings. The manual labor in fuel deliveries causing inefficiencies would be alleviated and reduce mistakes and accidents.

10.2.6 Alt 6: Airport Point: Commercial and Subsistence Fleet

Alternative 6 would be a harbor located at the headland west of Elim Beach, below Elim Airport (Airport Point). The harbor would be sized to provide access and moorage for 50 subsistence and commercial vessels varying in size from 18 ft to 32 ft. Two rubble mound breakwaters would provide moorage and turning basins with a total area of 3.0 acres. The moorage and turning basins and entrance channel would have a required dredge depth of -8.0 ft MLLW with an over-dredge depth of -10.0 ft MLLW. The west breakwater would be 819 ft long and the east breakwater 418 ft long. Local service facilities required would include a single boat launch, uplands with an area of 3.3 acres for parking and turn-around at the boat launch, and a road connecting the tank farm south of Elim Airport to the harbor uplands. The road would be 0.6 miles long and traverse 115 vertical ft.

Improved navigational access would provide benefits to local subsistence and commercial harvests. Vessel damage to the local fleet would be avoided. There would not be transportation cost savings; transportation costs would increase because the community would deliver the catch up 115 ft of vertical road to Elim Beach or Moses Point.

10.2.7 Alt 7: Airport Point: Commercial and Subsistence with Two Tenders and Fuel and Freight Barge Access

Alternative 7 would be a harbor located in the same location as in Alternative 6. The harbor would be sized to accommodate one 160-ft barge and associated 86-ft tug, two tenders, and 50 commercial and subsistence vessels varying in size from 18 ft to 32 ft. The plan would include a tender dock with a length of 87 ft. Two rubble mound breakwaters would provide mooring and turning basins with a total area of 6.0 acres. The moorage basin would have a required dredge depth of -9.0 ft MLLW with an over-dredge depth of -11.0 ft MLLW. The turning basin, tender dock access, barge landing access, and entrance channel would have a required dredge depth of -12.0 ft MLLW with an over-dredge depth of -14.0 ft MLLW. The west breakwaters would be 1,137 ft long and the east breakwater 594 ft long. Local service facilities required would include relocation of the fuel header currently located on Elim Beach, a single boat launch, uplands with an area of 6.2 acres for parking and turn-around at the boat launch, a tender dock, a barge landing, two moorage points, and a road connecting the tank farm south of Elim Airport to the harbor uplands. The road would be 0.6 miles long and traverse 115 vertical ft. The fish-buying station would be relocated from Moses Point to Airport Point. Benefits at Alternative 7 were assumed to be the same as those provided by Alternative 5 except for reduced opportunity cost of time benefits under Alternative 7.

10.3 Summary of Future With-Project Conditions

The identified alternatives would provide varying degrees of improved efficiencies. The benefits for each alternative were estimated based on vessel operations and the fleet that the alternative accommodates.

Alternatives 2 and 6 would serve the commercial and subsistence fleets. With improved access for commercial and subsistence activities, harvests would increase. A protected harbor would result in reduced vessel damage to the local fleet. Alternative 2 would be located at Elim Beach and would accrue some transportation cost savings. Alternative 6 would be at Airport Point, which is further from the town and Moses Point, so transportation costs would increase.

Alternatives 3 and 4 would improve efficiencies to fish tender operations in addition to harvest increases. With Alternative 4, a second tender would allow increased vessel traffic resulting from NSEDC's future Elim plans. These specific benefits are not quantified under NED but are measured under the CE/ICA.

Alternatives 5 and 7 are the largest-scale plans. They would serve a fuel and freight barge in addition to the vessels at Alternative 4. The NED benefits of these alternatives would derive from increased subsistence and commercial harvests, transportation cost savings, and more efficient barge operations. Reductions to barge delays and fuel offloading inefficiencies would translate to vessel operating cost savings.

10.4 Total Project Benefits

Each alternative provides relief from existing and expected future inefficiencies. The NED benefits are summarized in Table 20 and Table 21.

Table 20. Present Value of Benefits by Alternative

Category	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Increased Subsistence Harvest	$6,296,000	$6,296,000	$6,296,000	$6,296,000	$6,296,000	$6,296,000
Increased Commercial Harvest	$842,000	$1,994,000	$1,994,000	$1,994,000	$842,000	$1,994,000
Transportation Cost Savings	$735,000	$837,000	$837,000	$837,000		$837,000
Opportunity Cost of Time	$4,637,000	$4,637,000	$4,637,000	$4,637,000	$2,319,000	$2,319,000
Vessel Damage	$16,862,000	$16,862,000	$16,862,000	$16,862,000	$16,862,000	$16,862,000
Reduced Barge Delays				$635,000		$635,000
Total	**$29,370,000**	**$30,630,000**	**$30,630,000**	**$31,261,000**	**$26,319,000**	**$28,943,000**

Table 21. Annual Benefits by Alternative

Category	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Increased Subsistence Harvest	$222,000	$222,000	$222,000	$222,000	$222,000	$222,000
Increased Commercial Harvest	$30,000	$70,000	$70,000	$70,000	$30,000	$70,000
Transportation Cost Savings	$26,000	$30,000	$30,000	$30,000		$29,000
Opportunity Cost of Time	$164,000	$164,000	$164,000	$164,000	$82,000	$82,000
Vessel Damage	$595,000	$595,000	$595,000	$595,000	$595,000	$595,000
Reduced Barge Delays				$22,000		$22,000
Total	**$1,037,000**	**$1,081,000**	**$1,081,000**	**$1,103,000**	**$929,000**	**$1,021,000**

11. PROJECT COSTS

The USACE Alaska District cost engineers developed rough order-of-magnitude cost estimates for the alternatives, including costs to construct and maintain facilities. The Cost Engineering Appendix (Appendix E) details the procedures and assumptions used to calculate the estimates. Cost risk contingencies were included to account for uncertain items such as dredged material disposal methods. Project costs were developed without escalation and are in 2020 dollars. The rough order-of-magnitude costs for each alternative are shown in Table 22.

Table 22. Rough Order-of-Magnitude Project First Costs by Alternative

Cost Description	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Lands, Easements, Rights-of-Way, and Relocations	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000
Mobilization and Demobilization	$7,680,000	$7,680,000	$7,680,000	$7,680,000	$7,680,000	$7,680,000
Breakwater (East & West Walls)	$39,068,000	$41,409,000	$42,310,000	$42,000,000	$48,343,000	$72,145,000
Dredge and Dispose	$2,242,000	$2,670,000	$3,543,000	$6,890,000	$1,728,000	$4,477,000
Uplands	$7,581,000	$30,280,000	$30,408,000	$31,551,000	$20,125,000	$40,736,000
Access Road	$1,753,000	$1,753,000	$1,753,000	$1,753,000	$10,083,000	$10,083,000
Floating Dock, Moorage Points, Gangway	$298,000	$298,000	$298,000	$466,540	$298,000	$1,977,000
Preconstruction, Engineering and Design	$5,120,000	$5,120,000	$5,120,000	$5,120,000	$5,120,000	$5,120,000
Supervision, Inspection, and Overhead	$6,400,000	$6,400,000	$6,400,000	$6,400,000	$6,400,000	$6,400,000
Project First Costs	**$70,175,000**	**$95,643,000**	**$97,545,000**	**$101,892,000**	**$99,809,000**	**$148,650,000**
Note: Project first costs used in the benefit-cost analysis are discounted/indexed to a base year and amortized to compare the average annual benefits. These costs differ slightly from those in the Cost Engineering Appendix.						

As with benefit cash flows, costs are discounted/indexed to a base year and amortized to compare the average annual benefits. As such, the project first costs shown in Table 22 and detailed in the Cost Engineering Appendix differ slightly from those used in the benefit-cost analysis. Costs used in the benefit-cost analysis include the project's initial cost compounded to the base year using the FY20 discount rate, interest during construction, and estimated operations and maintenance costs greater than the FWOP condition. The costs for the benefit-cost analysis, referred to as NED or economic costs, are summarized in Table 23.

Due to climate characteristics and communities' remoteness in Alaska, construction periods are limited to ice-free seasons. Construction was assumed to be phased over 3 years in 4-month construction seasons for all alternatives. Interest during construction was calculated by a total of 12 months spread over the 3 years. The analysis assumed that the interest rate remains the same over those 3 years.

Table 23. NED Costs by Alternative

Cost Description	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Project First Cost	$70,175,000	$95,643,000	$97,545,000	$101,892,000	$99,809,000	$148,650,000
Interest During Construction	$874,000	$1,191,000	$1,214,000	$1,268,000	$1,242,000	$1,850,000
Operations, Maintenance, Repair, Rehabilitation, and Replacement	$2,970,000	$3,004,000	$2,739,000	$2,846,000	$1,206,000	$2,804,000
Total Economic Cost	**$74,020,000**	**$99,840,000**	**$101,500,000**	**$106,010,000**	**$102,260,000**	**$153,300,000**
Annual Average Equivalent Economic Cost	**$2,610,000**	**$3,520,000**	**$3,580,000**	**$3,740,000**	**$3,610,000**	**$5,410,000**

Maintenance dredging and armor rock replacements of varying degrees are assumed for each alternative. H&H developed the intervals and quantities for maintenance dredging and rock replacement. Cost Engineering developed the operations, maintenance, repair, rehabilitation, and replacement costs. Maintenance dredging consists of three components: mobilization and demobilization, dredge survey, and dredging. Maintenance mobilization cost was based on historical maintenance contract for Nome. The dredge survey was assumed to be $0.50 per square foot. Maintenance dredging was estimated at $10 per cubic yard. The maintenance dredging quantities vary by alternative.

Armor rock was assumed as a unit cost of $572 per cubic yard and was estimated to be replaced in varying quantities and frequencies by alternative. Maintenance frequency also varies by alternative. Using the Federal discount rate, the future stream of operations and maintenance costs was adjusted to the base year. The itemized operations, maintenance, repair, rehabilitation, and replacement costs in current dollars are presented in Table 24.

Table 24. Operations, Maintenance, Repair, Rehabilitation, and Replacement Costs by Alternative

Description	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Mobilization & Demobilization	$700,000	$700,000	$700,000	$700,000	$0	$700,000
Dredge	$180,000	$230,000	$250,000	$510,000	$0	$100,000
Dredging Survey	$264,000	$229,000	$392,000	$466,000	$0	$206,000
Armor Rock Replacement Mobilization & Demobilization	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000
A-Rock	$432,000	$459,000	$468,000	$465,000	$530,000	$800,000
Total	**$3,576,000**	**$3,618,000**	**$3,810,000**	**$4,141,000**	**$2,530,000**	**$3,806,000**

12. NATIONAL ECONOMIC DEVELOPMENT SUMMARY

Net benefits and the BCR are determined using the average annual benefits and average annual costs for each alternative. Net benefits are determined by subtracting the average annual costs from the average annual benefits for each alternative; the BCR is determined by dividing average annual benefits by average annual costs. The project costs, benefits, and BCR by alternative are given in Table 25. None of the alternatives have a BCR greater than 1.0. At BCRs below 1.0, the net annual benefits are negative. Alternative 2 yielded the highest net annual benefits of approximately -$1.5M compared to the remaining Alternatives.

Table 25. Summary of NED Benefits and Costs by Alternative

Description	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Average Annual Cost	$2,610,000	$3,520,000	$3,580,000	$3,740,000	$3,610,000	$5,410,000
Average Annual Benefits	$1,040,000	$1,080,000	$1,080,000	$1,100,000	$930,000	$1,020,000
Average Annual Net Benefits	-$1,570,000	-$2,440,000	-$2,500,000	-$2,640,000	-$2,680,000	-$4,390,000
Benefit Cost Ratio	0.40	0.31	0.30	0.29	0.26	0.19
Note: Slight differences between Average Annual Benefits presented in Table 21 due to rounding.						

13. FOUR ACCOUNTS

Four accounts facilitate the evaluation of the effects of alternative plans:

- The NED account reflects changes in the economic value of the national output of goods and services.
- The RED account reflects changes in the economic value of the regional output of goods and services.
- The EQ account reflects non-monetary effects on ecological and aesthetic resources, including the positive and adverse effects of plans.
- The OSE account reflects plan effects on social aspects such as community impacts, health, safety, displacement, and energy conservation. Each of the following project benefits, considered under the Section 2006 authority as listed in earlier sections, is qualitatively analyzed in the OSE account:
  - Public health and safety of the local community and communities in the region
  - Access to natural resources for subsistence purposes
  - Local and regional economic opportunities

- The welfare of the regional population to be served by the project
- Social and cultural value to the local community and communities in the region.

A summary representation of the four accounts is shown in Table 26. Note that Alternatives 6 and 7 at the Airport Point site were screened out after the NED analysis and are not presented in the table. The reasons for eliminating these alternatives was the higher cost of construction at Airport Point relative to Elim Beach, with little or no additional benefit. This cost increase was a function of the geography and geology of Airport Point and the distance of the site from existing infrastructure such as the fuel header. A more detailed discussion of screening is included in Section 5.6 of the *Integrated Feasibility Report and Environmental Assessment* main report.

Table 26. Four Accounts Summary

Alternative	Net Annual Benefits & BCR	EQ Positive Effects	RED Impact of Employment and Income in the Region	OSE
2	-$1,570,000 0.40	Low	$35M	Beneficial
3	-$2,440,000 0.31	Low	$47M	Beneficial
4	-$2,500,000 0.30	Middle	$48M	Beneficial
5	-$2,640,000 0.29	High	$50M	Beneficial

Note: The USACE Online Regional Economic System analyzed RED benefits: the impact of employment and income generated in the region by the construction of the project. The overall summary is discussed further in Section 14.6.

13.1 National Economic Development

The NED account shows changes in the economic value of the national output of goods and services. All of the alternatives show a benefit-cost ratio of less than 1.0. Based on project costs, average annual benefits would have to increase five times to achieve a BCR greater than 1.0.

Since the NED did not identify a preferred plan, the CE/ICA was used to support plan selection. Consistent with the authority of WRDA 2007 Section 2006, plan selection is also supported in part on OSE. The tentatively selected plan identified and endorsed is Alternative 5.

13.2 Regional Economic Development

The RED account measures changes in the distribution of regional economic activity that would result from each alternative. Evaluations of regional effects are measured using a nationally consistent income, employment, output, and population projection.

13.2.1 USACE Online Regional Economic System

The USACE Online Regional Economic System (RECONS) is a system designed to estimate regional, state, and national contributions of Federal spending associated with Civil Works and American Recovery and Reinvestment Act Projects. It also provides a means for estimating the benefits associated with non-Federal expenditures sustained, enabled, or generated by USACE projects. Contributions are measured in terms of economic output, jobs, earnings, and/or value-added. RECONS reports indirect and induced effects collectively as secondary effects. RECONS includes three categories of economic impacts:

- **Direct effects** are defined as expenditures made by USACE. In the impact area in which the project is located, direct effects represent the portion of expenditures that flows to material and service providers in the impact area. For employment and earnings measures, the direct effect represents the jobs associated with the work activity (e.g., onsite construction jobs).
- **Indirect effects** include the suppliers for any goods and services used by the directly affected activities.
- **Induced effects** on the region occur from household expenditures associated with direct- and indirect-affected workers spending their income within the impact area. Economic impact measures reported are jobs, employment earnings output (sales), and value-added (gross domestic product).

13.2.2 RECONS Analysis for Alternative 5

This section presents a summary of the RECONS analysis for Alternative 5, which the CE/ICA identified as a best-buy plan. Construction of a new harbor would create jobs and regional economic opportunities (for purposes of the RECONS analysis, the region was defined as the Nome Census Area). Most of the work would be contracted to firms operating or based in Alaska. Some work could benefit national firms. A smaller portion would benefit companies based in the Nome Census Area. The breakout of benefits for Alternative 5 is shown in Table 27.

Table 27. RECONS Summary for Alternative 5

Area	Local Capture ($000)	Output ($000)	Jobs*	Labor Income ($000)	Value Added ($000)
Local**					
Direct Impact		$42,529	327	$20,085	$24,580
Secondary Impact		$3,226	8.2	$475	$1,555
Total Impact	**$50,171**	**$45,755**	**335.8**	**$20,560**	**$26,135**
State					
Direct Impact		$62,901	476.5	$30,966	$42,158
Secondary Impact		$37,959	206.14	$12,417	$22,210
Total Impact	**$70,543**	**$100,860**	**682.57**	**$43,383**	**$64,368**
United States					
Direct Impact		$84,628	536.7	$34,886	$48,057
Secondary Impact		$134,892	630.9	$40,890	$70,340
Total Impact	**$94,817**	**$219,520**	**1,167.5**	**$75,776**	**$118,397**

* Jobs are presented in full-time equivalency (FTE)
** Local region was defined as the Nome Census Area

The expenditures associated with the implementation of Alternative 5 are estimated to be $101,892,000. Of this total expenditure, $50,171,000 would be captured within the local impact area. The remainder of the expenditures would be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value-added), as summarized in the table. The regional economic effects are shown for the local, state, and national impact areas. In summary, the project expenditures support a total of 335.8 full-time equivalent local jobs, $20,560,000 in local labor income, $26,135,000 in local gross regional product, and $45,755,000 in economic output in the local impact area. Nationally, these expenditures are estimated to support 1,167.5 full-time equivalent jobs, $75,776,000 in labor income, $118,397,000 in the gross regional product, and $219,520,000 in economic output.

The total regional economic benefits attributed to project implementation, including all construction phases, are displayed in Table 27. To estimate each FY's impacts, the percent of total implementation costs incurred each FY would be multiplied by the RED benefit categories (output, jobs, labor income, and value-added).

In addition to the effects shown above, there is potential to realize local and regional economic opportunities by delivering additional commercial fishing harvests to Elim and improved access for tenders and fuel and freight barges. Fish processing (fish cutters and trimmers) was identified as a top occupation in Elim in 2012 and 2013, indicating that it was a major employment opportunity for residents before its recent downsizing. Opportunities provided by improved navigational access coupled with the planned head and guts pre-processing plant in Elim would potentially grow fish processing jobs.

13.2.3 RED Account Summary for All Alternatives

While Alternative 2 would improve commercial fishing and subsistence opportunities, it would do little to enhance regional economic opportunities compared to the larger alternatives that provide additional access for tenders and the fuel and freight barges. The addition of a tender dock with Alternatives 3 and 4, coupled with a pre-processing plant in Elim, would improve the overall efficiency of commercial fishing operations in the region. These alternatives would improve job opportunities in the fishing industry, improve the quality of the product, reduce the change of a backlog at the Unalakleet plant, and allow fishermen to maximize the productivity of the salmon run.

While Alternatives 3 and 4 include a tender dock, which is critical for improving commercial fishing operations' efficiency, these alternatives would not improve access for fuel and freight delivery. Alternative 5 is the only alternative that provides safe access to barges that deliver fuel and freight to Elim. Having safe and efficient access to essential goods (including fuel) is foundational to community viability.

13.3 Environmental Quality

Environmental Quality (EQ) displays the non-monetary effects of the alternatives on natural resources and is described more fully in the environmental assessment sections of the IFR/EA. A reduction in the fleet’s fossil fuel usage and emissions is expected, resulting from reduced delays and idling time with improved access and moorage. However, improved efficiencies would also lead to more frequent traffic operations by the existing fleet, resulting in more or the same fossil fuel usage.

Enhancements to the environment resulting from constructing Alternative 5 include a reduction in the need for cargo barges to self-lighter. In turn, this would reduce oil leakages into the sea from construction equipment being offloaded into the water and walked to shore. In the existing conditions, vessel idling generates noise pollution in the marine environment, which can have hydroacoustic impacts on marine mammals and fish. A barge landing and tender dock would reduce vessel idling and noise pollution affecting marine resources. Alternative 5 would relocate the fuel header from the top of the bluffs to the barge landing on the beach and would eliminate the need to float the hose from offshore, reducing chances for small fuel spills during offloading from the barge to the fuel header.

13.4 Other Social Effects

OSE benefits include the following:

- Public health and safety of the local community and communities in the region
- Access to natural resources for subsistence purposes
- Welfare of the regional population to be served by the project
- Social and cultural value to the local community and communities in the region.

The OSE account displays the effects of a proposed intervention, such as a navigation project, on social aspects such as well-being that are integral to personal and community definitions of satisfaction and happiness (Dunning and Durden 2009). The USACE *Planning Guidance Notebook* further clarifies that these OSE also include effects on educational, cultural and recreational opportunities; effects on security of life, health, and safety; long-term productivity effects, including the maintenance and enhancement of the productivity of resources for use by future generations; and effects on emergency preparedness.

These social effects reflect a complex set of relationships between the social and cultural setting and the proposed plan (USACE 2000, Appendix D). The OSE account describes the above social effects under a framework of “social well-being factors,” as described by Dunning and Durden (2009). Social well-being factors are based in part on Maslow’s hierarchy of human needs theory, which states that people must have a number of essentials to survive and thrive (Maslow 1943). These social well-being factors are important to the long-term viability of a community.

The effects that a proposed project would likely have on the social and cultural landscape in Elim and the region are discussed within this framework of social well-being factors. The proposed project is a harbor that would provide safe access and moorage for subsistence and commercial vessels, fish tenders, and a freight/fuel barge. Section 14 discusses safe access as the non-monetary metric by which the alternatives are compared. The following discussion on social well-being factors expands on the effects of safe navigational access on the social and cultural landscape in Elim and the community and region's long-term viability.

13.4.1 Health and Safety

Personal and group safety is an important basic human need (Maslow 1943). Unsafe or unhealthy conditions can cause stress and dissatisfaction among those affected. An important way Alaska communities promote health is through participation in the traditional harvesting and consumption of subsistence resources. Subsistence activities provide traditional, healthy foods and are important for food security and food sovereignty in remote communities like Elim. Subsistence opportunities have been identified as a community strength in the project region (McDowell Group 2019).

Despite the abundance of subsistence opportunities, however, McDowell Group (2019) also identified the lack of access to healthy foods as a community challenge in the project region. Flint et al. (2011) observed that health challenges are increasingly experienced among Alaska Native communities as traditional subsistence foods are replaced with Western, packaged foods when access to subsistence lifeways are impeded or become inaccessible. Flint et al. (2011) also suggest a correlation between the reduction in subsistence harvesting and decreases in physical activity, as well as increases in drug and alcohol problems. On this premise, it is suggested that improved access to subsistence resources would support the physical health of Elders and community members who are the culture bearers and teachers of subsistence practices. Sections 2.2 and 6.1.1 discuss Elim's reliance on small vessels for subsistence activities during the open-water seasons and the challenges to subsistence activities due to the lack of safe navigational access. Improving navigation access will beneficially impact community members' abilities to pursue subsistence opportunities.

For commercial vessels, the effects of improved access include a reduced risk of boat accidents at Moses Point during the fishing season. In addition, a protected boat launch could support the timely mobilization of vessels responding to a vessel in distress. The existing conditions make it difficult to mobilize search and rescue efforts safely. Response vessels must often wait for better weather and wave conditions to launch from Moses Point or Elim Beach (USACE 2018). These conditions are hampered by reduced depths at Moses Point and the moving sand bars in front of Elim Beach. Even if the water depth conditions at Moses Point are favorable for boat launch, responders may not be able to access Moses Point if the gravel road has been damaged or flooded. The longer the delay in launching response vessels, the greater the potential risks for the vessel in distress. The proposed project would reduce these safety risks in the community.

Navigation improvements would also promote health and safety during barge operations. A barge landing and protected harbor would reduce risks associated with wave conditions to both crew members and community members in the vicinity. Additionally, the fuel header's relocation from the top of the bluffs to the beach near the barge landing would eliminate the need to float the fuel hose to shore and manually drag it across the beach and up the bluff. It will improve safety and efficiency in fuel delivery overall. The fuel leakages and oil spills described in the EQ account above impact subsistence species. The project would reduce these leakages and spills and, in turn, reduce environmental health risks.

13.4.2 Social Connectedness

According to Dunning and Durden (2009), "social connectedness" refers to the intricate social networks within which individuals interact; these networks provide meaning and structure to life. These social networks consist of families and community members cultivating an array of diverse voluntary associations known as "civic infrastructures."

These civic infrastructures can provide individuals with greater opportunities for connectedness, communication, and reciprocity; and also support subsistence lifeways. Improved access and moorage for subsistence vessels would support social connectedness among Elim community members. Subsistence activities consist of hunting, fishing, gathering, and the meticulous processing of those harvests; subsistence often requires a collective effort from extended family, friends, and neighbors. By having safe navigational access to these subsistence resources, community members' collective participation in the subsistence civic infrastructures can be enhanced, strengthening an individual's ties within and to the community.

Section 4.2 noted the prominence of students 4–11 years old in Elim under the current socio-economic conditions. This age group encompasses the formative years crucial for instilling cultural values and culturally specific social connectedness pathways through participation in subsistence activities. During one project meeting, an Elim Elder talked about the importance of young people being immersed in their traditional ways before they venture out of the community. In Elim, community events centering on subsistence activities are often organized to involve both the young and the old, such as a community picnic on the beach with traditional foods harvested and prepared collectively during the beluga harvest (C. Nagaruk, personal communication, April 2019).

In addition to serving as a crucial vehicle for subsistence harvests, small vessels serve as a marine highway connecting the region's remote villages. In this sense, the proposed navigation improvements would also support social connectedness with neighboring communities and kinship networks (e.g., Golovin, Koyuk, Shaktoolik). For example, when there is a funeral in Elim, family and friends from neighboring communities often visit by a vessel with wild foods (R. Keith, personal communication, 2019). This inter-village event further promotes regional reciprocity, which is a significant aspect of Yup'ik and Inupiaq cultural traditions and reflects the cultural importance of subsistence activities.

13.4.3 Social Vulnerability and Resiliency

Social vulnerability refers to the capacity for being damaged or negatively affected by hazards or impacts of a physical or social nature. Vulnerability is often associated with specific groups within a population (e.g., elderly, poor) who are generally more susceptible to such impacts than other population members. Social resiliency refers to the ability to cope with and recover from hazards or impacts (Dunning and Durden 2009). Without a functional harbor, Elim residents will continue to launch their vessels from Moses Point. The sand bar at Moses Point, which is approximately 10 miles away from Elim, is subject to shifting, and boat access from the ocean during most tides is difficult and hazardous. In addition to this ever-changing navigation hazard, the potential difficulty in landing vessels in a timely manner can impact the ability to process subsistence harvests safely.

Fishermen are often key subsistence and cash providers for their households. As fishermen age, they may be more vulnerable to the hazardous conditions at Moses Point. The proposed protected harbor could create stability in commercial and subsistence activities by providing safe access and moorage for vessels. With this stability, the fishermen may be less vulnerable to hazards such as shifting sand bars and tidal fluctuations. They may be more likely to secure cash from commercial fishing that can be used for equipment repairs. Having more available cash translates to improved resiliency in that community members could be better able to cope with and recover from hazardous events or unexpected impacts. Practicing knowledge and skill transfer from older fishermen to the younger generation of fishermen can also be improved when there is safe access for commercial vessels. Such knowledge transfer is an important aspect of social connectedness, which supports the mobilization of the civic infrastructures that serve the community in a time of crisis.

13.4.4 Cultural Identity

The cultural identities of Alaska Native Tribes are closely tied to subsistence activities associated with specific locations and deep historical knowledge of the land and marine resources. According to Dunning and Durden (2009, p.7), “identity is the sense of self as a member of a group, distinct from and distinguished from other groups by values, beliefs, norms, roles, and culture.” Cultural identity is multidimensional and complex; while a social well-being factor on its own, it is also key to realizing other social well-being factors, including health and safety, social connectedness, and social vulnerability and resilience. Therefore, it is difficult to separate a discussion on cultural identity from the social well-being factors mentioned above. As a social effect of the proposed project, cultural identity can be considered in the context of its pivotal role in some of the solutions to health challenges experienced by remote Alaska Native communities.

The *Bering Strait Community Needs Assessment* identified substance abuse and a lack of cultural-based activities among the top 10 community challenges in the Kawerak Service Area (McDowell Group 2019). Substance abuse is a well-documented problem in Native American and Alaska Native communities. Although it is a multifaceted problem, it has often been linked with cultural identity conflicts (Dickerson et al. 2010 Segal et al. 1999; Allen et al. 2014). A study by Rasmus (Rasmus et al. 2014) identified externally imposed changes to the Indigenous way of life that took place dramatically and quickly in Alaska Native communities as a cause of these behavioral health problems.

The causal role has been supported in recent years, as health interventions designed by and for Indigenous communities that are culturally grounded and that integrate indigenous knowledge have succeeded in helping combat substance abuse (Rasmus et al. 2019; Walters et al. 2018). One such health intervention initiative included developing Spirit Camps, where youth practiced the subsistence lifeways associated with summer fish camps. All of the subsistence activities that occurred at camp involved the whole community, including Elders, demonstrating the importance of social connectedness. The Elders present shared central values by teaching subsistence activities and cultural traditions to the youths. Participants reported that engaging in subsistence activities revived and sustained their sense of cultural identity, and it was here that healing from substance abuse began. By strengthening a sense of cultural identity in the young participants, camps helped prevent feelings of alienation, alcohol and drug abuse, and suicide (Segal et al. 1999).

Another long-term study found that the development of social and cultural connectedness within a supportive network of kinship relationships and enduring cultural traditions and practices like subsistence activities are important to youth resilience (Rasmus 2014).

These studies all demonstrate the important role subsistence lifeways play in maintaining the health and social connectedness of Alaska Native communities. As discussed above, these social factors are closely associated with community viability. During focus group meetings in Elim, residents identified the importance of subsistence practices and Indigenous knowledge to their cultural identity. A harbor that can provide safe access can facilitate the subsistence practices important to cultural identity, which can promote health and social connectedness. In this way, the proposed project could support local health and help address some of the top 10 community challenges identified in the *Bering Strait Community Needs Assessment* (McDowell Group 2019).

14. COST EFFECTIVENESS/INCREMENTAL COST ANALYSIS

Section 12 presented the NED analysis and demonstrated that there is no NED plan. In accordance with WRDA 2007 Section 2006, the CE/ICA was conducted to evaluate the effects of the proposed alternatives beyond the NED perspective. These effects are non-monetary outputs. The CE/ICA is utilized to inform decisions on sound investments by identifying options that yield maximum desired outputs for the least acceptable cost. The selected outputs are measured, for this analysis, in opportunity days for access and moorage for the Elim vessel fleet served by navigation improvements. This section describes the development of the CE/ICA variables, the underlying assumptions, and the hydraulics and hydrology (H&H) modeling that form the basis of the outputs. It discusses the computations and CE/ICA results completed on the IWR Planning Suite II. Alternatives 6 and 7 were screened out in the NED analysis due to a significant cost-share burden on the local sponsor and because overall project cost estimates or those alternatives are higher than those for Alternatives 2 and 5, respectively, for the same or lesser level of benefits.

14.1 CE/ICA Framework

The output used for this CE/ICA is rooted in the planning objectives developed to address the water resource problem at Elim:

1. Provide safe, reliable, and efficient waterborne transportation systems for the movement of commerce (including commercial fishing) and subsistence in Elim
2. Support the long-term viability of Elim

Opportunity days for safe access and moorage conditions directly impact waterborne transportation for the movement of commerce and subsistence in Elim. Given the integral significance of commercial fishing and subsistence practices to livelihoods, these support the community’s long-term viability. Opportunity days are therefore the optimal metric for the CE/ICA. The CE/ICA metric compares the accessibility and moorage conditions between the alternative plans and the no-action plan (Alternative 1).

The OSE benefits under which this study is authorized follow the same guiding principle as the National Ecosystem Restoration, for which Engineer Regulation 1105-2-100 sets the following requirements for plans being considered:

> *… meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness.*

The development and application of the CE/ICA analysis to determine the recommended plan followed with these guidelines. The Alaska District H&H collaborated with Economics on the development of the model metric and model input. The model was subsequently submitted to the Deep Draft Navigation Center of Expertise for review and approval. The model review was completed in December 2019, and an approval memorandum from the Deep Draft Navigation Center was received in May 2020. Moses Point is the base for the current and FWOP conditions and operations of the subsistence and commercial fleet, and Elim Beach is the location of the future with-project conditions and fuel and barge operations under the current and FWOP conditions.

The CE/ICA was performed on Planning Suite II using two variables: non-monetary outputs and the costs of the alternative plans. The non-monetary outputs are measured in days that allow for safe access and moorage. In this report, the terms output and metric are interchangeable.

14.2 Opportunity Days

Opportunity days, the non-monetary metric used for this CE/ICA, are defined as days that the Elim fleet can safely access and moor at the proposed navigation improvements. Vessels operate in and out of Elim from May to November, and accessibility and moorage conditions are evaluated within this season. Though safe access and moorage are assessed separately, opportunity days are combined as a single metric for the CE/ICA.

14.2.1 Safe Access

Safe access means that the wave and water level conditions exceed safety requirements for each vessel class. Safe access is based on wave and water level conditions at the existing moorage area at Moses Point (Alternative 1), or the proposed navigation improvements at Elim Beach (Alternatives 2–5). Safe access is controlled by the safe operating conditions for each vessel class included in the alternative. The H&H Appendix (Appendix C) details the methodology used to determine the wave and water level conditions at Moses Point and Elim Beach. Hindcast wind and wave data (1985–2014) was used to estimate the percent of historical hours that the wave conditions at Moses Point and the entrance of the proposed navigation improvements would have exceeded the safe operating conditions of each vessel class. Historical water level data at Nome (August 1992 through July 2019) was used to estimate the percent of historical hours that the water level was below the safe water depth clearance of each vessel class. It was assumed that large wave events and low water events do not occur at the same time.

14.2.2 Safe Moorage

Moorage represents the Opportunity Days for safe moorage within the proposed navigation improvements that exceed safe tender moorage requirements at each alternative, including improvements for tender operations. Subsistence, commercial, and barges vessels are assumed to gain safe moorage with access. Therefore, these vessel classes are not evaluated for moorage. Tenders require safe moorage for offloading and loading.

Moorage was determined by the estimated wave conditions of Moses Point for FWOP conditions and at the tender dock within the proposed navigation improvements at Elim Beach for future with-project conditions. Wave heights must be less than or equal to 2 ft at the tender dock for them to be offloaded or loaded. The H&H Appendix (Appendix C) details the methodology used to determine wave conditions within the proposed navigation improvements at Elim Beach. Diffraction analysis was used to estimate the wave height at the tender dock for each alternative that includes improved tender operations. Hindcast wind and wave data (1985–2014), coupled with the diffraction analysis, was used to estimate the percent of historical hours that the wave height at the tender dock would have exceeded 2 ft.

14.2.3 Calculation of Opportunity Days

Opportunity days do not represent calendar days. Safe access represents the opportunity window each vessel would have for safe access after accounting for wave conditions that exceed safe access requirements (Number of Days in Month x Percent Exceedance x Number of Vessels). Moorage represents the opportunity window the tender would have for wave conditions that exceed safe moorage requirements for each alternative that includes improved tender operations (Number of Days in Month x Percent Exceedance x Number of Vessels). To calculate the opportunity days for current and FWOP conditions, safe access was subtracted from the maximum opportunity days that would be available assuming perfect conditions (Number of Days in Month x Number of Vessels), then moorage was added.

To determine the number of opportunity days gained by proposed navigation improvements, the opportunity days for current and FWOP conditions were subtracted from the opportunity days for each alternative. Table 28 summarizes the opportunity days gained by each alternative for the season of interest (May through November). These outputs represent average annual benefits.

Table 28. Annual Opportunity Days by Alternative

Alternative	Subsistence Opportunity Days	Commercial Opportunity Days	Tender Opportunity Days	Barge Opportunity Days	Average Annual Opportunity Days
Alt 2	2,219	2,219			4,438
Alt 3	2,219	2,219	629		5,067
Alt 4	2,219	2,219	805		5,243
Alt 5	2,219	2,219	805	301	5,544

14.3 Demand for Access

Subsistence vessels typically operate from May through November. As highlighted in Section 5, subsistence resources are harvested in Elim throughout the year. Harvests such as caribou hunting and beluga whale harvest require vessel access. Subsistence harvest seasons tend to overlap with one another and occur during ice-free seasons.

Commercial fishing vessels typically operate during the salmon season, which runs from June through August or September. However, commercial fishing vessels are often also used as subsistence vessels. The season for commercial vessel operations is assumed to be the same as the subsistence vessels.

Tender vessels support the commercial salmon fishery. In the absence of tenders, some commercial harvest in Elim would be foregone. ADF&G coordinates the fish openings for commercial salmon by species each season from June through August. NSEDC reported that tenders deliver commercial fish from late May through August and sometimes through September. The wave analysis assumes tenders would operate intermittently from May to November if there were safe access.

Barges deliver fuel and cargo to Elim 2–4 times a year, typically at the start and end of the ice-free season (May and November). While the number of barge deliveries is less than 10, the opportunity days present a wider window for safe access and operation in cargo and fuel delivery. In addition, the barge deliveries for fuel and cargo to Elim are often part of an itinerary of deliveries to the rest of the communities in Norton Sound (M. Stover, personal communication, 2019). The number of opportunity days for barge access at Elim can improve delivery logistics for the barge operators

In Elim, vessel operations are tied to the maintenance and sustenance of livelihoods. Vessel operations at Elim vary by use and season; the demand for opportunity days also varies. Opportunity days are computed from accessibility conditions by the month of harvest or vessel operation. The benefits of opportunity days also vary by vessel operation. Table 29 lists the benefits or value per day of access for each vessel type.

Table 29. Demand for Access Summary

Vessel	**A Day of Access Would Support**	**Opportunity Days Gained**
Subsistence	Subsistence harvest	2,229
Commercial	Commercial harvest	2,229
Tender	Improved commercial salmon fishery	805
Barge	Delivery of the fuel (which is used by subsistence and commercial fleet) for half of the year for the community Delivery of materials for construction	301

14.4 CE/ICA Costs

As noted in the *Planning Guidance Notebook*, the cost-effectiveness analysis evaluates a plan’s level of outputs against its cost. The subsequent incremental cost analysis evaluates a variety of alternatives of different scales to arrive at a best buy option. Best buy plans are considered most efficient, providing the greatest increase in output for the least increase in cost. The cost variable for a CE/ICA refers to the average annual economic costs of each alternative. These costs include project first costs, interest during construction, and operation and maintenance costs. The costs are amortized using the Federal discount rate for FY21 over the period of analysis. The annual average costs used in the CE/ICA are summarized in Table 30.

Table 30. Average Annual Costs for CE/ICA by Alternative

Cost Description	Alt 2	Alt 3	Alt 4	Alt 5
Total Economic Cost	$74,018,000	$99,837,000	$101,498,000	$106,007,000
Annual Average Cost	$2,610,000	$3,520,000	$3,579,000	$3,738,000

14.5 CE/ICA Calculations and Results

The CE/ICA consists of four steps. The first is to estimate the average annual benefits of each alternative. These average annual benefits are the non-monetary units measured in access days. The second step is to estimate the average annual equivalent costs of the alternative plans. The first two steps are completed in the previous subsections. The third and fourth steps use the IWR Planning Suite II software to identify cost-effective plans and estimate incremental cost outputs, respectively. The cost-effective analysis results showed that Alternatives 3 and 4 are cost-effective, and the incremental cost analysis identified Alternatives 2 and 5 as best buys, or the most efficient plans. Alternative 2 has the lowest annual cost per output, at $588 per opportunity day. The next lowest annual cost per opportunity day is the largest scale plan, Alternative 5 ($675 per opportunity day). The CE/ICA results are summarized in Table 31. The relationship between cost and outputs and the cost-effectiveness of each alternative are displayed in Figure 21.

Table 31. CE/ICA Results Summary

Alternative	Opportunity Days Gained	Average Annual NED Cost (Rounded)	Annual Cost per Day Gained	Cost-Effective
Alt 2	4,438	$2,610,000	$588	Best Buy
Alt 3	5,067	$3,520,000	$695	Cost Effective
Alt 4	5,243	$3,580,000	$683	Cost Effective
Alt 5	5,544	$3,740,000	$675	Best Buy

The two best buy plans were compared using incremental cost analysis. The gain in access days (i.e., non-monetary outputs) relative to the increase in cost for the two is shown in Table 32 and Figure 22.

Table 32. Best Buy Plans Incremental Cost Analysis

Alternative	Opportunity Days Gained	Incremental Opportunity Days Gained	Annual Cost per Opportunity Day Gained	Incremental Cost per Opportunity Day
Alt 2	4,438	4,438	$588	$588
Alt 5	5,544	1,106	$675	$1,022

The cost-effective analysis results identified Alternatives 2, 3, 4 and 5 as cost-effective. The incremental cost analysis identified Alternatives 2 and 5 as best buy plans in addition to the No Action plan. The incremental cost analysis showed Alternative 5 would provide many more Opportunity Days than those provided with Alternative 2, including Opportunity Days for two fish tenders and barge access for a minor cost increase per increment.

The incremental cost per opportunity day for Alternative 2 is $588 for opportunity days for the subsistence and commercial fleet only. Alternative 5 would provide additional opportunity days for two fish tenders and barge access for an incremental cost of $1,022 per opportunity day. The incremental cost box graph in Figure 22 displays the best buy plan comparisons resulting from the incremental cost analysis.

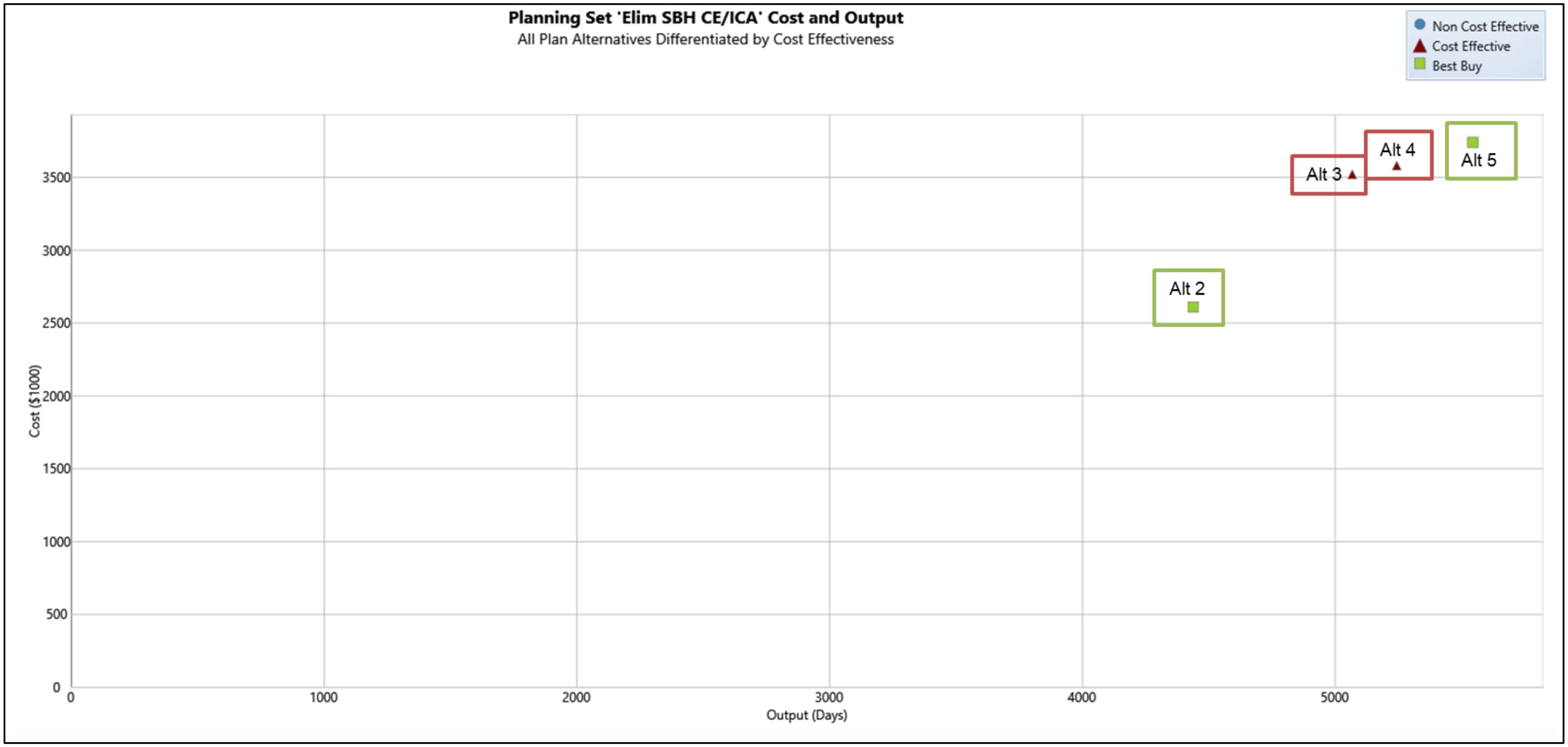

Figure 21. Alternatives Differentiated by Cost-Effectiveness

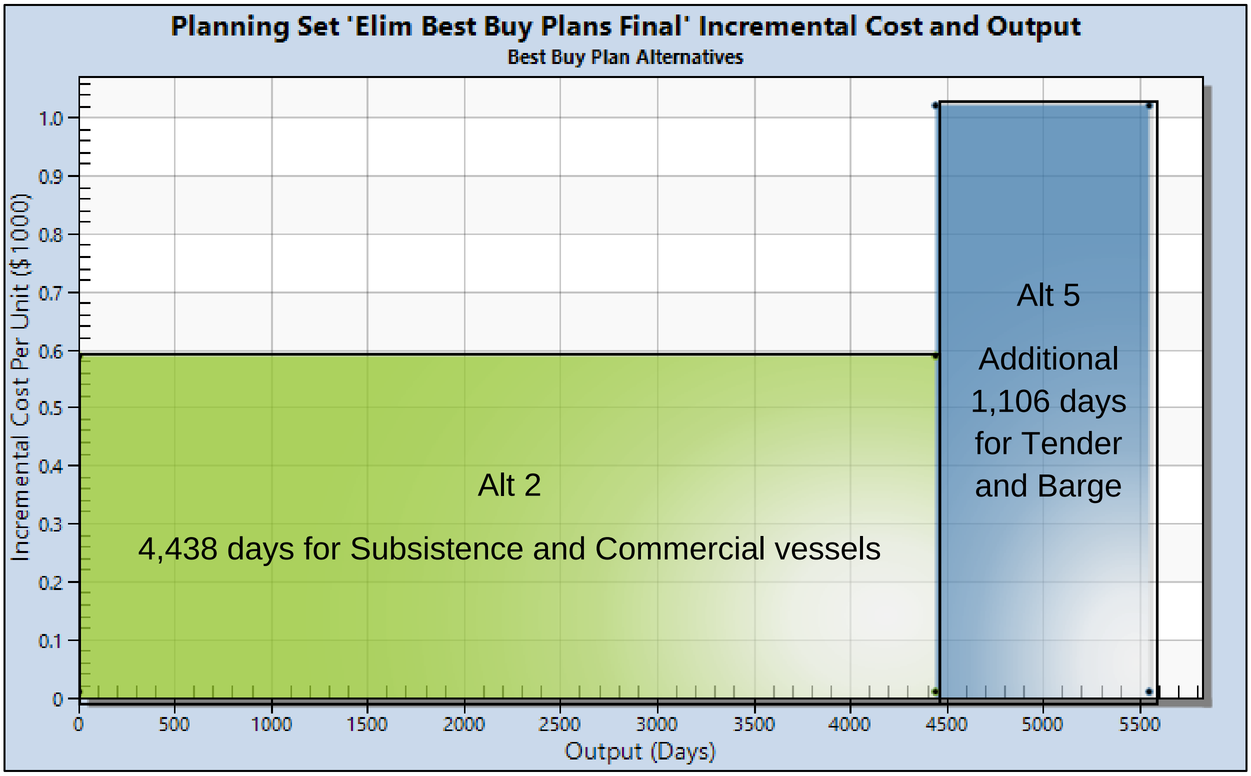

Figure 22. Incremental Cost Analysis of Best Buy Plans

14.6 Multi-Criteria Decision Analysis

While opportunity days are the optimal metric representing the benefits of safe access and moorage of vessels for each alternative plan, the use of this metric alone assumes that all vessel operations provide a uniform level of benefits. It fails to fully capture the nuances of benefits accrued by each vessel operation, the demand for access, and the specific contributions by vessel activities to community viability. The specific roles of vessel operations to community viability are qualitatively discussed in Section 9 and further expanded in Section 13.4. The multiple criteria decision analysis (MCDA) is used to account for these benefits in the framework of CE/ICA. MCDA allows for clarification and conveyance of tradeoffs across alternatives (CDM Smith 2017). The selection of criteria for the MCDA is based on key benefits that support community viability and meet the planning objectives. Table 33 presents the criteria selected for the MCDA.

The criteria utilized for this MCDA consisted of benefits from two of the four accounts: OSE and EQ. The benefits under these accounts are non-monetary, as detailed in Section 13. The criteria were selected for the MCDA due to their impacts on and/or benefits to community viability.

Table 33. Criteria Selected for MCDA

Criteria	Designated Account	Ranking Values
Health and Safety	OSE	LOW-3 MEDIUM-5 HIGH-7
Delivery of Essential Goods and Fuel	OSE	
Delivery of Materials for Critical Infrastructure	OSE	
Cultural Identity	OSE	
Reduction in Potential Fuel Spillage	EQ	LOW-1 MEDIUM-2 HIGH-3
Reduction in Fuel Consumption during Vessel Idling	EQ	
Reduction in Noise Pollution	EQ	

MCDA involves optimizing criteria by considering the minimization of undesirable effects and maximization of desirable effects. Since the selected OSE and EQ criteria represent benefits that support community viability, a maximization of each criterion is considered favorable.

14.6.1 Assigned Quantitative Values

The MCDA followed the methodology set out in the *IWR Planning Suite II User Guide* (CDM Smith 2017), with each criterion representing a measured quantity in a decision matrix. For qualitative criteria such as those presented in Table 33, the criteria were assigned a quantitative number in a ranking system based on how important each criterion is to each vessel operation served by the alternative plans.

Within the selected criteria, OSE criteria are more important to community viability and the planning objectives than EQ criteria. EQ criteria are considered secondary benefits to supporting community viability. Therefore, different quantitative values were assigned for ranking between OSE and EQ criteria. Ranking values for low, medium, and high were assigned as 1, 2, and 3, respectively, for EQ criteria and as 3, 5, and 7, respectively, for OSE criteria. The assigned values have some limitations, particularly in that the Medium ranking value is about twice the Low ranking value. However, for the level of analysis for the MCDA, it was determined that these ranking values, from an example by CDM Smith (2017), were appropriate.

The Project Delivery Team (PDT) conducted a ranking exercise of each criterion by vessel class. Each vessel class was ranked for each criterion based on how impactful improvements to its operations would be on meeting the planning objectives. The criteria rankings clarify the incremental benefits of opportunity days across the vessel classes, highlighting the unique opportunities gained by improving operations for each vessel class.

14.6.2 Criteria Definitions

14.6.2.1 Health and Safety

The Health and Safety criterion refers to the effects of safe access by vessel category operation on the health and safety of the vessel operators. It also refers to how the outcomes and activities of the vessel support the health and safety of the community members. The Health and Safety criterion is key to meeting Planning Objective 1.

14.6.2.2 Delivery of Essential Goods and Fuel

This criterion is elaborated on in the “Stemming from Effects” subsection in the IFR/EA main report. For remote communities such as Elim, the consistent and safe delivery of essential goods and fuel is important to sustaining community viability and vitality. Subsistence and commercial fishing activities are crucial for Elim, but access to equipment and fuel to participate in these activities is dependent on the delivery of essential goods and fuel. The Delivery of Essential Goods and Fuel criterion is ranked by the vessel class’s ability to support and maintain the delivery of essential goods and fuel in the future, which supports meeting Planning Objective 2.

14.6.2.3 Delivery of Materials for Critical Infrastructure

The community's ability to replace and upgrade critical infrastructure is impacted by the ability to deliver construction materials to Elim. The Delivery of Critical Infrastructure Materials criterion is ranked by each vessel class's capacity to deliver construction materials and support Elim’s ability to upgrade or replace critical infrastructure, which supports meeting Planning Objective 2.

14.6.2.4 Cultural Identity

Cultural Identity is elaborated on in various sections of this report as imperative to community viability. The ability of Elim community members to continue to practice subsistence activities and transmit cultural knowledge and practices to future generations is captured under the Cultural Identity criterion. The Cultural Identity criterion is important to ensure the navigation improvements meet Planning Objective 2.

14.6.2.5 Potential Reduction of Fuel Spills

This criterion refers to the ability of improved access for each vessel category to address potential fuel spills from the transfer of fuel delivery or fuel spillage from vessel activities.

14.6.2.6 Potential Reduction in Vessel Idling

The proposed navigation improvements support improved efficiencies in vessel operations, which reduce the need for vessel idling and thereby reduce fuel use. The Reduction in Vessel Idling criterion assesses the extent to which safe access and moorage for each vessel class reduce vessel idling

14.6.2.7 Reduction in Noise Pollution to Marine Resources

In the existing conditions, vessel idling generates noise pollution in the marine environment, which can have hydroacoustic impacts on marine mammals and fish. A reduction to noise pollution resulting from reduced vessel idling is assessed under the Reduction in Noise Pollution criterion.

14.7 MCDA Ranking Results

14.7.1 Scores

With criteria defined, the PDT conducted the ranking of each vessel class. Each criterion was ranked low, medium, or high based on the PDT's best knowledge of vessel operations and how an opportunity day for the vessels in question would meet the planning objectives incrementally. Following the ranking by vessel class, the ranking values were summed by criteria in each alternative. The MCDA results by vessel class and alternative plan are presented in Table 34 and Table 35, respectively.

14.7.2 Rationale

Justification for the rankings is discussed below, to capture the PDT rationale and enable a review of the MCDA results. Each vessel class was ranked for each criterion to highlight the differences in how the opportunity days help the proposed navigation improvements meet the planning objectives. The ranking exercise follows the rationale elaborated on in the “Stemming from Effects” section in the IFR/EA main report.

Table 34. MCDA Ranking by Vessel Class

Vessel	Subsistence	Commercial	1 Tender	2 Tenders	Barge
Health and Safety	7	7	7	5	7
Goods and Fuel Delivery	3	3	3	3	7
Critical Infrastructure	3	3	3	3	7
Cultural Identity	7	5	5	3	5
Potential Reduction in Fuel Spill	1	1	1	1	3
Potential Reduction in Vessel Idling	1	1	2	1	3
Reduction in Noise Pollution	1	1	1	1	3

Table 35. MCDA Total Value by Alternative

Alternative	Alt 2	Alt 3	Alt 4	Alt 5
Health and Safety	14	21	24	31
Goods and Fuel Delivery	6	9	12	19
Critical Infrastructure	6	9	12	19
Cultural Identity	12	17	20	25
Potential Reduction in Fuel Spill	2	3	4	6
Potential Reduction in Vessel Idling	2	4	5	8
Reduction in Noise Pollution	2	3	4	7

14.7.2.1 Health and Safety

The Health and Safety criterion was ranked High for all vessel classes, except the second tender, due to the risk that large waves and unpredictable water depths have on the safe operation of vessels when there is no safe moorage or known adequate water depth. The second tender was ranked Medium because the ability for a second tender to have access to safe moorage provides safety to the tender crew but provides less health and safety benefits to the Elim community.

14.7.2.2 Delivery of Essential Goods and Fuel

The efficient delivery of essential goods and fuel accrues more benefits than efficient operations for the barges. Raymond-Yakoubian (2019) described that the cost of fuel can be prohibitive for some Elim residents who want to participate in subsistence activities. Improved efficiency of fuel delivery can lead to more affordable fuel to residents and support the subsistence and commercial vessels activities. The Delivery of Essential Goods and Fuel is unique to the freight and fuel barges. As described in Section 8.5, improving the efficiency of delivering goods and fuel could reduce the cost of essential goods in Elim, which is significantly higher than the national average (Section 4.3.3). As a result, the barge vessel class was ranked High, given its function in supporting community viability, while all other vessel classes were ranked Low.

14.7.2.3 Delivery of Critical Infrastructure Materials

The Delivery of Critical Infrastructure Materials is unique to the freight and fuel barges. As described in Section 9.3, improving the delivery of critical infrastructure materials can improve housing and combat social and health issues associated with housing conditions such as overcrowding and poor air quality. The barge vessel class was ranked High while all other vessel classes were ranked Low.

14.7.2.4 Cultural Identity

All vessel classes support cultural identity in some form. For some vessel classes, there is an obvious direct link, such as the subsistence vessels that support the transmission of traditional environmental knowledge and other important cultural practices, while other vessel classes support cultural identity indirectly. The Cultural Identity criterion was ranked High for the subsistence vessels. A robust commercial fishery supports the mixed subsistence-cash economy, allowing families to stay in Elim and promoting the generational transmission of cultural knowledge; therefore, the criterion was ranked as Medium for the commercial vessels and first tender. Decreasing the cost of living and improving the housing supports the mixed subsistence-cash economy and the community's health and viability. Providing improved access for the freight and fuel barges results in a Medium rank.

14.7.2.5 Potential Reduction of Fuel Spills

Potential Reduction of Fuel Spills is unique to the fuel barge. Due to the fuel barge making up less than half of the barge operations at Elim, it was ranked Medium.

14.7.2.6 Reduction in Vessel Idling

The freight and fuel barges have one option each for operations (Section 6.1), leading to significant wait times and inefficiencies, and increasing the amount of fuel used. Reducing barge idling was ranked High. The first tender was ranked Medium.

14.7.2.7 Reduction in Noise Pollution

Reduction in Noise Pollution is unique to the freight and fuel barges. Freight and fuel barges require tugs for their operations.

14.7.3 Summary

The MCDA values from Table 35 were fed into the MCDA module on the IWR Planning Suite II software. The MCDA module conducted a weighting by maximization and weighted the multiple criteria, including annual costs and opportunity days. The MCDA helps to unpack the complexities within the single metric of opportunity days. Figure 23 shows the MCDA weighting by alternative; the incremental benefits of the opportunity days are more apparent when compared across alternatives.

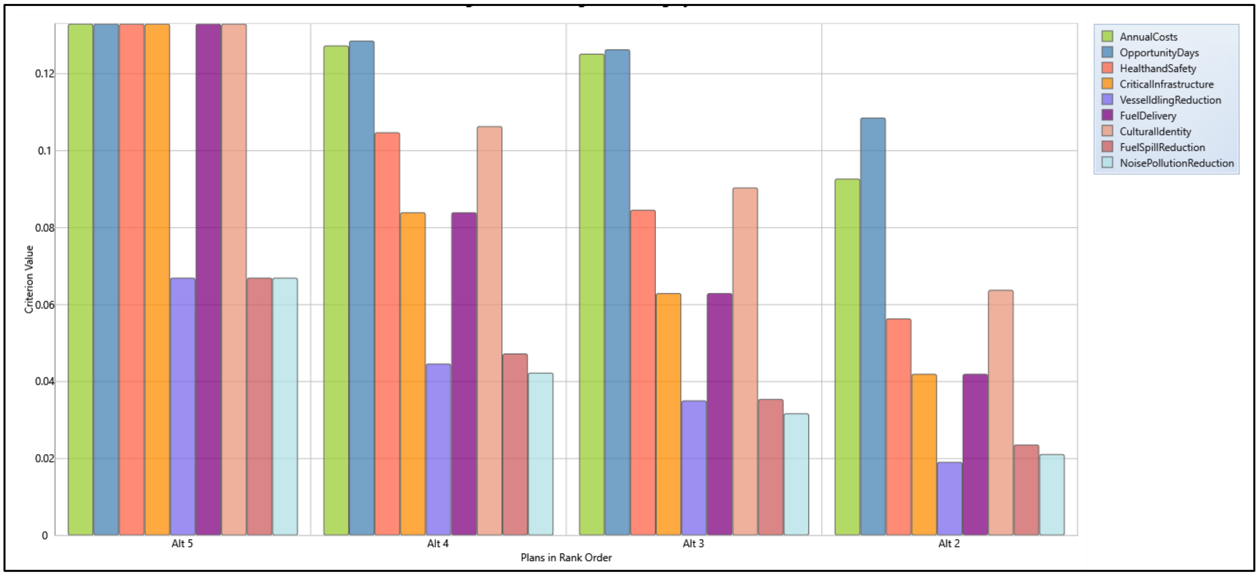

Figure 23. MCDA by Alternative

15. ECONOMIC RISK, UNCERTAINTY, AND SENSITIVITY

The risks in the NED analysis lie in the uncertainties of the NED benefit categories. The benefit estimates are derived from the best available information. For Alaska, data is typically unavailable or limited to short time periods. Additionally, this economic analysis builds on the previous CAP 107 study from 2013. Following a review of the CAP 107 study model and literature, assumptions and extrapolations were developed to reflect Elim's current conditions. However, remaining data gaps and uncertainties result in the risks on the accuracy of benefits the project would realize. A risk is considered acceptable if its consequences are slight or the risk is adequately controlled (IWR Risk-Informed Manual, July 2017). Given that plan selection is based on OSE and not NED, this risk's consequences are considered acceptable.

USACE’s risk-informed planning is intentional about uncertainty. As such, this analysis is identified as a micro-level uncertainty, which refers to the absence of complete information needed to estimate the effects of plans in an accurate and precise way. The assumptions used in this analysis are based on socio-economic and H&H information available, which are subject to uncertainty. For example, H&H's estimated accessibility uses the best information available but based on hindcast and historical data from the location closest to the proposed project site. It does not account for future wave conditions under climate change.

For the CE/ICA, risk and uncertainty of Elim's wave and water level analyses were performed. The wave analysis used modeled offshore hindcast wave and wind conditions from 1985 to 2014 at the boundary of Norton Sound and Norton Bay. The offshore wind data was used to estimate fetch-limited wave conditions approaching the project site from Norton Bay. The use of modeled hindcast data is a necessary low risk and is an industry-accepted practice for locations that do not have long-term buoy data. It is anticipated the offshore and fetch-limited waves estimated are larger than those experienced at the proposed project site. The offshore wave data location is more exposed to wave forcing from the Bering Sea. The fetch-limited wave analysis assumed fully developed waves for all wind conditions, which is anticipated to over-predict the wave heights out of Norton Bay.

The water level analysis utilized historical water level data at Nome, about 96 miles west of Elim, from 1992 to 2019 that does not consider relative sea-level change at Elim. The use of best-available water level data is a necessary low risk due to the lack of water level data at the project location. Based on the analysis of other water level sensors around Norton Sound, the Nome data appeared to have more frequent low water, which was one of the contributing factors to safe access.

16. CONCLUSION

This appendix presents the economic analysis of six alternatives for providing navigation improvements at Elim, Alaska. The alternatives were evaluated using the four accounts established in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*: National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE).

Consistent with the authority of WRDA 2007 Section 2006 (Remote and Subsistence Harbors), a NED analysis was performed, which demonstrated that none of the alternatives had a benefit-cost ratio (BCR) greater than 1.0. Since there was no NED plan, cost effectiveness and incremental cost analysis (CE/ICA) was used to support plan selection. Additionally, the Multiple Criteria Decision Analysis (MCDA) tool was used to aid in capturing the incremental value of the CE/ICA metric used. Economic risks and uncertainties were identified and discussed to support risk-informed planning and decision-making under uncertainty.

Alternative 2 had the highest average annual net NED benefits. Still, its BCR is below 1.0. Alternatives 2 and 5 were identified as best buy plans through the CE/ICA, meaning these alternatives provide the greatest increase in output for the least increase in cost. The CE/ICA, with the MCDA and OSE accounts, demonstrates how the proposed alternatives support Elim's long-term viability. These analyses inform plan selection as detailed in the main report of the *Integrated Feasibility Report and Environmental Assessment*.

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