# Natural Resource Development and Sustainable Arctic Villages

## Planning To Avoid The Natural Resources Curse


Prepared For:

Ocean Conservancy

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February 2014

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Revised Report, July 2014

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**Final Report**
July 10, 2014

# Acknowledgements

The Arctic Studio Class would like to thank the following individuals and organizations for their guidance on the project.

- Ocean Conservancy
- Anna Kerttula, Program Officer, Office of Polar Programs, National Science Foundation
- Nature Conservancy
- Tony Nelessen, Rutgers University
- Michael Phipps, Millennium Group International
- Greg Purvis, Linked Strong Services
- Audubon Alaska
- Jed Drolet, Alaska Energy Authority
- Anne Henshaw, Oak Foundation
- Glenn Sheehan, Barrow Arctic Science Consortium
- Anne Jensen, Ukpeaġvik Iñupiat Corporation
- Enrique Curchitser, Marine Science, Rutgers University

This Studio course was taught by Professor Hal Salzman and draws on his research supported by an International Polar Year grant from the National Science Foundation, Arctic Social Science Program/Office of Polar Programs (Grant #0732973). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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## EXECUTIVE SUMMARY

Within the decade, U.S. offshore oil and gas (O&G) activity will locate and expand in, and around the small, traditionally subsistence-based Iñupiat villages of Alaska's North Slope Borough. This new development has the potential for significant negative impacts on the unique, vulnerable communities and existing natural environments. Alternatively, or at the same time, offshore oil and gas development could provide unprecedented opportunity for coastal Arctic communities to plan for economic impacts that support sustainable development.

This report explores that potential in the City of Wainwright, Alaska – a traditional Iñupiat community of about 550 people, and the likely location for offshore development support facilities and receiving point for offshore-to-shore O&G regional transportation pipelines. It identifies new planning concepts to reduce conflicts between O&G development and community sustainability by identifying ways that a community can leverage the incoming development activity to receive long-lasting benefits. To characterize and assess development opportunities, the study defines, compares, and evaluates four possible development trends for Wainwright under conditions of O&G development and select climate change impacts.

We distinguish Wainwright conceptual site plans representative of four contrasting development scenarios by the level that shore-side O&G development (in "enclaves") is integrated with the existing community. The project considers two general types of integration – 1. Physical (i.e., infrastructure), and 2. Social (e.g., local O&G employment and non-native worker village access). Brief scenario definitions are as follows (the full scenario discussion is in Section 3):

- *Bypassed* – Offshore O&G development occurs, but no pipelines pass through or near Wainwright.
- *Isolated* – pipelines pass through Wainwright, but the enclave (development/infrastructure site) is completely separated.
- *Integrated* - pipelines pass through Wainwright, and the enclave is completely integrated.
- *Hybrid* - pipelines pass through Wainwright, and enclave infrastructure is partially integrated and social integration is restricted.

Social impacts for each scenario are compared and analyzed on three dimensions: (1) Community well-being, (2) Physical infrastructure development, and (3) Coastal hazard mitigation. Each of the three dimensions includes three selected social impact components (SIC), for a total of nine impact dimensions (see report Section 3.5). Conceptual site plans were designed to represent the projected development pattern of each of the four scenarios defined above to add a visual component to the comparison approach and guide the planning framework (see Section 3 for maps and 6.5 for methods).

Using a heuristic approach to assess the impact of each planning scenario, we provide initial evaluations for each SIC using non-weighted scoring from low, medium, to high opportunity. The bypassed scenario provides an impact baseline of "low" development opportunity for all SICs. Among the three scenarios assuming O&G pipeline development through Wainwright, the SIC opportunity scores were lowest for the Isolated development, midrange for the Integrated development, and highest for the Hybrid development - (see Section 4).

A central product of the study is an initial sketch of the Hybrid development scenario, an innovative approach to guide the planning process of introducing a large-scale, infrastructure and labor intensive project in a small village. The approach provides that net benefits for development are maximized through strategic integration of the existing community and selected aspects of the incoming O&G industry with calculated negotiations between both broader parties (see Section 4.4). In the initial hybrid sketch we present, outcome assumptions include: (1) a plan to shift to renewable energy, including new infrastructure; (2) a plan to support a local agriculture industry and regional infrastructure (hydroponic and hothouse infrastructure); (3) plan for a coastal natural hazard adaptation strategy guided by infrastructure integration and location decisions to attract development and reduce exposure; and (4) Wainwright as a regional oil spill asset staging area and high capacity Incident Command System (ICS) that integrates local knowledge in oil spill response plans.

The illustrative development site plans could serve as both analysis and negotiation tools. Some recommended next steps: (1) Adapt existing (dated) enclave development computer model (MMS 1982) enhanced in a Geographic Information System (GIS), (2) Expand and improve SIC evaluations to include local perceptions of tradeoffs, and a more thorough treatment of climate change impacts, (3) Edit and refine scenario maps to include direct community input, (4) Expand assessment on hazard analysis specific to Wainwright to incorporate factors such as localized erosion, relative sea level rise, and related hazards such as storm surge, and (5) incorporate findings of this report and community feedback to create a plan to prepare for the impending large-scale oil and gas development activities.

## 1. INTRODUCTION

Climate change and global energy demand has the potential to transform the Arctic as melting sea ice increases access to maritime shipping and offshore petroleum development (e.g., Leichenko and O'Brien 2008; Arctic Council 2009; Brigham 2011). Reduced technical challenges from retreating sea ice in combination with increased economic feasibility from shipping cost savings for some routes and global energy demand could precipitate a dramatic increase in overall Arctic maritime activity. Some argue that with the shipping savings alone the Arctic could emerge as the next global economic engine (Backus and Strickland 2008). A recent estimate based on global climate projections (Smith and Stephenson 2013) suggests that reduced sea ice from global warming could significantly increase shipping access by midcentury. Diminished sea ice would also increase access to offshore oil and gas (O&G) development by reducing technical challenges associated with operating in harsh Artic Ocean conditions.

While there appears to be a consensus that the Arctic is likely on the verge of significant change, research on the potential social impacts on Arctic coastal communities is lacking (e.g., Arctic Council 2009). In this study, we contribute to the social impact research while at the same time offering a community-driven development tool that could assist Arctic communities in planning for the impacts. The study develops a set of development scenarios for a community in Alaska's North Slope Borough (NSB), an Alaska Native-controlled US municipality. The development scenarios are driven by hypothetical onshore impacts from offshore petroleum development in the Chukchi Sea, just off of Alaska's North coast (see Figure 1.1). In 2012, the US Bureau of Ocean Energy Management (BOEM) opened over 55 million acres of the Chukchi Sea to 5-year leases for O&G development. The BOEM estimated that there are 28 billion barrels of recoverable oil and 103 trillion cubic feet of natural gas stored in the US outer continental shelf (OCS) (MMS 2006). Exploration is currently underway, and offshore development could occur within decades, presenting a set of development tradeoffs for North Slope communities.

In addition to wanting economic development, maintaining traditional land uses (e.g., subsistence hunting and gathering) is important to many North Slope residents. As with other native communities around the world impacted by global change, North Slope residents seek to maintain traditional and subsistence-based life in the context of mounting pressures from economic modernization and climate change. The indigenous people of the North Slope identify themselves with the ocean, calling themselves Tagiumiut – "people of the sea." Hunting the Bowhead whale not only provides a primary source of nourishment, it is also an important factor organizing social structure, and maintaining community and social identity. Balancing traditional life with development goals in the context of environmental and economic change presents a significant challenge for North Slope Alaska Native communities.

Potentially at the center of onshore impacts from US Arctic offshore development is the City of Wainwright, a NSB settlement of around 550 people located along a wave-eroded coastal bluff adjacent to the Chukchi Sea (see Figure 1.1). Wainwright may be the landfall site for O&G pipelines that would connect offshore reserves to the existing Trans-Alaska Pipeline System (TAPS), located about 250 miles east of Wainwright.

In addition to preparing for O&G and related development impacts, Wainwright is among the many coastal communities in Alaska challenged with planning for the long-term effects of climate change. In Alaska, an estimated 86% of native villages are affected by flooding and erosion (GAO 2003). Coastal erosion and related hazards are of particular concern for North Slope communities as the region has among the highest erosion rates in the world, ranging upwards of 55 feet per year in some locations (Clement 2013). (Erosion rates along coastal Wainwright are much lower than 55 feet per year, ranging from 10 feet lost to 1 foot gained per year. See section 2.4 for Wainwright erosion estimates.)

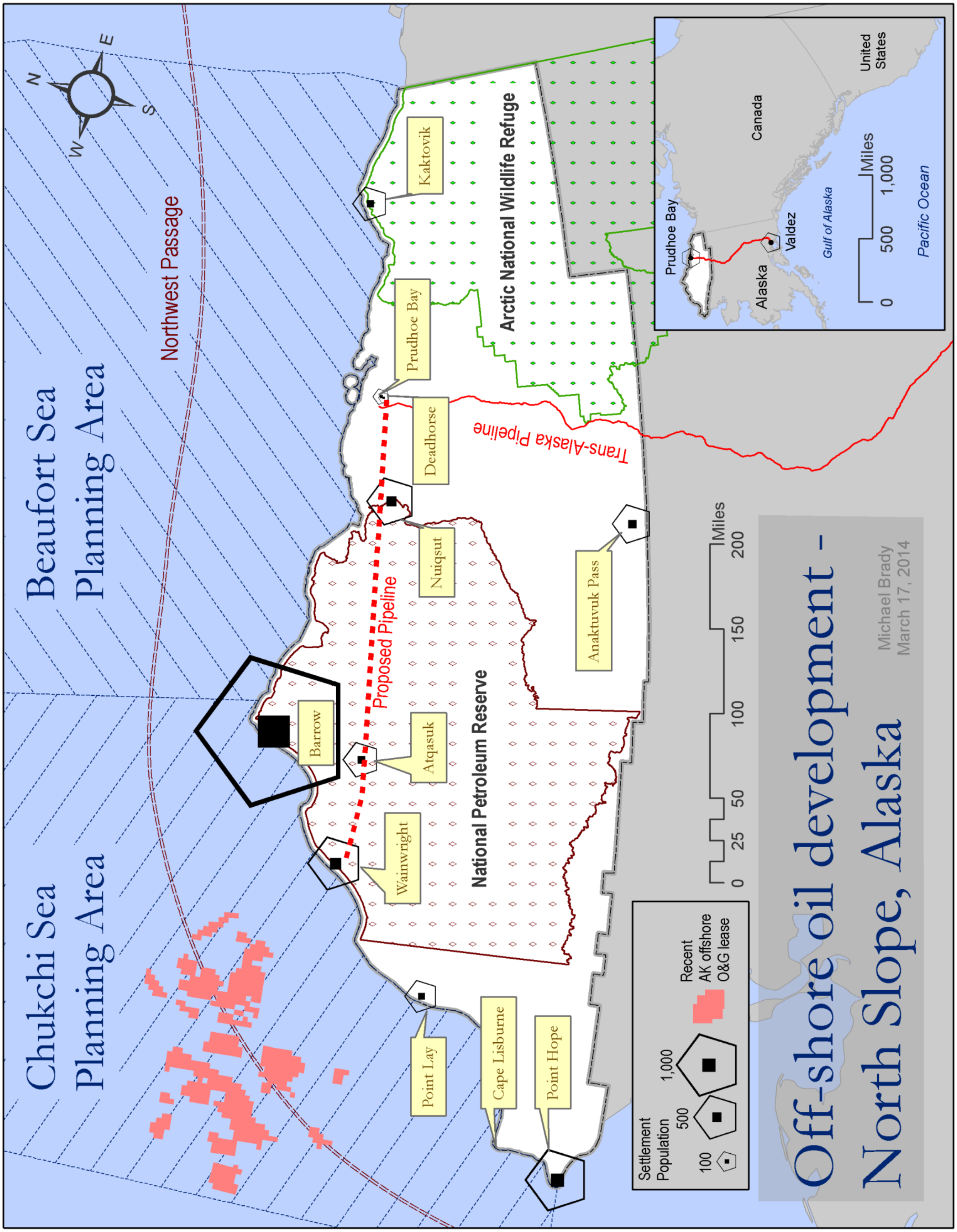


**Figure 1.1.** Arctic Alaska Offshore Oil Prospects Map

This report defines four development scenarios for Wainwright to illustrate conceptual futures in the context of offshore O&G development and climate change (Section 3). Tradeoffs in terms of selected opportunity criteria are identified and analyzed under each of the defined development paths (section 4). Draft scenario site plans are included to illustrate the opportunity analyses. A primary contribution of this study is the conceptualization and an initial description of a “hybrid” development model where Wainwright effectively influences onshore O&G activities through negotiations to meet long-term development goals (see Section 4.4). The Hybrid development model, to our knowledge, has not previously been developed or implemented elsewhere. It is an innovation that addresses local community and industry development that has high potential to be implemented effectively in Wainwright, AK, but also in other comparable villages on the North Slope and elsewhere in the Arctic and beyond.

The development scenarios are distinguished by the degree to which onshore support facilities and activities are integrated with the existing community in Wainwright. We define integration as either shared physical infrastructure or social integration, as in administrative rules that allow interaction between temporary O&G workers and the permanent community. The four scenarios include the Bypassed, Isolated, (fully) Integrated, and the selectively integrated Hybrid model. See Section 3 of this report for expanded scenario descriptions.

Support bases called man camps are typically shipping or flown in as self-contained kits to house project construction/operation workers and provide support activities. Figure 1.2 below illustrates a typical oil and gas support base, or "man camp" development enclave, and associated facilities. In an isolated enclave, the man camp components shown in Figure 1.2 would be entirely separated from a permanent settlement. In an isolated model, the camp is fully removed when operations are completed. Alternatively, a fully integrated enclave would share facilities such as electricity generation, sewage treatment, roads, and housing. While full integration may be undesirable as construction and production operations would likely overwhelm small communities, a completely isolated camp would prevent benefits that the introduction of local economic activity from services demanded by workers and infrastructure would offer. We argue that selective integration of infrastructure and economic activities associated with the man camp would provide net benefits to the community by improving development opportunities and limiting harmful effects that would accompany a fully integrated model. We call this partially integrated approach the Hybrid model, where selected man camp facilities and activities are integrated with a nearby community to promote development and long-term sustainability.

Three innovative factors distinguish the Hybrid model from the other scenarios. First, we propose that temporary facilities established for the project construction phase be separated from the community, but be designed with the intent to repurpose the facilities for community use after construction is completed. Second, some camp activities can be "pulled-out" to allow local business activities, such as a movie theater and commissary run by the host community. The third factor involves sustainable development options that become viable when the introduced camp is viewed as an opportunity to develop the permanent community. For example, installing shared renewable energy infrastructure designed to be transferred to the community after the construction phase would provide a sustainable low cost energy supply alternative. Reduced energy costs would support other innovative opportunities for the region such as introducing indoor agriculture. In Section 3 of this report, we explore some opportunities that would accompany a hybrid development scenario. More research is needed to fully explore the possibilities that partial integration could offer and to understand how they are interdependent and mutually reinforcing, and therefore potentially present viable alternative development pathways.

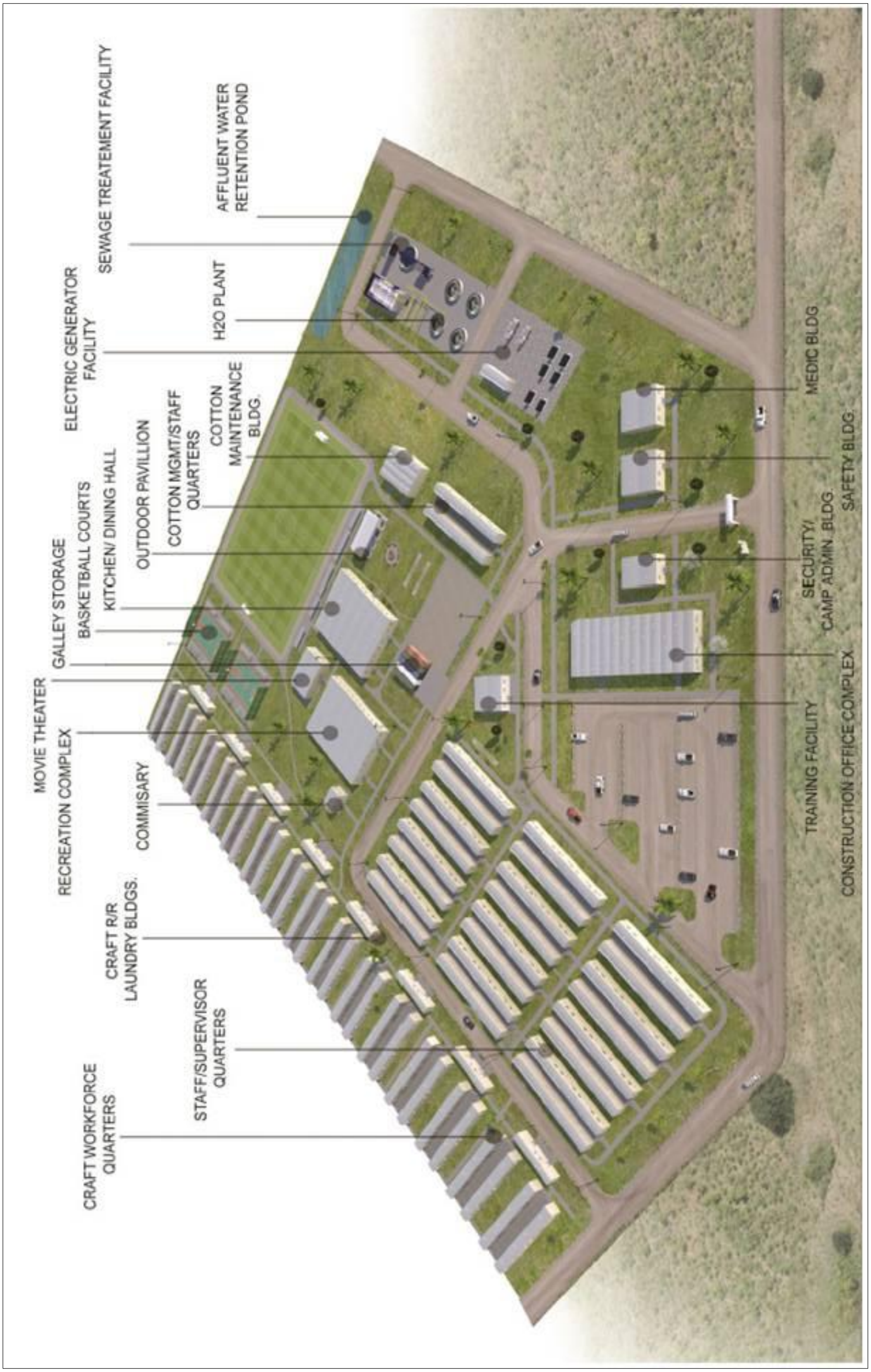


**Figure 1.2.** Typical Man Camp (Source: Linked Strong Services)

## 2. STUDY AREA

The City of Wainwright, Alaska is a small Iñupiat settlement with a population of around 550. Land in the immediate area is native-owned or -controlled as shown in Figure 2.1 below.

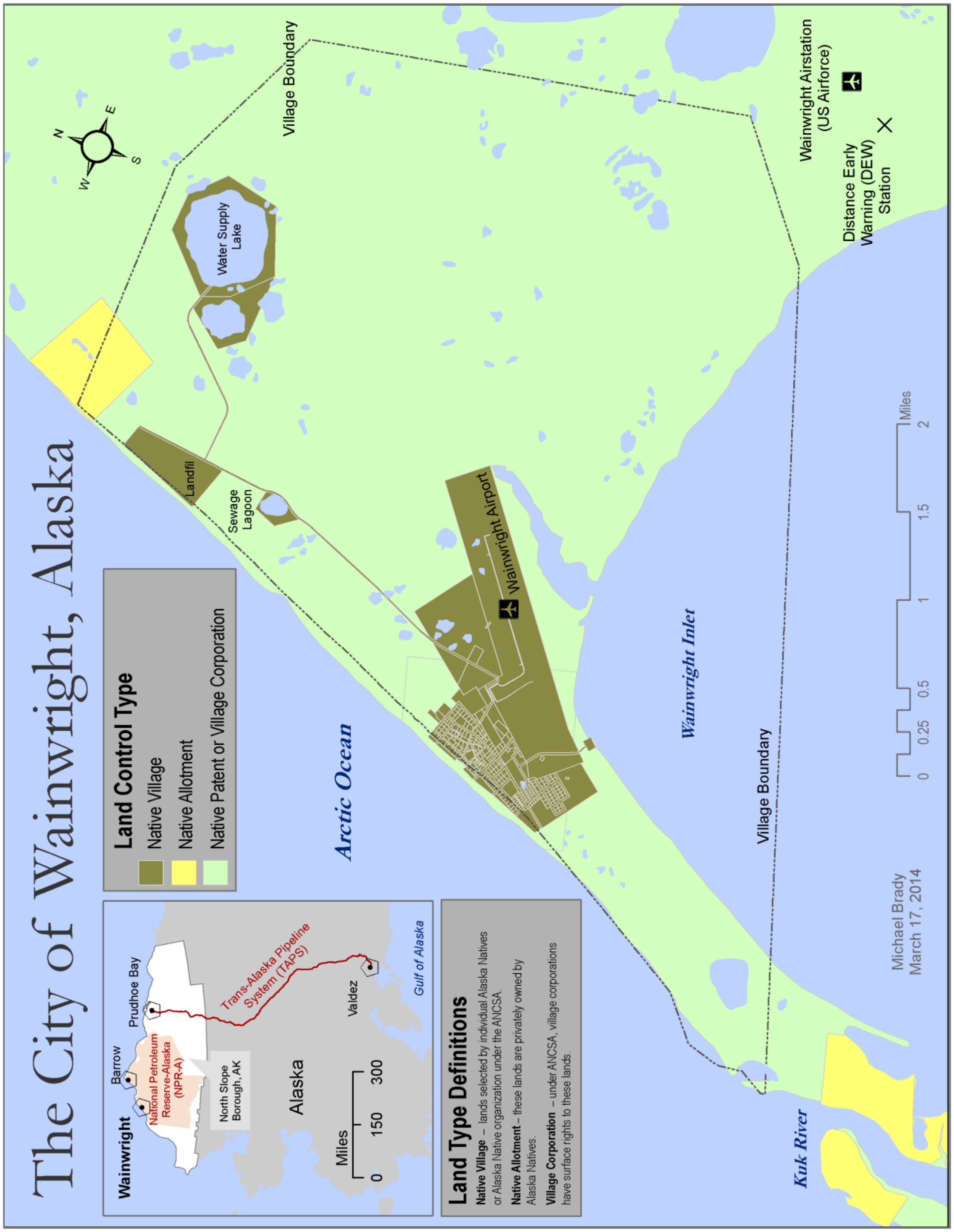


**Figure 2.1.** Study Site – Wainwright, Alaska

Wainwright's village corporation, Olgoonik Corporation (OC), has the surface rights to 115,200 acres of federal land within the area (NSB 2005). According to the NSB (2005), in 2005 111,489 acres were patented to the OC, with the remaining 3,771 acres of entitlement remaining. Below is summary information on these land control types.

- *Native Village* - defined in 42 USCS sec 2992c, is land under the jurisdiction of an Indian tribe recognized federally or by a state or any lands selected by individual Alaska Natives or Alaska Native organization under the ANCSA. Native Village lands in Figure 2.1 are controlled by the federally-recognized village tribe of Wainwright called the Native Village of Wainwright.

- *Native Allotment* – these lands are privately owned by Alaska Natives. Until 1971 with ANCSA, individual Alaska Natives received up to 160 acres of vacant land, Authorized under the Native Allotment Act of 1906,.

- *Village Corporation* – under ANCSA, village corporations have surface rights to these lands.

*Management Context*

Wainwright is located within the U.S. National Petroleum Reserve – Alaska (NPR-A) and its city limits are contained entirely within the North Slope Borough Coastal Zone. The NPR-A is operated by the Bureau of Land Management (BLM), which is authorized to lease the reserve's land for O&G exploration and development (see BLM 2013). The areas within the coastal zone are subject to the requirements of the North Slope Borough Coastal Management Program (NSB CMP). The NSB CMP, in addition to other Borough management tools (e.g., comprehensive plans), help resolve land use conflicts and promotes balanced, long-term development (see, e.g., NSB, n.d.).[1] As the focus of this report is on long-term development outcomes, the CMP in this report is considered a main source of capacity (in addition to village, city, and local corporation land ownership and control) for Wainwright and the NSB to negotiate opportunities with shore-side O&G development and mitigate potential harmful effects. Other important sources of potential leverage (e.g., political) are not focused on this report; this analysis focuses exclusively on the opportunities in the planning process.

The village tribe of Wainwright is a federally recognized tribe called the Native Village of Wainwright and is governed by the Wainwright Tribal Council. The local Alaska Native Claims Settlement Act (ANSCA) village corporation is the Olgoonik Corporation.

## **2.1.** Physical Profile:

The arctic village of Wainwright sits on a relatively flat bluff 50 feet above sea level facing the Chuckchi Sea on the northwest coast of Alaska. Wainwright is 90 miles west of Barrow, Alaska, the largest town in the North Slope Borough, and is not connected to Barrow or any other communities by a road system. Wainwright encompasses 17.6 square miles of land and 24.9 square miles of water. The village is exposed to water and ice erosion caused by coastal hazards and melting permafrost. Permafrost is soil that remains at or below the freezing point of water for more than two years; the permafrost of the North Slope remains from the previous Ice Age. During the summer months on the North Slope plain, permafrost melts an

[1] The methods in the current project may provide an additional tool to increase NSB capacity for coastal management.

annual average of 1-5 feet in depth from the ground surface, resulting in marsh-like conditions (URS Corporation, 2005). In conjunction with land-side summer ice melt, these boggy conditions pose a serious development constraint for future growth in the area.

Temperatures in Wainwright range from -56 to 55 degrees Fahrenheit and remain below freezing for nine months of the year. The village receives an average of 5 to 8 inches of rainfall and 20 inches of snow annually. These dry but frigid conditions classify Wainwright environment as arctic tundra, a desert-like, cold climate. Though average yearly snowfall is low, snow and ice cover the area from September to early June. The sun does not rise above the horizon from November 18th until January 24th, and it does not set from May 10th until August 2nd due to the proximity to the North Pole.

**2.2.** Wainwright Utilities and Select Existing Infrastructure:

***Dwelling Units -*** According to the 2010 U.S. Census, Wainwright had 179 housing units, of which 147 were occupied and 32 were vacant (7 of those list as vacant had only seasonal use). Of the 179 dwelling units, 99 (~67%) were owned and 48 (33%) were rented.

***Airport*** - The Wainwright airport (AIN) is similar to most rural communities in Alaska, transportation takes place mostly through a local airstrip. The airport in Wainwright is undergoing expansion but it is not large enough to accommodate large cargo planes required to deliver materials for O&G development. Hangar and storage space would need expansion for anything exceeding the present usage.

***DEW Line Station -*** The DEW (Distant Early Warning) Line Station is situated about 4 miles east of Wainwright at the mouth of the Kuk River and is not usually connected to the village by road (during some winters, an ice road is built to connect the village with the DEW station). The station was built in 1956 as part of a system of radar stations throughout the Arctic Circle for the purpose of detecting incoming Soviet Bombs during the Cold War. The Wainwright Station was in operation until 1993, at which time it was converted to a North Warning Station, part of a surveillance radar system for the atmospheric air defense of North America. The site contained an airstrip of comparable size to the current Wainwright airstrip, a command center, and residential accommodations for the workers that manned the station. In 2007, the federally-owned station was decommissioned.

***Port Communities*** on the North Slope receive barged shipments of non-perishables such as building materials and diesel fuel. This transportation is slow but able to transport large and heavy cargo that cannot travel by air and is less expensive than air. Development may necessitate additional shipments and more barge traffic. Wainwright anchorage can accommodate vessels with a draft up to 60 feet and the Wainwright inlet can only accommodate vessels with a draft of less than 10 feet. There is no dock or pier indicated in the North Slope Subarea Contingency Plan (Alaska Department of Environmental Conservation 2012).

Like other North Slope villages, Wainwright is not connected to a regional road system, so travel and shipments in and out are coordinated by air or sea. Transportation in Wainwright currently meets the needs of the town, but would require significant changes potentially including a port to accommodate larger vessels and a larger airport to support pipeline construction and operation.

***Water Supply*** – Wainwright's primary water source is located approximately 3 miles northeast of town at Merekruak Lake. The current water system was constructed in 1998 by the NSB. The water system treats and distributes water both piped (by way of above ground pipeline transmission) and delivered by truck to the town (URS Corporation 2005). Water must be piped through above-ground transmission methods to insulate it from freezing. Most heavy infrastructure must be elevated above ground to avoid structural problems associated with melting permafrost (summer months) and extreme freeze in the remaining months.

According to the 2010 census report, all homes in Wainwright have running water in some capacity. Currently, 9% of the population still receives their water by delivery. Homes typically utilize 250-gallon water tanks, and homes that require water delivery require so every 4-8 days. The average cost of water per month is $69 (North Slope Borough 2011).

Fire control assets in Wainwright include a fire station, a pumping apparatus including a pumper/water tender, and 22 fire hydrants (URS Corporation 2005). The station is equipped with fire trucks and an emergency ambulance. The pumper apparatus and tender are collectively capable of pumping 2,000 gallons of water per minute (Steurmer 2005, cited in URS Corporation 2005). Wainwright currently has 22 fire hydrants. However, at an average distance of more than 500 feet apart they do not meet International Fire Codes (Steurmer 2005, cited in URS Corporation 2005). Additionally, water pressure in Wainwright currently does not meet requirements to handle a large-scale fire (URS Corporation 2005). Therefore, expansion of the fire hydrant system to meet, at a minimum, International Fire Codes is an immediate need in order to accommodate any level of growth.

***Sewage*** - The most recent data regarding sewage in Wainwright is from 2003. According to the North Slope Borough Wainwright Village Profile, 93% of Wainwright households had flush toilets hooked up to sewer lines; the remaining homes use holding tanks that are require draining (North Slope Borough 2011). The sewer utility is run by the North Slope Borough. The authors of this report were unable to confirm exactly how wastewater is treated in Wainwright, but according to the URS Corporation (2005), wastewater is treated at a nearby treatment plant located one and a half miles away from town and discharged into the Kuk River. According to the land use parcel data made available by the North Slope Borough, the village has a sewage lagoon (see Figure 2.1), suggesting that wastewater is treated on land before being discharged into the ocean. This suggestion is consistent with a dated U.S. Environmental Protection Agency report (Puchtler et al. 1976). More research is needed to confirm Wainwright's wastewater treatment practices.

***Solid Waste*** - Solid waste is disposed of in a nearby landfill northeast of Wainwright. The landfill is only estimated to be a viable site for solid waste disposal for another 7-10 years (URS Corporation 2005). This timeline does not anticipate any future development which would shorten that time. Siting of a new location for a new landfill or expansion of the existing site is an immediate need to sustain future growth and even to maintain status quo.

***Power*** - Approximately 97% of homes in Wainwright are heated by diesel fuel. Most homes own personal back-up diesel generators; the local power plant is also diesel powered. In the arctic, back-up generators are a vital necessity, for, if the primary source of heat or power fails, then this breakdown could prove fatal. Power from the plant is then transmitted to homes by above ground line transmission. The average electric bill in Wainwright is $180/month, and an additional $200/month is spent on heating. Diesel must be barged into Wainwright during the summer months and stored in above-ground tanks. The process of transferring fuel from the barge and storing the fuel in tanks creates increased spillage risks (URS Corporation 2005).

An increase in population and visiting workers with significant land-side O&G development would require significant investments to make transportation, water, electricity and landfill meet the higher demands.

**2.3.** Social and Economic Profile

Wainwright's total population is 546 with an equal proportion of males to females and an average age of 35 years old. The municipality is a mostly indigenous, with less than 6% listed as non-Native (mostly Caucasian with a small fraction listed as "other minorities"). Only 35.9% of Wainwright citizens hold a high school diploma or have attained a higher level of education. The number of fluent Inupiaq speakers is down drastically from 154 in 2003 (North Slope Borough Census) to 65 as of the 2010 census (Wainwright 2010 Census Snapshot).

Approximately 92% of the households in Wainwright engage in the local subsistence economy, although there has been a decline in the number of households that rely on a steady diet of wild foods.
Active participation in the subsistence economy requires ongoing time and resources investments throughout the year for fishing, hunting, and marine harvesting. Subsistence activities are supported by and balanced with wage work. The subsistence economy is mostly ocean oriented; seals are hunted all year and bowhead whales are harvested in the spring and summer. The mean household expenditure on subsistence activities is $4,504 with a median expenditure of $2,500 (URS Corporation 2005).

Wainwright native residents receive revenue from development and oil transportation on native lands through three sources: the Olgoonik Corporation (OC), the local ANSCA village corporation; the Arctic Slope Regional Corporation (ASRC), the native regional corporation of the North Slope; and the Alaska State Permanent Fund Dividend (PFD). These funding sources decide dividend dollar amounts to pay shareholders and how much to re-invest in the corporation or allot for village services.

The Alaska Native Claims Settlement Act (ANCSA), established in 1971, gave village corporations such as the OC surface rights and the native regional corporation, ASRC, subsurface rights in the NRPA. This arrangement would allow OC to receive lease payments for O&G land uses, but the regional corporation would collect tax revenues from product development, which would then be divided annually among the 12 regional corporations per ANCSA Section 7(i).

Most native residents of Wainwright are shareholders of the village corporation – the Olgoonik Corporation (OC). The mission statement of the Olgoonik Corporation is "[t]o engage in profitable business activities that will enable the corporation to provide training and employment opportunities for its shareholders while protecting the land and maintaining Iñupiat culture, traditions, and values" (OC n.d.). Like many other corporations, the OC bids for project state, national and global contracts, though they are also eligible for bidding through the minority contractor provisions on federal contacts. Like any other corporation, profits are distributed to shareholders as dividends or re-invested in the company. However, unlike other corporations, OC interests are largely aligned with general interests of the community within which they operate, as most community residents are shareholders. (This coupling between corporation activities and general community welfare is also found in the other NSB villages.) Through the potential for higher dividends and more local jobs with higher corporation capacity, residents benefit from projects secured by Olgoonik. While residents may be generally concerned about potential harmful non-traditional land use (e.g., O&G development) impacts on traditional uses, increasing dividend amounts and village development through State, ASRC, and OC projects generates some resident support for such activities.

Traditional land use interests in the village are represented by the Wainwright Tribal Council under the ANSCA. To support Tribal Council decision making, the NSB maintains a database of subsistence uses by coordinating village liaisons who administer data collection programs. Goals of the traditional land use database program include monitoring and documenting development impacts on subsistence activities, and identifying potential land use conflicts.[2]

*Wage Employment*

The 2006-2010 American Community Survey (ACS) estimated 326 residents as employed. The ACS identifies wage and self-employment, but does not consider subsistence activity or other unpaid activity, and the majority of Wainwright residents engage in subsistence and related work. In the formal economy captured by the ACS, the local unemployment rate was 32.9% and the underemployment rate was 39.8%. (Rate of underemployment is comprised of persons with some employment working less than 40 weeks). The percentage of workers not in the labor force was 30.9%. The ACS surveys established that average median household income (in 2010 inflation-adjusted dollars) was $65,156 (~ +/-$4,569). The per capita income (in 2010 inflation-adjusted dollars) was $19,395 (~+/-$3,162). About 11.4% of all residents had incomes below the poverty level.

The 2010 census notes that most income in Wainwright is derived from wages and corporation dividends. The median per capita income in 2009 was $28,000. The median per capita income disparity is stark; the median income for Iñupiat individuals was $25,200 and $72,000 for others. Eighty-five percent of Wainwright households received dividends from the Arctic Slope Regional Corporation (ASCR) and/ or the Olgoonik Village Corporation. The average amount per household was $24,062.

Three major employers in the village provide for 76% of jobs; they are the North Slope Borough (28%), North Slope Borough School District (26%), and Olgoonik Corporation and its subsidiaries (22%). Other employers in Wainwright are the government and the Wainwright Co-op Native store

## **2.4.** Coastal Hazards and Climate Change

*Coastal Hazards*

***Storm Surges*** - Storm surges threaten homes and infrastructure in Wainwright (North Slope Borough Risk Management Division 2005). The North Slope storm of record on October 3, 1963 created a surge of 11-12 feet in Wainwright, damaging homes and buildings, and leaving 50% of the city flooded (North Slope Borough Risk Management Division 2005). Significant historical surge impacts include a storm in 1986 that

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[2] A goal of this project was to map sensitive habitats, and build this information into the impact analysis. However, the Studio was unable to access subsistence data detailed enough for an impact analysis as these data are highly sensitive and regulated. Using very coarse publically available data and information from the North Slope Subarea Contingency Plan of May 2012 (Alaska Dept of Environmental Conservation 2012), the studio developed a habitat map with the intent to identify locations with the least harmful impact from industrial development. Based on this limited data, the north-west direction was identified as having the fewest conflicts with wildlife. The map of wildlife ranges for the subsistence economy is in Appendix 6.1. More work is needed to better map this important decision-making consideration. While restricted, extensive subsistence data for the NSB exist (see e.g., Braund and Kruse 2009).

left four homes hanging over the coastal bluff edge and a 2008 storm, which destroyed several ice cellars (Army Corps. of Engineers 2008).

***Coastal Erosion -*** Coastal erosion undercuts existing infrastructure such as roads, houses and critical utilities, and over time increases the potential for flooding during storm surge events. Estimated coastal erosion annual rates averaged for the years 1949 to 2011 range from 3 meters (~ 10ft) coastline lost to 0.3 meters (~1ft) of coastline gained per year (email comm. USGS staff, July 24, 2013; Gibbs et al. 2011). The NSB reported in 2005 that in Wainwright two homes and a coastal road in addition to utility infrastructures that parallel the road were [immediately] threatened by erosion (North Slope Borough Risk Management Division 2005). The infrastructure that runs along the shore includes a direct-bury sewer system constructed in the late 1990s (USACE 2008).

***Oil Spills*** - Threat of large-scale and profuse small-scale coastal oil spills in the Chukchi Sea is a future hazard for Wainwright that will come with off-shore oil development.

*Coastal Hazard Mitigation Strategies*

Following climate adaptive responses (see e.g. Dronkers 1990), natural coastal hazard mitigation strategies can be categorized as three types – protection, accommodation, and retreat. Strategies in Wainwright to manage coastal erosion and flooding currently (and historically) focus on protection measures, including "soft" (e.g., beach nourishment) and "hard" (i.e., coastal armor) infrastructure to defend from natural coastal threats.

After severe storm damage in 1986, the NSB began researching ways to protect the villages from coastal erosion in Barrow and Wainwright. After a detailed study of flood protection options, in 1989 the NSB reported that a beach nourishment program would be the most cost effective strategy (NSB 1989; NSB 1997). The nourishment program involves creating a sacrificial beach along the coast using dredged offshore material to provide a buffer zone for erosion and to dissipate storm wave energy (BTS/LCMF 1995; NSB 1997; USACE 2008).

In 2005, a sea wall using locally sourced materials (i.e., a cage, or gabion, filled with rocks and other local earth materials) was placed along the shore to protect the sewer system, but the wall was found to be structurally inadequate against storms and received substantial damage from a 2008 storm (USACE 2008). In the summer of 2013, the gabion wall was replaced with a 19 foot high rock sea wall with funds authorized by the Federal Emergency Management Agency (FEMA) following a disaster declaration from a 2008 storm (NSB 2012). According to The Alaska Contractor (2012), the Wainwright sea wall reconstruction cost around $9.5 million.

*Climate Change*

Like other Arctic coastal communities, Wainwright is sensitive to climate change including effects from melting sea and land ice and permafrost, rising sea levels, and increasing rates of coastal erosion. Below is a brief discussion of climate sensitivities that impact coastal erosion and sea level rise hazard.

- Melting sea ice – sea ice along the North Slope mitigates ocean wave energy that contributes to coastal erosion. As sea ice recedes, erosion potential increases with loss of natural protection that the sea ice provides to the North Slope coast during storms. Permafrost melt exacerbates erosion, e.g., as ice wedges melt and large blocks of land are lost (see Walker 2013).

- Sea level rise – rising average sea levels along the North Slope increase coastal erosion and flood potential.

***Erosion Projections*** – the authors of this report are unaware of any erosion projections for the North Slope that attempt to account for climate change. Erosion rates could increase or decrease by location depending on the effects of permafrost melt, changes in coastal storm intensity, duration and frequency, and the existence and performance of coastal protection structures. Historical rates, while not a reliable indicator of future conditions, could be used to identify areas with highest rates of erosion, allowing some rough projections. To avoid the assumption that historical erosion patterns are a reliable indicator of future rates, the current project uses a recent North Slope average of 1.6 meters (~5ft), as an illustrative erosion rate that can be extended to other coastal villages in the region. At this rate the development scenario maps show a setback distance of 526 feet from the present beach to accommodate a 100-year horizon for erosion only.

***Sea Level Rise*** – the authors of this report are unaware of any reliable sea level rise estimates specific to the North Slope. Globally, the International Panel on Climate Change (IPCC 2007, Brubaker et al. 2010) estimates a minimum global sea level rise will be between 0.6 to 1.9 feet within 80 to 90 years, but these estimates could be overly conservative (e.g., Clark, P. et al., 2008, cited in Brubaker et al. 2010). In general, some scientists expect sea level rise to be greatest in the Arctic (Walsh, J. 2005, Brubaker et al. 2010). Relative sea level rise could be exacerbated (or offset) by regional and local subsidence (or bulging) from geological factors and land use practices such as oil and water extraction.

In 2010, Sultan et al. (2010) reported no significant trend in changes in sea level, storm frequency, duration and intensity by analyzing a tide gauge located at Prudhoe Bay, Alaska (located in the North Slope). The gauge had been collecting water surface elevation since 1993 (NOAA, n.d.). However, the 16.8 years of tide data available to analyze was insufficient to make definitive regional climate change conclusions (Sultan et al. 2010).

## 3. METHODS

Four conceptual development scenarios are defined for Wainwright. As noted in the Introduction (Section 1), the purpose of the scenarios is to provide a way to compare and evaluate tradeoffs that accompany the many development possibilities. The tradeoffs of focus in this report include three sometimes competing opportunities: (1) mitigate coastal hazards, (2) support community well-being, and (3). promote infrastructure development. Scenario definitions are included below, and Section 4 provides opportunity analysis results for the four scenarios.

The scenarios are distinguished by distinct growth trends that may occur in the context of O&G development and climate change. The first scenario (i.e., “bypassed”) provides a close-to-baseline picture of Wainwright with only indirect impacts from oil development, but still threatened by long-term planning challenges such as coastal erosion. This scenario is based on a potential outcome where Wainwright does not receive a pipeline, but is still exposed to the coastal hazards described above in Section 2.2.

The remaining three scenarios: “isolated,” “integrated,” and “hybrid” are based on select development adjustments that illustrate potential negotiation outcomes. The first three scenarios are intended to provide insight into social impacts (both positive and negative) associated with integrating and isolating various O&G project development elements. These scenarios inform a “hybrid” scenario where the aim is to maximize benefits and limit negative impacts.

To gain insight into how Wainwright (and other North Slope villages) may be impacted by oil development under the various scenarios, locations that have already experienced oil development impacts were researched. In this section, this information source is referred to as “analogous cases”.

Nine impact criteria organized broadly under three categories – coastal hazard mitigation, infrastructure investment, and community well-being - were defined and used to evaluate and compare the scenarios. (Impact criteria descriptions are in Section 3.5.) The evaluation focuses on opportunities under the four development scenarios. While not exhaustive, the tradeoffs presented in this report allow an analysis of how these important social impacts interact, and in this way provide a framework for comparing potential development outcomes.

Site plans were created to illustrate the four development scenarios. "Natural" coastal hazards and climate change are accounted for in the maps by including illustrative erosion trend lines for 50 and 100 years into the future. The erosion rates are based on a recent North Slope average of 1.6 meters per year as detailed in the above section, “Climate Change” (AMSS 2013). The maps are the same as the analysis maps noted above.

There is limited coastal hazard and climate change information available for Wainwright. The current project only accounted for erosion as one climate change variable among many that should be incorporated into local planning. A full assessment would expand on the hazard analysis to incorporate factors such as localized erosion, relative sea level rise, and related hazards such as storm surge . Reliable information for these factors is lacking, so our project serves as a starting point for such research in the context of scenarios planning.

**Table 3.1.** Scenario Descriptions

| Scenario Name | Scenario Description (Report Section) | | Opportunity Analysis Section |
|---|---|---|---|
| Bypassed | No pipeline – offshore O&G is transported to market by federal waterway. | (3.1) | 4.1 |
| Isolated | Wainwright receives pipeline, but construction and operations are completely separated, located in a self-contained enclave. | (3.2) | 4.2 |
| Integrated | Wainwright receives pipeline, and both O&G project construction and operations are fully integrated with the community. | (3.3) | 4.3 |
| Hybrid | Wainwright receives pipeline, and select O&G project construction and operation components are integrated with the community. | (3.4) | 4.4 |

### **3.1.** Bypassed Scenario Description

In the bypassed scenario, offshore oil is developed and shipped to market through federal waters, with no land-side pipeline connecting to TAPS. While there would be no pipeline construction and maintenance directly impacting Wainwright, Wainwright could receive offshore support facilities and operations including facilities for crew transportation, and expanded U.S. Coast Guard operations (i.e., search and rescue and oil spill and chemical release response).


**Figure 3.1.** Bypassed Scenario Map

*Potential Impacts*
If offshore O&G is not transported by a land-side pipeline, there may be an intense but only short-term increase in local marine and air traffic during offshore construction and operations, thus increasing Wainwright's exposure to oil spills. Though unlikely, this level of traffic may bring a secondary population growth to Wainwright to support the offshore O&G development. For example, migrants may come from outside to support hotels, restaurants or other commercial interests required on a temporary basis. With little certainty as to numbers or duration of activity in Wainwright, it would be difficult to plan for this kind of growth.

In the Bypassed Scenario, Wainwright would potentially have fewer opportunities to negotiate with O&G companies for facilities or financing because it would not be directly involved with oil production or transportation. However, we assume that Olgoonik and/or other village corporations and ASRC would secure some contracts to support the offshore operations, but local stakeholder negotiation positions to influence land-side development is viewed as very limited in this case.

This scenario offers few direct financial benefits to Wainwright. Although the Olgoonik Corporation may secure contracts for construction or related works, given its remoteness and size it is unlikely that the city will achieve many economic interactions with the development. Additionally, business competition with Barrow to the north would contribute to limited economic opportunity.

Potentially harmful impacts include diminished ecosystem health and human health and well-being from due to high potential for more oil spills due to increased maritime and air traffic. No direct efforts are made to mitigate exposure to coastal hazards.

*Analogous Cases*
Two small coastal Alaska communities with erosion problems – Shishmaref and Newtok - illustrate the financial challenges of supporting a "retreat from erosion" adaptation strategy with no direct local oil development impact.

Shishmaref is an island community located in the Chukchi Sea with a population of roughly 600 people. Erosion is a major concern for this community, and the location is susceptible to severe coastal storms that exacerbate the problem. For example, a 1997 coastal storm eroded over 30 feet of the north shore (Christdoulou 2012). The town voted to relocate 18 miles away on the Alaskan mainland after several homes were damaged due to ongoing erosion that shows no signs of slowing down. The Army Corps of Engineers projects a cost of 95 million dollars (Bronen 2013) and relocation efforts have been stalled due to a lack of federal funding (Cochran 2007). The Mertarvik Relocation Report (Newtok Planning Group 2011) lists funding collected from multiple public and private agencies.

Newtok is a slightly smaller community than Wainwright with a population of approximately 350 residents. Newtok is surrounded by a river and borders the ocean; erosion and flooding from both bodies of water led the town to undertake a relocation project. As in Wainwright, thawing permafrost has also played a part in erosion in Newtok. The town recognized the possible need for relocation as early as 1994 (Gregg 2010), but was forced to negotiate a land agreement with the U.S. Fish and Wildlife Service regarding the new community location. The project had preliminary cost estimates between $80-130 million (Gregg 2010), roughly $228,000 to $371,000 per person. The initial move was scheduled for 2011, though now the process is stalled, planning a community emergency shelter and looking for funding while it plans a slow transition to the new location and the challenges of revitalizing the independent nature of the native subsistence culture (Newtok Planning Group 2011).

While erosion risk in Wainwright is currently not as high as the above communities, the problem could worsen with climate change and continued coastal development. The examples of Shishmaref and Newtok demonstrate that it is better to be proactive than reactive; their financial and logistical challenges have caused delays and a distressing sense of urgency. Wainwright and other villages in the North Slope have the advantage of time and potential investment opportunities from oil development to effectively plan for and implement relocation possibilities.

**3.2.** Isolated Scenario Description

The isolated (or enclave) development scenario assumes that petroleum projects are almost completely separated socially and functionally from the existing community. In anticipation of potentially negative social impacts, isolation of work camps will minimize adverse effects on the local subsistence communities. Oil and mineral extraction projects require large infrastructure and are labor intensive, thus inundating the host area with large numbers of workers for construction and operations. If O&G projects are located within an existing village, they will likely over stress existing livelihoods, facilities and services. For these and related reasons, physical infrastructure is separated to avoid having to integrate construction and maintenance, which would decrease flexibility and autonomy of both the operation and village planning.

To limit social impacts, some oil development projects follow the enclave model, where workers rotate on a shifting basis to work camps near to the industrial operation. The camps are self-sufficient, and residents are separated either by distance or other administrative means to be socially separated (e.g., village access restrictions). In the case of Wainwright, a combination of both distance and administrative means would buffer the O&G activity from the existing community in an isolated, enclave scenario.

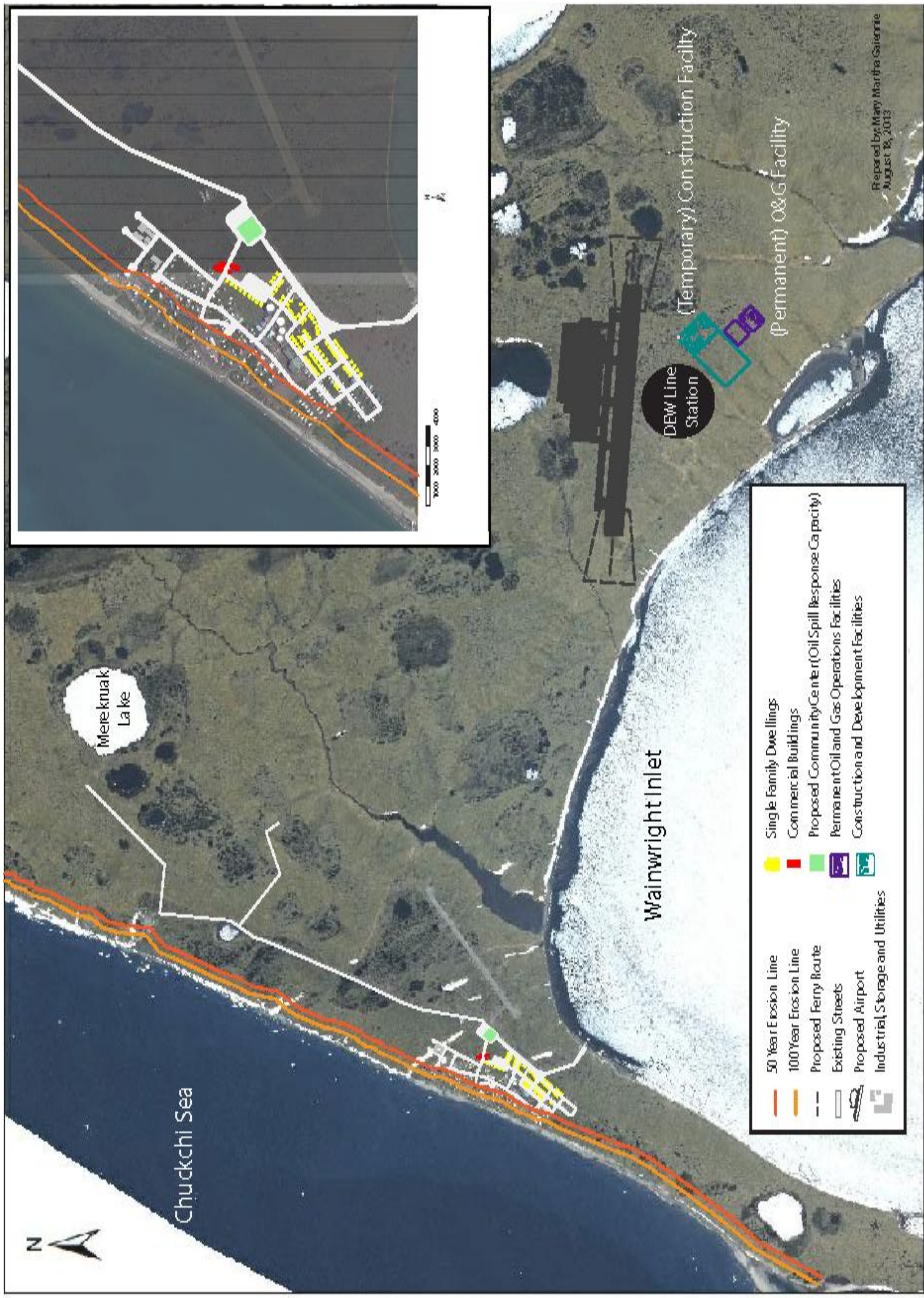


**Figure 3.2.** Isolated Scenario Map

*Potential Impacts*
This scenario assumes the installation of a pumping station where the pipeline would come ashore, but with the location outside of Wainwright's land rights and far enough away to avoid direct social interaction.

As a hypothetical condition, this scenario assumes almost full social isolation of petroleum projects, which is not realistic. Even with distance and rules in place, there is usually at least some interaction between existing communities and project operations, such as local employment, shared roads, and regional transportation.

While taxes would not be paid to Wainwright, the community would still receive monetary benefits from royalties paid to the ASRC and the State of Alaska brought back to Wainwright in the form of state and borough services.

It is likely that a pipeline from the Chukchi Sea would pose moderate to high levels of interference with Wainwright subsistence activity in the ocean and on the land, so harmful impacts are assumed. Additionally, significant threats to ecosystem health and human health and well-being are also assumed in this scenario from the potential for oil spills and increased maritime and air traffic.

*Analogous Cases*
The Prudhoe Bay operation on the North Slope is an example of a somewhat isolated operation, though it is not completely without social impact. In addition to displacement of aboriginal settlers who occupied the site, negative and positive social impacts range from regional subsistence resource habitat disruption and reduced access to hunting grounds to borough-wide impacts from revenues received by the state, borough, and localities through land use taxes and transportation royalties.

Two operation camps in North Dakota, Capital Lodge and Tioga Lodge, are examples of how an isolated camp can affect the local community. In both cases, the camps had their own water supply and waste treatment facilities. Although the camps were isolated, there were still impacts on the community. The main complaints include: cluttered views, overburdened emergency services, and traffic jams (Sulzberger 2011).

**3.3.** Integrated Scenario Description
In the integrated scenario, land-side physical infrastructure and personnel to support off-shore development are fully integrated with the existing community. Unlike in the isolated scenario, camp facilities are not self-sufficient, but instead share utilities, roads, community spaces and governance with the village. Additionally, there is free interaction between oil workers and the local population. To the direct benefit of Wainwright, new medical facilities, police force and jails, recreation facilities, and other resources may be shared between the town and camp employees. Both new construction and retrofits of existing infrastructure are assumed in the integrated scenario.

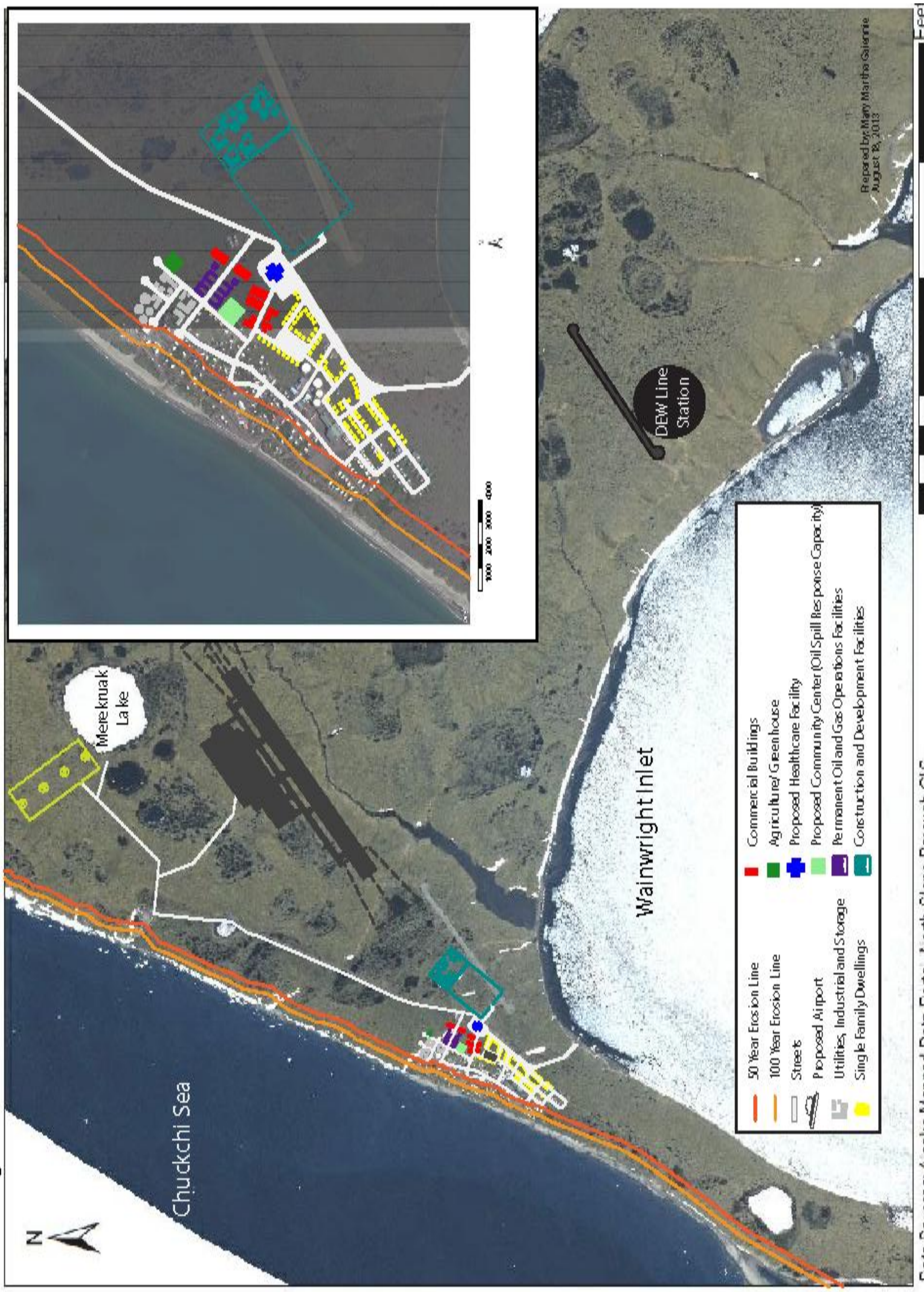


**Figure 3.3.** Integrated Scenario Map

*Potential Impacts*
While full integration would likely have damaging social effects on the existing community and/ or the local subsistence economy of Wainwright, levels of integration could benefit the community by enhancing the cash economy and related social opportunities. Partial integration is a theme explored in the Hybrid Scenario described in Section 3.4.

It is important to highlight that though the cash economy would be bolstered by incoming development, the effects are not lasting. It is suggested that policies be written to encourage local entrepreneurship by encouraging locals to provide services to the O&G development that would normally be provided in house.
.
The large scale construction of oil and gas operations would have the initial effect of fueling the local economy beyond its natural capacity. However, once the migrant workers leave as the construction phase is completed, local economic activity in Wainwright would experience a negative shock as services demanded by the construction phase discontinues. The impact from the shock would depend on the degree to which the local economy becomes dependent on temporary economic activity in support of project construction.

*Analogous Cases*
There are examples of the integrated scenario in the United States, Canada, and Australia, providing some insight into the social impacts. In general, this scenario has large negative impacts on existing communities, but economic opportunities tend to be high but not lasting.

The Eagle Ford camp at Carrizo Springs, Texas has negatively affected the local community by causing housing rents in town to increase, as well as increases in theft and traffic accidents, more lunchtime traffic and more hotels. Women specifically have complained about harassment from the men living in the 'man camp'. However, the integration with the community brought many jobs to the previously impoverished local community (Cerna 2013). In Canada, the camp at Fort McMurry experienced increased growth that put demands on medical and other social services that exceeded local capacities. These negative impacts were partly caused by lack of overall planning and funding (Storey 2010). A camp located in the Surat Basin in Queensland, Australia had mostly negative effects on the local community including making housing unaffordable or the local population, and a lack of appropriate infrastructure and services (Storey 2010).

The social impacts found in the above examples of integrated camps are similar in most mixed communities, though these negative impacts are by no means the only effects felt by host communities.

**3.4.** Hybrid Scenario Description
The previous scenarios were detailed to understand and visualize existing O&G development patterns on small villages and towns and what these effects might look like in Wainwright. An exploratory scenario offers a "hybrid" model of development that is not based on any known existing analogous development. It offers an innovative approach to planning for large scale labor and infrastructure intensive projects by selecting best practices found in the isolated and integrated examples while minimizing negative effects, with an aim to promote long-term sustainability of an affected village. The concept assumes that it is possible to select the benefits of partial integration in order to outweigh the negative effects on a community. This approach could support village sustainability better in Wainwright and other small towns in a similar situation, as opposed to the traditional haphazard plan involving undue isolation or integration.


**Figure 3.4.** Hybrid Scenario Map

*Potential Impacts*

The hybrid model seeks to: diversify the economy and provide new jobs as a response to mitigating the negative effects likely to occur when operations terminate; provide alternative energy sources; and adaptively reuse select components of oil and gas infrastructure to advance the erosion retreat strategy. These objectives could be achieved by developing the temporary work camp on a site pad that could be converted to permanent use by the community. An enterprise zone could be designated to cultivate new economic activities like (indoor) experimental agriculture or alternative energy solutions like wind turbines. We estimated that capital costs to produce four common vegetables locally under a projected Wainwright population would be around $600,000 (see Section 6.4). Funding could be made available to help develop local businesses to meet the demands of incoming O&G activity. As previously noted in the integrated scenario, policies could be enacted to promote local entrepreneurial activities by shifting typical in house services of the work camps to the new, local ventures. For example, a Wainwright native could provide laundry services to the enclave.

An important concept in the hybrid model that makes it unlike any existing resource development plan is the concept of transferring physical and administrative infrastructure introduced by a petroleum project to the village after the project is completed. This concept may dramatically change the resource development planning approach. For example, project site restoration requirements are a major consideration when planning support infrastructure as service lifetimes are based on the timing of the project. That is, when oil production ends, infrastructure is put out of service and/ or removed. Instead, the initial siting of the O&G "man camps" can be selected strategically, so that once the operation is complete, the village can slowly begin to encourage development to these sites placed at higher and drier areas, away from the coast. In conjunction with this strategy, it is paramount to reach an agreement with the O&G company to develop the pad for permanent use and leave the site to be (at least) "pad site ready" in order to reduce moving and development costs.

The infrastructure transfer approach in addition to the above guiding concepts and techniques are (loosely) applied to the draft hybrid scenario developed for this report. Two primary long-term strategies drive our hybrid model: 1. Infrastructure introduced to support the construction phase is designed to be integrated and transferred to the village and measures are taken to as much as possible isolate activities with negative impacts and enable beneficial impacts (e.g., workers are partially separated), and 2. Infrastructure introduced exclusively for operation and maintenance along the pipeline (e.g., pumping stations) are designed to be temporary and isolated, while workers are partially separated.

Future work could include more in-depth treatment of a way to control isolation and integration of development components. Criteria could include:

1. ***Long-term planning*** – thinking about conditions when oil operations are complete, to inform sustainability decisions now.

2. ***Expanded suitability analysis*** - to limit negative impacts to long-term development (e.g., avoid disrupting valuable and sensitive hunting sites and placing critical infrastructure in locations not unduly exposed to natural hazards in the long-term) and maximize potential benefits such as locating a shared resource (e.g., wellness center) where access is equitable and business (e.g., restaurant) is most profitable.

3. ***Social impact regions*** - both positive (e.g., access to new airport) and negative (diminished air and water quality).

4. ***Functional* regions** - physical infrastructure and administrative, such as water supply and emergency response service areas.

5. ***Administrative constraints*** - such as village accessibility limitations (e.g., limiting who can visit a village and at what times).

6. ***Travel cost considerations*** - (e.g., geographic distance or seasonal terrain constraints or enablers) between the village and introduced project components (e.g., man camp).

**3.5.** Selected Opportunity Tradeoff Criteria

Social impacts by scenario are compared and analyzed on three dimensions: (1) Community well-being, (2) Physical infrastructure development, and (3) Coastal hazard mitigation. Each of the three dimensions include three selected social impact components (SIC), for a total of nine impact dimensions (see Section 3.5). The nine impact criteria were then used to assess and evaluate tradeoffs associated with the four scenarios. The impact criteria and description are in Table 3.2 below.

**Table 3.2.** Selected Long-term Opportunity Tradeoff Evaluation Criteria[3]

| Category | Criteria | Description |
|---|---|---|
| Well-being | Subsistence activity | Direct (i.e., habitat disruption) and indirect (wage work) impact on subsistence activity in the long-term (e.g. loss of hunting skill, language, and other critical cultural attributes). |
| Well-being | Community welfare[4] | Community values and traditional way of life. For example, taking wage work at the opportunity cost of less traditional life activity. |
| Well-being | Cash economy effect[5] | Oil development dividends, private business and other services |
| Physical infrastructure | General infrastructure | Improved community access to roads, water supply and waste treatment, energy routing, communications, housing, community centers, and schools |
| Physical infrastructure | Energy infrastructure | Improved access to energy sources - diesel, gas, and renewable sources. |
| Physical infrastructure | Regional transportation infrastructure | Docks for maritime shipping, air ports, regional gravel and ice roads |
| Coastal hazard | Coastal erosion | Expressed as a function of erosion rate and assets exposed. Criterion focus on the ability for O&G project integration ability to provide a slow retreat adaptation strategy. |
| Coastal hazard | Sea level rise[6] | Expressed as a function of sea level rate, associated hazards (e.g., storm surge), and assets exposed. Criterion focus on the ability for O&G project integration ability to provide a slow retreat adaptation strategy. |
| Coastal hazard | Spill response capacity | The ability (access to local assets and preparedness) to respond to a major oil spill. The criterion focuses on how O&G project integration can support an effective Incidence Command System (ICS) with assets and local knowledge. |

[3] Some variables correlate positively and others negatively. For example: sea level rise and coastal erosion correlate positively, and regional transportation infrastructure may negatively correlate with subsistence activity. While in the current assessment all factors are considered equal in importance, future work could define weights to better capture the opportunity cost effects.

[4] Including, e.g.: crime rates and continuity of the native culture.

[5] I.e.: The increase in business and economic growth that stems from oil development.

[6] Note: we did not model sea level rise. Exposure to sea level rise is considered here as a function of what is exposed. For example, a scenario with high infrastructure along the coast will have higher exposure to sea level change than a scenario with less coastal infrastructure development.

The attributes in Table 3.2 were selected based on our understanding of principal concerns for Wainwright, though the residents likely have a much better understanding of what is important for their community, and might identify other criteria or classify and weigh the opportunities differently. Wainwright has the opportunity to engage with O&G companies for sustainable development planning. We suggest some of these opportunities for business development, renewable energy and new construction could be requested (or negotiated) to build towards a sustainable future.

## 4. RESULTS & ANALYSIS

This section defines and evaluates the speculative level of opportunities of each potential development scenario by tradeoff criteria described in the above Table 3.2. All impact assessments are summarized in Section 4.5.

### **4.1.** Bypassed Scenario - Opportunities

In the Bypassed Scenario, offshore O&G development occurs offshore, but no pipelines or land-side development occurs in or near Wainwright. This scenario assumes that due to the positioning of the O&G activity offshore, Wainwright's leveraging position is significantly reduced as the village is essentially "bypassed" by the incoming development. Below are summaries of expected impacts by opportunity category for the bypassed scenario, and Table 4.1 summarizes the scores by component.

- *Community Well-being*: Subsistence[7] will be negatively impacted by development and oil spill risk, and this threatens community welfare with a relatively small offset from cash economy opportunities from some contracts secured by Olgoonik and increased dividends[8]. However, negative cultural impact may be minimal with limited direct social interaction.

- *Physical Infrastructure*: Both general and energy infrastructure opportunities for Wainwright are assumed to be low with little-to-no O&G-related development within village limits. Also, regional air and maritime travel infrastructure introduced to the Wainwright area with bypassed O&G activity would likely be inaccessible to Wainwright residents because it is located outside of the village and not easily accessible.

- *Coastal Hazard Mitigation*: While borough and state revenues could be applied to mitigate coastal erosion and sea level rise in Wainwright, the limited development may put Wainwright low on the priority list among other NSB communities. The low infrastructure development within city limits expected means hazard exposure would mostly be a function of changes in the coastal threat, and future development would be negligible in the assessment. Also, with little infrastructure development, locally effective spill response capacity would be inadequate with limited local support infrastructure (e.g., housing for the oil spill response team).

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[7] The opportunity to limit subsistence hunting is classified as low as little leverage is expected with bypassed development. However, it is unclear where the oil development will be located and Wainwright may be able to assert its rights over traditional hunting grounds.

[8] In this scenario, due to limited O&G workers entering the city, the economic multiplier assumed is low. However, Wainwright may have to expand the hotel and some supporting services, and possibly security, though to what degree is unknown.

**Table 4.1.** Bypass Scenario - Opportunities

| Opportunity Impact Component | Long-term Opportunity Impact Potential | Long-term Opportunity Impact Description |
|---|---|---|
| Limit Harmful Impact on Subsistence | Low | **Traditional land use**. Wainwright traditional land use extends far beyond city limits. With development around the village some threat to traditional land use is expected. While the oil transportation will go around Wainwright, the village is still exposed to oil spill risk with no local spill response capacity. |
| Limit Harmful Impact on Community Welfare | Low | **Traditional land use and cash economy**. Wainwright traditional land use extends far beyond city limits. With development activity (e.g., air travel) around the village some impact is expected. This threat is partially offset by cash economy opportunities, but here considered negligible. However, cultural losses from local development are expected to be minimal since local employment in the O&G sector is assumed to be almost entirely by non-local workers. |
| Increase Cash Economy Capacity | Low | **Village contracts and businesses.** Very little to no indirect local employment and locally-run services is predicted; potential increase in individual dividends is expected, but low. |
| Improve General Infrastructure | Low | **Roads and basic services (e.g. water sanitation).** With construction and operation activities located away from Wainwright, little local infrastructure impact is assumed with slightly increased borough revenues. |
| Improve Energy Infrastructure | Low | **Non-renewable and renewable potential**. With construction and operation activities located away from Wainwright, small-scale investment in local infrastructure improvement is possible with slightly increased borough revenues. |
| Access to Regional Transportation | Low | **Regional roads (ice and gravel), maritime and accessible air travel.** It is assumed that maritime and air infrastructure brought with bypassed O&G activity will not be accessible for Wainwright residents. |
| Mitigate Coastal Erosion Hazard | Low | **Capital exposed**. Exposure change is mostly a function of coastal hazard risk change. |
| Mitigate Sea Level Rise Hazard | Low | **Capital exposed**. Exposure change is mostly a function of coastal hazard risk change. |
| Increase local in Spill Response Capacity | Low | **Response capacity**. Current spill response capacity is low. With little infrastructure development (e.g. housing), this condition is expected to remain unimproved in the bypassed scenario. |

**4.2**. Isolated Scenario - Opportunities

The Isolated Scenario projects the offshore-to-onshore pipeline that connects to TAPS by way of the Wainwright area and the associated land-side development necessary to support such operations. In this scenario, the operations and the existing community of Wainwright are spatially near, but separated physically and socially through administrative and physical infrastructure measures. We argue that Wainwright's negotiation position is stronger in the Isolated Scenario than the previously described Bypassed Scenario, but not the highest of the four. That is, while an enclave operating within proximity to Wainwright would likely be subject to constraints associated with local administrative controls within the Coastal Zone and (if applicable) village boundaries, we assume that a spatially integrated but otherwise separated enclave would favor autonomy of the project and limit other types of influence by Wainwright residents that would come with shared infrastructure, employment, and social integration. Local stakeholder negotiation position, in this scenario, depends on our assumption that Wainwright as residents of the North Slope Borough and State of Alaska have some influence on permitting procedures for local development activity. This assumption is the basis for distinguishing Wainwright's negotiation position between the bypassed and isolated scenarios. Below are summaries of expected opportunities evaluated by category for the isolated scenario, and Table 4.2 summarizes the scores by component.

- *Community Well-being* – opportunities for limiting harmful impact on subsistence and community welfare are viewed as medium and increases in the cash economy are considered low. While O&G projects are socially and physically isolated in this scenario, subsistence may still be impacted as these activities extend far beyond Wainwright city limits; we assume predominantly harmful impacts. Additionally, oil spill risks exist with unimproved spill capacity as infrastructure development is minimal. Subsistence economy risk is not offset by cash economy opportunities. However, fewer locals taking wage jobs offsets subsistence opportunity costs and associated culture value loss. Cash economy opportunities are low and the scenario assumes minimal increases in individual dividends from local village corporation activity.

- *Physical Infrastructure* – opportunities for all infrastructure categories are assumed to be low. With O&G construction and operations isolated, any introduced infrastructure such as roads and buildings do not benefit the community and are decommissioned when projects are completed.

- *Coastal Hazard Mitigation* – opportunities to mitigate coastal erosion and sea level rise are low and potential to increase local oil spill response capacity is medium. Selected physical infrastructure introduced by O&G projects could be located with intent to encourage development away from the coast, providing a relatively low-cost slow retreat strategy for adjusting to coastal hazards. However, in the isolated scenario, all infrastructure is designed only to service the oil project, so mitigation by slow retreat is not applied. In terms of mitigating local oil spill hazard risk, the community benefits by having response assets staged locally. Wainwright's capacity to respond to oil spills is low due to local knowledge not being incorporated into the response system in planning and preparedness activities required by incoming O&G companies. The lack of integration would limit an effective Incident Command System (ICS) structure.

**Table 4.2.** Isolated Scenario - Opportunities

| Opportunity Impact Component | Long-term Opportunity Impact Potential | Long-term Opportunity Impact Description |
|---|---|---|
| Limit Harmful Impact on Subsistence | Med | **Traditional land use**. Wainwright traditional land use extends far beyond city limits. With development around the village some threat to traditional land use is expected. While the oil transportation will go around Wainwright, the village is still exposed to oil spill risk with limited local spill response capacity. These threats are not offset by cash economy opportunities. However, impact to subsistence culture may be offset by less wage job employment. |
| Limit Harmful Impact on Community Welfare | Med | **Traditional land use and cash economy**. Wainwright traditional land use extends far beyond city limits. With development around the village some impact is expected. This threat is not offset by cash economy opportunities. However, immediate impact to the community traditional way of life from local development is expected to be minimal. |
| Increase Cash Economy Capacity | Low | **Village contracts and businesses**. Limited local cash economy impact and minor increases in individual dividends are expected. Jobs likely awarded to non-local workers. |
| Improve General Infrastructure | Low | **Roads and basic services (e.g. water sanitation).** New roads and other general service infrastructure are isolated from Wainwright, and are decommissioned when oil operations stop. |
| Improve Energy Infrastructure | Low | **Non-renewable and renewable potential**. With construction and operation activities isolated from Wainwright, little energy infrastructure improvement for the village is assumed. Infrastructure is decommissioned after oil operations stop. Any introduced energy systems are assumed to be non-renewable. |
| Access to Regional Transportation | Low | **Regional roads (ice and gravel), maritime and accessible air travel.** Shipping docks, ice roads, and new airports are completely isolated (i.e., inaccessible), so little benefit to the village. Infrastructure is assumed to be decommissioned after oil operations stop. |
| Mitigate Coastal Erosion Hazard | Low | **Capital exposed**. Regional infrastructure located away from the coast could attract development inland in the long-term. However, this scenario assumes little or no interaction between the village and oil projects and infrastructure is decommissioned after oil operations stop. |
| Mitigate Sea Level Rise Hazard | Low | **Capital exposed**. Regional infrastructure located away from the coast could attract development inland in the long-term. However, this scenario assumes little or no interaction between the village and oil projects and infrastructure is decommissioned after oil operations stop. |
| Increase local Spill Response Capacity | Med | **Response capacity**. While operations are isolated from Wainwright, spill response capacity is increased due to availability of more local assets. However, local skill, knowledge, and infrastructure are not adequately incorporated into response plans due to the nature of independent decision making of the isolated strategy. |

**4.3.** Integrated Scenario - Opportunities

In the integrated scenario, land-side physical infrastructure and personnel to support off-shore development are fully integrated with the existing community. Because of the increased strain on existing infrastructure and utilities imposed directly on Wainwright, here is increased opportunity to seek O&G company support for infrastructure improvement. Below are summaries of expected impacts by opportunity category for the integrated scenario, and Table 4.3 summarizes the scores by component.

- *Community Well-being* – impacts range from low to high. The integrated scenario is considered the worst case for subsistence culture, but the best case for cash economy opportunities, and the mix of these factors (in a non-weighted evaluation schema) implies a medium impact for overall community welfare. The subsistence economy is at high risk as relatively high cash economy activity increases traditional life opportunity costs as more time is spent by more people engaging in the cash economy instead of the subsistence economy. Cash economy opportunity is high as demand for tertiary sectors with relatively unrestricted consumption of services by O&G personnel, which would drive the need for supply and demand. Traditional life is at high risk, but cash economy and new or retrofitted facilities may increase well-being, partially offsetting the negative effects.

- *Physical Infrastructure* – opportunities for infrastructure development is highest in this scenario, and assumed high in all considered categories. With full integration, existing infrastructure would be overwhelmed requiring new and retrofitted works ranging from medical facilities to energy supply. Infrastructure introduced for O&G projects are assumed to continue operation after project completion, unlike in the isolated scenario where works are decommissioned.

- *Coastal Hazard Mitigation* – Both coastal erosion and sea level rise mitigation opportunity are considered low, but the opportunity for oil spill response capacity is considered highest for this scenario. With O&G infrastructure development, exposure to natural coastal hazards is assumed to increase because as assets increase, coastal hazard exposure increases. Due to the elevated negotiation position, oil spill response capacity opportunity is high due to significant infrastructure, including high regional transportation access from the airport and shipping dock developments. For these reasons, Wainwright is assumed to be a main staging area for regional spill response, which would imply a relatively high level of protection for the immediate area if a spill occurred. Additionally, Incident Command System (ICS) capacity is assumed highest in the scenario as local knowledge, skills, and related physical infrastructure is expected to be significantly integrated with local employment preference.

**Table 4.3.** Integrated Scenario - Opportunities

| Opportunity Impact Component | Long-term Opportunity Impact Potential | Long-term Opportunity Impact Description |
|---|---|---|
| Limit Harmful Impact on Subsistence | Low | **Traditional land use**. The fully integrated scenario is considered here the highest negative impact case for subsistence for two reasons. 1. The direct impact ecosystems impact (as expected with other scenarios), and 2. The subsistence economy opportunity costs in the long-term. In a more sophisticated analysis, these impacts would carry high weight. Full integration would transform Wainwright into a company town, and high cultural and livelihood losses are assumed at the cost of temporary monetary gains. |
| Limit Harmful Impact on Community Welfare | Med | **Traditional land use and cash economy.** This scenario is assumed to have the largest impact on the welfare of the community, though not necessarily all negative. The key negative impacts are tangential (but critical) to subsistence activity, such as activities around whale hunting that bind communities and strengthen cultural values (e.g. sharing). However, the community welfare could benefit from shared facilities such as new medical and recreational facilities. |
| Increase Cash Economy Capacity | High | **Village contracts and businesses**. This scenario assumes the highest level of opportunity for locally operated businesses to supply various amenities (e.g. food and entertainment) that would increase in demand from the influx of O&G personnel. In addition to all facilities being shared (which would increase demand and drive supply), the integrated scenario assumes no administrative restrictions of O&G personnel access to the village. An implication of this is more economic activity as personnel can freely consume where and when they want. |
| Improve General Infrastructure | High | **Roads and basic services (e.g. water sanitation).** This scenario also assumes the highest potential impact on infrastructure development, since full integration would overwhelm existing infrastructure. For example, Wainwright could have access to better road systems, updated or new water and sewer treatment plants, and a new landfill with increased operating capacity and efficiency. |
| Improve Energy Infrastructure | High | **Non-renewable and renewable potential**. The impact on the energy infrastructure will be significant, with access to new power sources to supplement or replace the existing diesel power plant. While Wainwright could benefit from a retrofitted or new power supply system, the scenario assumes continued reliance on non-renewable sources. |
| Access to Regional Transportation | High | **Regional roads (ice and gravel), maritime and accessible air travel.** Access to regional transportation systems is assumed to increase significantly. The scenario also assumes: one or both of the nearby airports would be greatly expanded during the O&G construction phase, a regional road system follows the pipeline to TAPS, and a new shipping dock to accommodate increased barge traffic. |
| Mitigate Coastal Erosion Hazard | Low | **Capital exposed**. Exposure to coastal erosion increases if development continues along the coast. However, this scenario assumes developed projects and system designs will not take a long term perspective and climate change, or worsening coastal hazards will not be a consideration. |
| Mitigate Sea Level Rise Hazard | Low | **Capital exposed**. Exposure to coastal erosion increases if development continues along the coast. However, this scenario assumes developed projects and system designs will not take a long term perspective and climate change, or worsening coastal hazards will not be a consideration. |
| Increase local Spill Response Capacity | High | **Response capacity**. This scenario assumes highest oil spill response capacity due to two factors: 1. Wainwright will be a major regional spill response staging area due to significant air travel capacity (expanded airport) barge and small vessel entry (shipping dock), and 2. Local knowledge is strongly built into large scale oil spill response systems –i.e. fill critical roles in Incident Command System (ICS) – due to preference for local employment, increasing ICS capacity for effective response. |

**4.4.** Hybrid Scenario – Opportunities

The Hybrid Scenario assumes pipelines pass through Wainwright and O&G related land-side infrastructure is integrated with the existing community. This scenario is different from the Integrated Scenario because it selects the benefits of integration while balancing the negative effects of full integration or isolation. Compared with the Integrated Scenario, Wainwright's influence on potential negotiations with O&G companies is believed to be commensurate. Below are summaries of expected impacts by opportunity category for the hybrid scenario, and Table 4.4 summarizes the scores by component.

- *Community Well-being* – Opportunities to limit harmful impact to subsistence and overall community-well-being are high and the opportunity to increase cash economy capacity is medium. The hybrid model assumes O&G development and integration explicitly accounts for potential impact to ecosystem health, the need to maintain substance culture, and selective integration to allow good cash economy impacts while limiting negative impacts that may accompany the activities. Cash economy impact is not as high as in the fully integrated model due to consumption restrictions. However, this tradeoff criterion as currently conceived (see Table 3.2) does not capture the potential for a significant economic transformation that may take hold in Wainwright. For example, reduced regional transportation costs with the introduction of a new barge shipping dock and higher capacity airport could reduce transportation costs and drive a regional production/service operation such as a cash agriculture sector (see Table 4.4: "Access to Regional Transportation"). This impact could have high cash economy capacity impact.

- *Physical Infrastructure* – the hybrid model assumes that critical infrastructure is fully integrated with the existing community, and design allows a long term plan to transfer the O&G -introduced infrastructure to the city or borough after production ends. Another key aspect of this scenario is that Wainwright effectively negotiates energy infrastructure that includes significant renewable sources, and the O&G developers assist the city with a long-term plan to substantially shift the community to renewable, alternative energy sources in the long-term. The hybrid scenario also assumes that Wainwright negotiates that plans for the shipping dock, regional road network, and expanded airport include a long-term plan on how the city could use the infrastructure in the future to support an independent regional cash economy sector (see Table 4.4).

- *Coastal Hazard Mitigation* – opportunities in all coastal hazard categories are all high. The scenario assumes that future coastal erosion and sea level rise exposure potential are fully considered in infrastructure design and development plans. A key aspect of the hybrid model is that critical infrastructure (e.g., water supply) placement is used to guide future development away from locations exposed to coastal hazards now and in the future, in effect supporting a cost-efficient long-term retreat adaptation strategy. Oil spill response capacity is high as Wainwright effectively negotiates that the city be the site of a regional spill response staging area, in effect increasing the likelihood that equipment and other assets will be available to respond to a large scale spill. Additionally, the hybrid model assumes innovative plans that dovetail capital improvement project objectives. For example, a community center could be designed to be readily available as spill response housing by, e.g. plumbing the building to anticipate this use. Another key factor in the hybrid model is that, since the workforce is largely integrated, local knowledge is substantially incorporated in the Incidence Command System (ICS), increasing spill response effectiveness.

**Table 4.4.** Hybrid Scenario - Opportunities

| Opportunity Impact Component | Long-term Opportunity Impact Potential | Long-term Opportunity Impact Description |
|---|---|---|
| Limit Harmful Impact on Subsistence | High | **Traditional land use**. This scenario assumes some impact to ecosystem health and subsistence opportunity costs, but development negotiations effectively limit these impacts (as much as possible). Detailed suitability analyses involving detailed habitat impact is done for every introduced infrastructure to assess impact, and habitat destruction and hunting access is minimized at additional costs to O&G projects for potentially inconvenient placement of some infrastructure and activities. Additionally, local employment and retention efforts/programs center on jobs that allow flexibility to accommodate a subsistence lifestyle (e.g. hunting seasons) (e.g. habitat impact in-field monitoring/mapping for oil spill protection of critical marine habitats and education of the public and visiting work force). |
| Limit Harmful Impact on Community Welfare | High | **Traditional land use and cash economy.** In addition to local employment preference and retention programs noted above that explicitly attempt to offset impacts to subsistence culture, the hybrid scenario is also selective when deciding how and to what degree to integrate O&G workforce activities with the local community. This integration involves both physical and administrative considerations to allow some integration that maximizes cash economy opportunities without unduly encouraging negative community impacts. For example, camps are located at a distance that does not allow easy access, but access is possible and restricted using administrative rules. An example would be providing a seasonal ferry service across the Wainwright Inlet for workers to the village once it has thawed in the summer months, or the establishment and enforcement of a curfew for non-resident workers. |
| Increase Cash Economy Capacity | Med | **Village contracts and businesses**. Cash economy impacts may be significant, but not as high as with a fully integrated model as O&G consumption of local products and services is restricted. Another key aspect of the hybrid scenario is the bolstering of the cash economy by promoting the provision of services to O&G “man camps” by local (new) entities. Services could include services typically provided by a self-sufficient man camp, for example, catering and laundry services. This approach differs from the traditional method of jobs skills training and [empty] promises of jobs made by incoming (O&G) company. It also provides the locals the opportunity to maintain a flexible lifestyle to support the subsistence economy. The combination of limitations on consumption of local products and local entrepreneurial activity ideally will mitigate the likely impending economic depression following the departure of the large influx of temporary construction laborers. |
| Improve General Infrastructure | High | **Roads and basic services (e.g. water sanitation).** In this scenario, critical infrastructure is fully integrated with the existing community and is designed to continue operations after O&G production ends. An exception may be made with infrastructure that is used by personnel such as the hospital. Negotiations may involve restrictions on who can use the facility and when. However, hospitals and other visited facilities are designed to be transferred to the city or borough after O&G operations end. |
| Improve Energy Infrastructure | High | **Non-renewable and renewable potential**. This scenario assumes that Wainwright successfully negotiates a fully integrated energy supply system that includes a renewable source and a long-term plan/strategy to shift the city substantially to renewable energy in the long-term. |
| Access to Regional Transportation | High | **Regional roads (ice and gravel), maritime and accessible air travel.** Like other infrastructure, regional transportation nodes introduced by the O&G projects are designed to be operated after production ends. This scenario also assumes that Wainwright successfully negotiates that O&G developers assist the city in their capital improvement plan involving an innovative way to make use of the expanded regional transportation capacity. For example, high regional transpiration capacity could make a |

| | | |
|---|---|---|
| | | locally-run regional supply/service economically feasible by reducing transportation costs. In this report, we briefly explore the development of a cash economy agriculture sector to take hold in Wainwright to supply itself and other NSB villages with fresh produce. |
| Mitigate Coastal Erosion Hazard | High | **Capital exposed**. This scenario assumes that O&G project development considers long-term coastal erosion potential and infrastructure design/performance standards and development plans are based on non-stationary assumptions. That is, viewing coastal hazard exposure as a function of threat potential and assets exposed, cost-benefit analyses of adaptation strategies consider possible change in erosion rates and development in locations at risk in the future. A key aspect of the hybrid model is that development plans use critical infrastructure placement (e.g. power supply) to guide development away from locations at risk to coastal hazards now and in the future, thereby supporting a cost-efficient long-term retreat strategy and reducing loss potential. |
| Mitigate Sea Level Rise Hazard | High | **Capital exposed**. This scenario assumes that O&G project development considers long-term sea level rise and related potential (e.g. storm surge) and infrastructure design/performance standards and development plans are based on non-stationary assumptions. That is, viewing coastal hazard exposure as a function of threat potential and assets exposed, cost-benefit analyses of adaptation strategies consider possible change in sea level rise rates and development in locations at risk in the future. A key aspect of the hybrid model is that development plans use critical infrastructure placement (e.g. power supply) to guide development away from locations at risk to coastal hazards now and in the future, thereby supporting a cost-efficient long-term retreat strategy and reducing loss potential. |
| Increase local Spill Response Capacity | High | **Response capacity**. Spill response is high for two reasons: (1) The scenario assumes Wainwright effectively negotiates that the city be a regional oil spill response staging area, and 2. Assets and employment in the response sector are fully integrated with the local community. The first aspect assumes Wainwright as a staging area will provide adequate spill response supplies (e.g. hard boom; boats) and accommodations (e.g. housing) to respond to a worst-case scenario oil spill. The second aspect dovetails with the first by employing innovative ways to ensure adequate assets by, for example,. designing a community center to be readily retrofitted for spill response housing (e.g. this is considered in how the building is plumbed). Also, the hybrid model assumes integration of local workers with spill prevention and response employment, so local knowledge is significantly incorporated into the Incident Command System (ICS) structure, allowing for more effective spill responses. |

**4.5.** Results Summary

Table 4.5 below includes social impact assessment results for all scenarios. The same results are graphed in Figure 4.1 below to facilitate comparison.

**Table 4.5.** All Scenarios – Opportunities Summary

| | **Bypassed** | **Isolated** | **Integrated** | **Hybrid** |
|---|---|---|---|---|
| Component | Opportunity | Opportunity | Opportunity | Opportunity |
| Subsistence | Low | Med | Low | **High** |
| Community Welfare | Low | Med | Med | **High** |
| Cash Economy | Low | Low | **High** | Med |
| General Infrastructure | Low | Low | **High** | **High** |
| Energy Infrastructure | Low | Low | **High** | **High** |
| Regional Transportation | Low | Low | **High** | **High** |
| Coastal Erosion | Low | Low | Low | **High** |
| Sea Level Rise | Low | Low | Low | **High** |
| Spill Response | Low | Med | **High** | **High** |

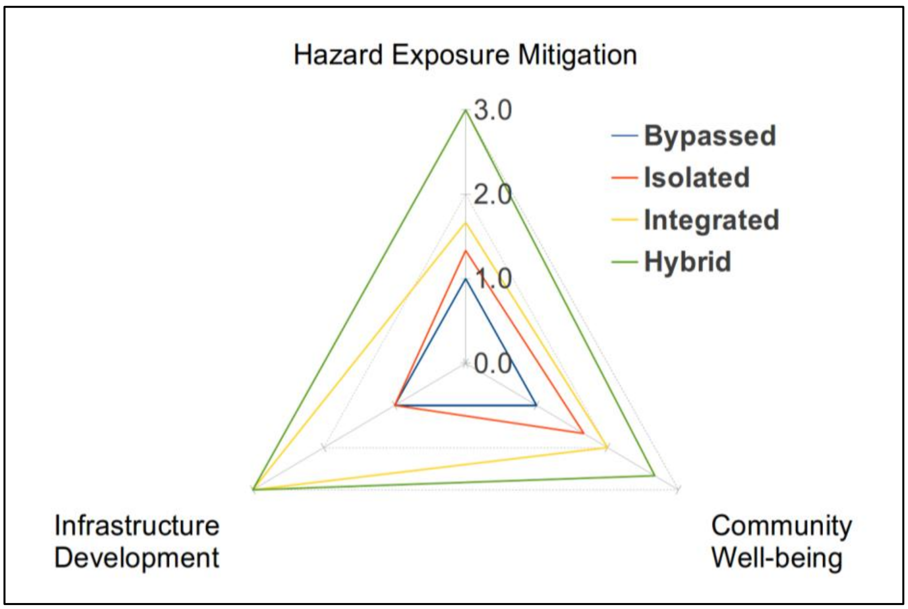


**Figure 4.1**. Scenario Opportunity Tradeoffs Summary Diagram

In Figure 4.1 above, tradeoffs for all scenarios (see Table 4.5) are averaged and plotted on the appropriate axis. The diagram shows the bypassed scenario as a baseline, and how opportunities vary between the remaining development trends. The diagram provides a way to visualize not only how scores by category compare between the scenarios, it also helps the reader think about how the impact dimensions interact. For example, while the integrated scenario (yellow) involves high infrastructure development opportunity, it is at the cost of community well-being and increased coastal hazard exposure due to haphazard social integration and little consideration of leveraging a managed retreat adaptation.

## 5. CONCLUSION AND DISCUSSION

This study evaluated and compared potential social impacts for four conceptual development scenarios in Wainwright, Alaska as a likely shore-side support site for future outer continental shelf (OCS) oil and gas (O&G) development and product transportation activities. The aim of the scenarios was to capture community sensitivity to differences in level and type of integration (i.e., physical infrastructure and social) of O&G project activities with the existing Wainwright community. The scenarios include: (1) Bypassed, where Wainwright receives very little shore-side development, (2). Isolated where infrastructure and people are largely separated from the existing community, (3). Integrated, involving full infrastructure integration and unrestricted movement of people, and (4). Hybrid, where select integration is negotiated to maximize net O&G development benefits. Criteria for evaluation include considerations of community well-being, infrastructure development potential, and opportunities to leverage O&G development for coastal hazard mitigation.

Project results suggest that partial integration in the Hybrid Scenario would best balance costs and benefits of large-scale O&G development. More specifically, select integration of physical infrastructure would support long-term village sustainability, and restricted social integration would support the local cash economy (i.e., locally-run businesses and local employment), while limiting potentially harmful impacts to the community by controlling where and when the visiting O&G workforce can enter the village and consume local products and services.

*Discussion and Next Steps*

A central aspect of the study is the notion of a "hybrid" development scenario, where we explored the complications of partial integration in addition to offering examples of innovative solutions for long-term sustainability. Tradeoff findings from the integrated and isolated scenarios were used to inform the hybrid model. This project introduced the hybrid concept as an alternative development trend from the extremes (i.e., full isolation or full integration) that tend to be the defaults. The hybrid model presented in this document should be viewed as a first sketch to outline alternative approaches, to suggest alternative paths that can be developed through a community-driven planning process.

The concept of partial O&G project integration with existing communities has been explored in the past by O&G developers and the federal government operating in rural Alaska. However, our literature review did not uncover any recent detailed studies of this type, and it's unclear if past efforts were ever included in O&G planning. In 1982, the U.S. Minerals Management Service (MMS), now Bureau of Ocean Energy Management (BOEM), contracted the development of a computer model to project the socioeconomic and cultural effects of the regional OCS petroleum industry under scenarios defined by levels of integration and isolation from existing native communities (see MMS 1982). The usage of the model (or more recent versions) beyond illustrative model runs (see MMS 1982) is unclear as is what impact, if any, it had on O&G development decisions in the North Slope. With the likely installation of O&G works crossing the North Slope from Wainwright to TAPS, revisiting the model may be warranted to guide the developments.

Refinement of scenario impacts as a community-driven planning process, assisted by a model, could be a next step to more concretely identify and compare social impacts by scenario. Additionally, significant advancements in technology and spatial analysis techniques could significantly improve the modeling effort employed in the 1982 MMS study.

A critical next step is to include community input in creating the hybrid scenario maps. The site plans would provide an effective means to increase engagement within the community and between the community and O&G developers, increasing local capacity to influence sustainable and resilient development decisions. Once this phase is completed, it is paramount to start the planning process, incorporating the findings of this report for a community-driven planning process.  Here, time is the greatest asset.  With O&G development projected to be years away, this gives Wainwright the advantage of creating a prudent plan to accommodate this specific type of growth, instead of being unprepared, and thus overwhelmed by  large O&G development driven from outside the community.

Within the decade, the North Slope is likely to enter the beginning stages of a dramatic social transformation as massive offshore O&G projects get underway, marking a next chapter in the story of adaptation of the Iñupiaq people. The developments will come with a set of tradeoffs which will threaten longstanding communities at the same time offering opportunities for development that are unprecedented for the region. The ability for Wainwright and other North Slope communities to influence early development decisions to serve their long-term development goals will largely define adaptation outcomes. Studies like this that increase capacity to consider potential long-term effects under development scenarios strengthen the capacity to plan and adapt.

## 6. APPENDIX

**6.1.** Expanded Wainwright Habitat Profile[9]

Subsistence land use is critical for Alaska Native communities, both in terms of culture and nutrition. As such, the various development scenarios described in this report consider the effects that development might have on species habitats located within the general Wainwright area. Several important species in the area include polar bears, waterfowl, and Arctic fox. As the town itself is located within a general habitat area for all three species, development that affects those habitats may be unavoidable. However, the growth patterns recommended in this report push the town's footprint northward towards an area that serves as only an Arctic fox habitat according to our limited species habitat dataset. Avoiding these habitats is nearly impossible as the Arctic fox habitat area covers nearly the entire North Slope. It is assumed, then, that construction will not have a deleterious effect on the Arctic fox population given their large habitat area. Finally, while offshore oil development and increased vessel traffic will have serious consequences in relation to various species important to the Alaska subsistence culture (e.g. Bowhead whales), these species were not considered as the development scenarios focused on onshore impacts.

[9] A goal of this project was to map sensitive habitats, and build this information into the impact analysis. However, the Studio was unable to access subsistence data detailed enough for an impact analysis as these data are highly sensitive and regulated. Using very coarse publically available data and information from the North Slope Subarea Contingency Plan of May 2012 (Alaska Dept of Environmental Conservation 2012), the studio developed a habitat map with the intent to identify locations with the least harmful impact from industrial development. Based on this limited data, the north-west direction was identified as having the fewest conflicts with wildlife. More work is needed to better map this important decision-making consideration. While restricted, extensive subsistence data for the NSB exist (see e.g., Braund and Kruse 2009).

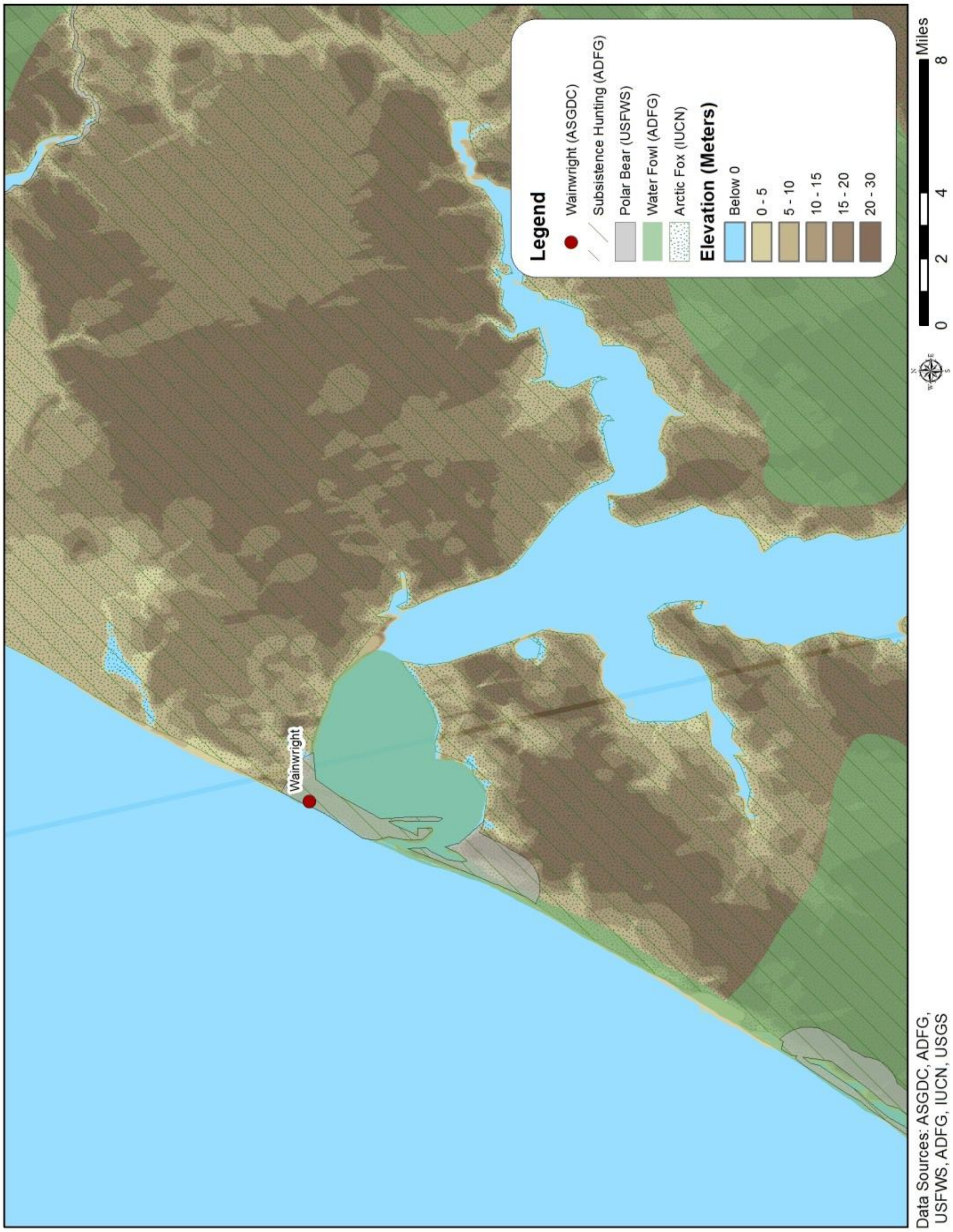


**Figure 6.1.** Wildlife Habitat – Wainwright Area

## **6.2.** Calculations and Assumptions

### 6.2.1. Employment Numbers & Camp Population

Data from a University of Alaska Northern Economics Centers report (NE 2009) were used to estimate a maximum number of construction employees. The Northern Economics report estimates that development in the Chukchi Sea would generate a peak employment of 4,000 on the North Slope. We assume 90% of those jobs created will be based in Wainwright and that shift-work will mean that only one half to two thirds of jobs will be on-shift at any one time. We assumed the larger number and rounded up to 2,500.

We assume that this estimate will leave extra capacity for crew-changes or bad weather conditions because many of the jobs will also be off-shore on rigs or support vessels. Alyeska, which operates TAPS, reports that the largest pipeline camp during construction was Isabel Pass, with 1,652 beds (Alyeska Pipeline Service Company).

We also assume a permanent camp size of 500 which will hold personnel for the permanent pumping station and operations. This number includes all the additional staff that would be required for new facilities not exclusively owned and operated by the town based on an assumption that all employment would come through an outside entity “oil developer.” The five hundred camp size estimation includes staff for a pumping station, maintenance personnel for the camp, airport and any camp-exclusive utilities, housekeeping, company pilots, administrators, and medics. After the construction camp is closed, the camp will take over the extra capacity for crew-change and to house engineers, researchers, inspectors and visitors associated with industrial operations.

### 6.2.2. Airport Design

The expanded airport in the Isolated, Integrated, and Hybrid conceptual site plan is modeled after the airport in Deadhorse, Alaska because it is the largest airport on the North Slope and accommodates a similar level of O&G activity that is projected for Wainwright. The airstrip and taxi way are sized large enough, according to FAA standards, to harbor large cargo planes (Hercules) necessary to transport materials for construction of the proposed O&G development. The total runway (safety) area is 8,500 feet by 1,000 feet. The sited footprint also includes seven airfields 2,500’ x 3,000’ (Alaska Dept. of Transportation and Facilities). It is important to note that this is merely a scalable placeholder.

## **6.3.** Energy Options

With new potential onshore investments to support offshore development, Wainwright may be presented with the opportunity to switch from a diesel-fueled power plant to a natural gas power source. Natural gas is a cleaner and cheaper fuel compared to diesel. Diesel fuel emits 15 times more carbon dioxide than natural gas. The switch from diesel to natural gas is a current trend occurring in other towns on the North Slope as the extraction of natural gas in the Arctic increases. As it stands currently, the population may be too small to make power system upgrades feasible, however, with the projected revenues from new O&G development, an upgrade may become feasible as the project costs could be shared with O&G companies also in need power of a power source for construction, operations and maintenance.

Wind power is another viable option to power Wainwright. With average yearly wind speeds of 11.7 miles per hour, Wainwright is capable of supporting wind turbine energy production (Western Regional Climate Center, 2006). Wind power has proven successful in extreme cold weather conditions around the world. Ross Island in Antarctica successfully installed three wind turbines at a scientific research center. According to ABS Alaskan, temperatures of 35 degrees Fahrenheit and lower have been known to cause wind turbines to out-produce their maximum rated output by as much as 20%. However, high winds can present a challenge if the town opts to adopt wind farms. Wind turbines must be capable of handling high-speed winds and produce optimally in the average wind conditions in that area. This is because temperatures this low increase the density of air, which allows the turbines to produce more electricity.[10]

The possibility of solar farms was also explored as an alternative energy source for Wainwright. The summer months in Wainwright provide long exposure periods for panels to gather solar power. There are some concerns regarding the efficiency of solar panels in Arctic regions because of the angle of the sunlight and because sunlight is less powerful close to the poles. However, there are also solar installations that use sensors to track the sun throughout the day and angle the panels to a position that optimizes energy harnessing performance. Solar panels work most efficiently in lower temperatures; as cells in panels heat up they gather energy less efficiently. Even in the summer, Wainwright's low average temperature reduces the problem of overheating solar panels.

**6.4.** Wainwright Estimated Agriculture Capital Costs for Select Fresh Vegetables

There is growing interest in the potential for Arctic agriculture production. We begin to explore the development of an agriculture sector in Wainwright as part of the hybrid scenario to support North Slope access to fresh produce and introduce a new local industry. Currently, the North Slope does not commercially produce any fruits or vegetables, largely due to environmental constraints including a harsh Arctic climate. While examples of agriculture projects in the Arctic perfectly analogous to the North Slope case are lacking, existing methods for estimating production feasibility in cold regions could be extended to the North Slope.

To explore the potential for agriculture production in the North Slope, we apply the Chena Model (Mager et al. 2008) to estimate capital costs of locally producing select vegetables in Wainwright. The model is based on the successful greenhouse business model implemented at the Chena Hot Springs Resort located 60 miles north of Fairbanks, Alaska, which is approximately 500 miles southeast of Barrow. The model estimates the capital and operating costs for a standard-size Controlled Environment Agriculture (CEA) greenhouse of 60ft x 72ft (4,320 $ft^2$). Mager et al. (2008) provides the cost estimation for one standard 4,320 $ft^2$ greenhouse (i.e., $138,303) and the share of one standard greenhouse that each vegetable type requires (called greenhouse units). The model is applied to specific locations by summing the total greenhouse units required for each produce type according to per capita demand. Capital costs are then estimated by multiplying the total greenhouse units required for a given population by the costs for one standard greenhouse. Here, we apply this method in Wainwright with a projected population to get some sense of CEA greenhouse costs.

Following O'Brien (2011), we estimate CEA greenhouse costs for producing four common vegetables: leafy greens, cucumbers, bell peppers, and tomatoes. Table 6.1 below shows US three year average per capita consumption rates for these vegetables.

[10] Note: at the time of writing this report, the Alaska Energy Authority is evaluating Wainwright as a potential site for wind turbines.

**Table 6.1.** Estimated Per Capita Consumption of Fresh Vegetables

| US Three Year Average Per Capita Consumption of Fresh Vegetables | | | |
|---|---|---|---|
| Leafy Greens | Cucumbers | Bell Peppers | Tomatoes |
| 38 | 6.4 | 9.6 | 19.2 |

** Includes Cabbage, Romaine and Head Lettuce

Source: <http://www.ers.usda.gov/>, cited in O'Brien (2011)

Demands for these vegetables in Wainwright are estimated by multiplying per capita demand unique for each vegetables by total population (Table 6.2).

**Table 6.2.** Estimated Vegetable Per Capita Consumption Based on US Average

| **Wainwright Projected Population** | **2,500** |
|---|---|
| Estimated Per Capita Consumption Potential | |
| Leafy greens** | 95,000 |
| Cucumbers | 16,000 |
| Bell peppers | 24,000 |
| Tomatoes | 48,000 |
| Total consumption potential | 183,000 |

After Mager et al. (2008) and O'Brien (2011)

The Wainwright fresh vegetable demand is based on our projected population during offshore project construction activities (i.e., 2,500 people). We used the temporary population to be consistent with tenants central to the hybrid model we propose, namely select project integration and transferability after project completion. That is, initial greenhouse design would be based on the local population within proximity to Wainwright expected to demand the produce during the project construction phase assuming Wainwright is supplying produce for the project in addition to the permanent population (we consider this arrangement as an instance of project integration with the permanent community). When local demand decreases with the completion of the project construction phase, Wainwright may be pressured to distribute to neighboring North Slope villages such as Barrow and Point Lay to find new markets (we consider this an instance of project transfer to the community following project phase completion and site decommissioning).

To estimate greenhouse square footage required by Wainwright with a population of 2,500, the average yield for each vegetable type is divided by per capita average from Table 6.1 (O'Brien, 2011).[11] Table 6.3 shows greenhouse square footage required by the projected Wainwright population to produce the four vegetable types. We include estimates by O'Brien (2011) for four Alaska municipalities for comparison.

[11] We use the average yield from Canadian industry statistics reported in 2009, following O'Brien (2011).

**Table 6.3.** Green House Size Potential in Square Feet (Chena Model)

| | Projected Population | Population in 2009 for Comparison Alaska Municipalities | | | |
|---|---|---|---|---|---|
| | **Wainwright** | **Akutan** | **Dillingham** | **Kodiak** (community Island) | **Saint Paul** |
| **Population** | **2,500** | **846** | **2,264** | **13,062** | **459** |
| | greenhouse size requirement (ft²) | | | | |
| Leafy greens** | 9,331 | 3,164 | 8,468 | 48,858 | 1,717 |
| Cucumbers | 907 | 307 | 821 | 4,737 | 166 |
| Bell peppers | 4,450 | 1,529 | 4,093 | 23,615 | 830 |
| Tomatoes | 5,141 | 1,711 | 4,578 | 26,414 | 928 |
| Total greenhouse size requirement | 19,829 | 6,712 | 17,961 | 103,624 | 3,641 |

** Leafy Greens include: Cabbage, Romaine and Head Lettuce
Source : Mager et al. (2008) and O'Brien (2011)

Greenhouse units required are estimated by dividing the needed greenhouse sizes by the standard 4,320 $ft^2$ greenhouse, shown in Table 6.4. The total number of greenhouse units required for Wainwright with 2,500 people is 4.59, which is the sum of all units calculated by vegetable type for the population. The size for the 4.59 unit of greenhouse will occupy 19,839 $ft^2$.

**Table 6.4.** Greenhouse Units (4,320 $ft^2$)

| | Projected Population | Population in 2009 for Comparison Alaska Municipalities | | | |
|---|---|---|---|---|---|
| | **Wainwright** | **Akutan** | **Dillingham** | **Kodiak** (community Island) | **Saint Paul** |
| **Population** | **2,500** | **846** | **2,264** | **13,062** | **459** |
| | greenhouse units | | | | |
| Leafy greens** | 2.16 | 0.73 | 1.96 | 11.31 | 0.40 |
| Cucumbers | 0.21 | 0.07 | 0.19 | 1.10 | 0.04 |
| Bell peppers | 1.03 | 0.35 | 0.95 | 5.47 | 0.19 |
| Tomatoes | 1.19 | 0.40 | 1.06 | 6.11 | 0.21 |
| Total greenhouse size requirement | 4.59 | 1.55 | 4.16 | 23.99 | 0.84 |

** Leafy Greens include: Cabbage, Romaine and Head Lettuce
Source: Mager et al. (2008) and O'Brien (2011)

According to the Chena Model, the total cost for one standard 4320 $ft^2$ greenhouse is $138,303 (Mager et al. 2008). The capital cost for Wainwright to meet demand for the four vegetable types is estimated by multiplying greenhouse units by the cost for one standard greenhouse, shown in Table 6.5.

**Table 6.5.** Greenhouse Capital Costs

| | Projected Population | Population in 2009 for Comparison Alaska Municipalities | | | |
|---|---|---|---|---|---|
| | Wainwright | Akutan | Dillingham | Kodiak (community Island) | Saint Paul |
| **Population** | **2,500** | **846** | **2,264** | **13,062** | **459** |
| | | greenhouse capital cost | | | |
| Leafy greens** | $298,734 | $ 101,398 | $ 271,112 | $ 1,564,164 | $ 54,965 |
| Cucumbers | $29,044 | $ 9,823 | $ 26,288 | $ 151,665 | $ 5,330 |
| Bell peppers | $142,452 | $ 48,965 | $ 131,037 | $ 756,010 | $ 26,566 |
| Tomatoes | $164,581 | $ 54,771 | $ 146,573 | $ 845,642 | $ 29,716 |
| Total greenhouse size requirement | $634,811 | $ 214,867 | $ 575,010 | $ 3,317,482 | $ 116,577 |

** Leafy Greens include: Cabbage, Romaine and Head Lettuce
Source : Mager et al. (2008) and O'Brien (2011)

According to the Chena Model, capital costs for Wainwright to locally produce the four vegetables under the projected population scenario is around $600,000. Greenhouse operating costs can also be estimated using the Chena Model (Mager et al. 2008), which is an area for future work. More research is needed to estimate costs to locally produce fresh fruits and other vegetables and to determine if capital and operating costs deviate from those assumed in the Chena Model.

## **6.5.** Development Scenario Map Methods

This section includes maps created for each scenario, along with mapping methods.

*General Methods*

All conceptual site plans include a recent Bing Maps areal image (inset map) and SPOT orthoimagery overlaid with estimated/illustrative erosion impact lines for 50 and 100 years into the future. Maps also include basic digitization of land use and structure type.

Illustrative coastal erosion projections are overlaid onto the scenario maps. As noted in section 2.3, historical erosion rates along Wainwright's coast range from around -10 ft. to +1 ft. To avoid the assumption that historical erosion patterns are a reliable indicator of future rates, the current project uses a recent North Slope average rate of 1.6 meters (~5 ft.), as an illustrative erosion rate that can be extended to other coastal villages in the region. More work is needed to map accurate erosion projections that include climate change assumptions. Future work should also include other coastal hazards influenced by climate change such as sea level rise and storm surge.

At a rate of 1.6 meters, the maps show a setback distance of 526 feet from the present beach to accommodate a 100-year horizon for erosion only.[12] Approximately seventy-nine housing units and some commercial structures are within this distance from the shore.

6.5.1. Bypassed Scenario Mapping Methods

The bypassed scenario site plan illustrates a vision of Wainwright if the existing structures located in the 100 year erosion hazard zone were relocated away from the coastline. This map highlights the projected erosion lines and shows what Wainwright would look like if the structures located in the hazard zone were moved inland. Instead of expanding along the coast as is the current development pattern in Wainwright, residential structures are relocated to higher ground to the north- and south-eastern edges of the village's boundary. Relocated commercial buildings are moved to a more central location in town.

6.5.2. Isolated Scenario Mapping Methods

In this scenario, the relocated development pattern is reiterated on the site plan. The map highlights the projected erosion lines and shows what Wainwright would look like if the structures located in the hazard zone were moved inland. We located a permanent production camp and construction just over 4 land miles from Wainwright at the DEW Line Station. These camps are expected to house 500 permanent positions working year-round for the entire period of oil production and 2,500 temporary workers during the peak construction phase. The newly constructed camps would be completely separated from the town and require independent water systems, sewage, and power utilities.

The airport at the DEW Line Station will need to be upgraded according to FAA standards to accommodate larger planes and more flights to carry supplies to a nearby camp. The map shows a new airport, following the dimensions of the airport in Deadhorse, to be built slightly north and on the existing siting of the current airport to accommodate land and water features (such as melting permafrost). The dimensions of the airport in Deadhorse and the rationale for the expected numbers of workers are presented in 6.2.

6.5.3. Integrated Scenario Mapping Methods

In the Integrated Scenario map, housing structures for both temporary and permanent residence are located on the northeast of town, providing a natural extension of the town's current development. Permanent operations are situated in a more central location in town, as part of the newly relocated commercial corridor. Integrated development also allows for Wainwright to center its commercial uses into a new enterprise zone that can act as a downtown where citizens and workers can both go to consume goods and services. Shared recreational facilities sited (highlighted as a light yellow square on the map) are intended to provide multiple uses: as temporary housing for spill response crews or for cultural events. Thinking about multiple uses in building design would involve relatively easy retrofits to convert facilities on an as-needed basis. An example would be installing the building plumbing system of such capacity to handle the functions of a community center and housing for an oil response workforce.

For the integrated model, all utilities from water, solid waste, sewage, and energy are jointly used by the local community and oil workers. This requires upgrades to vital infrastructure; Wainwright has the opportunity to request newer and cleaner technology. This scenario also features the expanded airport and the alternative energy location which is drawn to include wind turbines. New road construction is necessary to connect to the new, enlarged airport; likely other road improvements will be required to handle the

[12] This is not an indication of erosion, and associated impacts. More work is needed to better map erosion and related hazards.

anticipated greater truck traffic. With the large incoming population, medical care facilities will need to be improved and expanded, as represented by the red, cross-shaped building place holder on the map.

6.5.4. Hybrid Scenario Mapping Methods

In the hybrid map, the construction camp is located at the DEW station about 4.25 miles east of the village. It is assumed that construction will only take place during the summer months, so transportation could occur by a locally run ferry system since the DEW Line Station is not accessible by way of road. This creates a controlled barrier between the large, temporary worker population and the locals and provides another local entrepreneurial activity. The production/operation facilities are placed about 2.75 miles north the village at an elevation higher than Wainwright, just past the current landfill site. The distance facilitates restricted social interaction as structured visits can be enforced (e.g. busing workers into the village during the day), but allows for workers to access Wainwright when needed by road.

A unique part of this hybrid scenario would go into effect several years in the future after the construction phase is over when housing requirements decrease and the construction camp is decommissioned. At that time, the buildings will be left vacant and the land will be left “site pad ready." The town would acquire the camp with its utilities, to repurpose as housing and other structural needs.

This scenario provides an opportunity for Wainwright to assist in the design of a new town with custom facilities to be constructed at the expense of oil development companies in a location and from materials that will withstand environmental concerns and meet or exceed building standards. Wainwright residents should be prepared to ask for specific items to be included which will complement existing facilities to accommodate all of the functions of a town including town offices, maintenance facilities, community spaces, medical center, grocery store, school, police station and more. The designs could incorporate state-of-the-art technology and innovative structures designed for efficiency and sustainability in the Arctic such as the "dome home" (Tagiugmiullu Nunamisullu Housing Authority, 2013) and participate in projects from the Tagiugmiullu Nunamiullu Housing Authority. Also of note, is the agriculture industry detailed in Section 6.4 on the Hybrid plan.

Creating this vision for a sustainable Wainwright would require carefully negotiated plans and concessions between the town and oil companies and financing. To achieve maximum benefits, it would also require full participation in design and construction.

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