# REVISION HISTORY AND APPROVAL

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## Authorization Signatures

Paul Ramert, AES Alaska Project Manager  

Date

Amanda Henry, AES Alaska Deputy Project Manager  

Date

Faith Martineau, OPMP Executive Director  

Date
# Table of Contents

REVISION HISTORY AND APPROVAL .............................................................................................................i

ACRONYMS ..........................................................................................................................................................v

GLOSSARY ..........................................................................................................................................................vii

EXECUTIVE SUMMARY .................................................................................................................................... ix

1.0 Introduction ................................................................................................................................................ 1  
1.1 Background and Key Messages ..................................................................................................... 1  
1.2 Scope of Study ........................................................................................................................................ 2  
1.3 Study Limitations .................................................................................................................................... 3  

2.0 Objectives for Cumulative Benefits Analysis Tools and Processes ........................................................... 5

3.0 Literature Search ........................................................................................................................................ 7

4.0 Project Framework ................................................................................................................................... 11

5.0 Potentially Applicable Tools .................................................................................................................... 15  
5.1 Stage 1 Infrastructure Project Identification Tools for Stakeholder Engagement ............................. 15  
5.2 Stage 2 Project Screening and Prioritization Tools ............................................................................. 17  
5.3 Stage 3 Analytical Tools to Define and Analyze Priority Projects ..................................................... 19  
5.4 Stage 4 Project Advancement Tools ................................................................................................. 26

6.0 Conclusions and Recommendations ........................................................................................................ 27  
6.1 Conclusions ............................................................................................................................................ 27  
6.2 Recommendations ............................................................................................................................ 27

7.0 References ................................................................................................................................................ 33

**LIST OF EXHIBITS**

Exhibit 1: Scope of Work for Assessment of Potential Tools for Cumulative Benefits Analysis ...................2  
Exhibit 2: Publications and Media Reviewed During Literature Search .........................................................7  
Exhibit 3: ASTAR Project Stages .....................................................................................................................11  
Exhibit 4: Example of Likert Scales ...............................................................................................................15  
Exhibit 5: Typical SWOT Analysis Matrix ........................................................................................................16  
Exhibit 6: Quality Improvement Team Advisory Group for NSB Comprehensive Planning .......................18  
Exhibit 7: Example Decision Matrix – Foothills West Transportation Access Project ............................. 21  
Exhibit 8: Example Primary Evaluation Criteria for ASTAR ................................................................. 21  
Exhibit 9: Example Criteria Weighting for Stakeholder Viewpoints – Foothills West Transportation Access Project ................................................................. 22  
Exhibit 10: Example Weighted Decision Matrix – Foothills West Transportation Access Project ............. 23  
Exhibit 11: Summary of ASTAR Stages, Potential Tools, and Criteria for Analysis .....................................27  
Exhibit 12: Flow Chart for Stage 1 – Project Identification ...........................................................................28  
Exhibit 13: Recommended Members of ASTAR Advisory Committee ......................................................29
Assessment of Tools for Cumulative Benefits Analysis
Arctic Strategic Transportation and Resources Project

Exhibit 14: Flow Chart for Stage 2 – Project Screening and Prioritization ....................................................... 29
Exhibit 15: Flow Chart for Stage 3 – Project Definition and Analysis................................................................. 30
Exhibit 16: Flow Chart for Stage 4 – Project Advancement................................................................................. 30

LIST OF APPENDICES

Appendix A  PowerPoint Presentation - May 22, 2018 Project Kickoff Workshop
Appendix B  Annotated Bibliography of Literature and Media Reviewed
Appendix C  Executive Summaries of Literature and Media Reviewed
Appendix D  Likert-Type Scale Response Anchors
Appendix E  Sample Stakeholder Engagement Survey
Appendix F  NSB Comprehensive Planning SWOT Analysis Summaries

Distribution
**ACRONYMS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADNR</td>
<td>Alaska Department of Natural Resources</td>
</tr>
<tr>
<td>ADOT&amp;PF</td>
<td>Alaska Department of Transportation and Public Facilities</td>
</tr>
<tr>
<td>AES Alaska</td>
<td>ASRC Energy Services Alaska, Inc.</td>
</tr>
<tr>
<td>AHP</td>
<td>Analytical Hierarchy Process</td>
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<tr>
<td>ASRC</td>
<td>Arctic Slope Regional Corporation</td>
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<td>ASTAR</td>
<td>Arctic Strategic Transportation and Resources</td>
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<tr>
<td>CBA</td>
<td>Cumulative Benefits Analysis</td>
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<tr>
<td>ESRI</td>
<td>Environmental Systems Research Institute</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System(s)</td>
</tr>
<tr>
<td>LCPA</td>
<td>Least-Cost Path Analysis</td>
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<tr>
<td>MCDA</td>
<td>Multi-Criteria Decision Analysis</td>
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<tr>
<td>MCDM</td>
<td>Multi-Criteria Decision Making</td>
</tr>
<tr>
<td>MCE</td>
<td>Multi-Criteria Evaluation</td>
</tr>
<tr>
<td>NPR-A</td>
<td>National Petroleum Reserve – Alaska</td>
</tr>
<tr>
<td>NSB</td>
<td>North Slope Borough</td>
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<tr>
<td>QIT</td>
<td>Quality Improvement Team</td>
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<tr>
<td>RDI</td>
<td>Resource Data, Inc.</td>
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<tr>
<td>SME</td>
<td>Subject Matter Expert</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunities, Threats</td>
</tr>
<tr>
<td>UIC</td>
<td>Ukpiagvik Inupiat Corporation</td>
</tr>
<tr>
<td>USACE</td>
<td>US Army Corps of Engineers</td>
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# GLOSSARY

This glossary defines key terms and concepts as used within the context of this report. Additional information on many of these terms can be found through the sources listed in Section 3.0 Literature Search.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Analytic Hierarchy Process (AHP)</td>
<td>Mathematically based decision-making tool that seeks to reduce complex problems into a hierarchical structure in which pairwise comparisons can be used to synthesize results into discernable preferences among alternatives. AHP can capture both subjective and objective elements of a decision-making problem. Development of this method is attributed to the late Dr. Thomas Saaty.</td>
</tr>
<tr>
<td>Benefit</td>
<td>Actions or ideas that produce good or helpful results or effects that promote well-being or an advantage to humans, cultures, or the physical environment.</td>
</tr>
<tr>
<td>Consistency Ratio</td>
<td>Mathematically-derived measure of consistency among judgments made within the Analytic Hierarchy Method (AHP). It is calculated by dividing computed reciprocal matrix results by an Index value calculated by Saaty (see AHP above) based on the number of inputs to the matrix. A value of &lt;0.1 is considered acceptable, while a value of “0” indicates perfect consistency of input judgments.</td>
</tr>
<tr>
<td>Constraint</td>
<td>Analytical inputs that may restrict or alter project development when considered against a specific desired outcome; stakeholder preference; or regulatory/environmental limitations.</td>
</tr>
<tr>
<td>Criteria (Criterion)</td>
<td>Set of defined standards, parameters, or inputs used to make a judgment or decision.</td>
</tr>
<tr>
<td>Cumulative Benefits Analysis</td>
<td>Analytical approach that seeks to identify changes to economic, environmental, or social values from planned or reasonably foreseeable actions or events that maximize benefits for a broad spectrum of stakeholders and which has the local support of affected people and communities.</td>
</tr>
<tr>
<td>Cumulative Effect</td>
<td>Changes to economic, environmental, and social values caused by the combined effect of present, past, and reasonably foreseeable actions or events. Actions or events can have either positive or negative effects on values.</td>
</tr>
<tr>
<td>Cumulative Effects Assessment</td>
<td>See Cumulative Impacts Analysis.</td>
</tr>
<tr>
<td>Cumulative Impacts Analysis</td>
<td>Analysis that evaluates design criteria and seeks to minimize the risk and undesirable impacts or effects of proposed projects.</td>
</tr>
<tr>
<td>Effect</td>
<td>Actions, ideas, or results that have the power to bring about a result or create a distinct impression in reality or by perception.</td>
</tr>
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Factor

Inputs to any analysis and may be either spatial or non-spatial in nature depending on the tool or analytical process used. In the spatial realm, they may be considered individual layers of data representing mappable features.

Impact

Inputs to analysis that seek to account for human action that may have a direct effect upon or collide with other objectives.

Multi-Criteria Decision Analysis (MCDA) or Multi-Criteria Decision Making (MCDM)

Decision-making concept that offers a means for structuring and solving complex problems, typically those requiring a choice among alternatives where an optimal solution is not obvious. MCDA methods divide problems into smaller, more understandable sub-problems that can be analyzed and synthesized into a meaningful answer. It involves setting goals, identifying stakeholders, and defining alternatives and evaluation criteria in order to produce an answer with the most benefits to stakeholders.

Pairwise Comparison

Process of comparing analytical input factors in pairs to judge which factor is preferred, or has a greater amount of some quantitative property, or whether the two factors are identical.

Python

Open Source programming language often used in Geographic Information Systems (GIS) tools and processes.

Raster Data

Image format composed of cells (pixels) organized in a grid (rows and columns) in which each cell stores a data value that can be used to view or analyze spatial data. Rasters can contain different value types, such as elevation, temperature, population density, or light values that form an aerial image. Many GIS analysis models employ raster data as both inputs and outputs.

Subject Matter Expert (SME)

An SME is a person who is an authority in a particular area or topic. ASTAR SMEs are listed in AES Alaska’s Group 1 and Group 2 proposals.

SWOT Analysis

Planning method used to help identify the strengths (S), weaknesses (W), opportunities (O), and threats (T) of a business organization, but can be adapted for project planning. In the context of project planning, it is intended to specify the strengths and weaknesses of the project and identify internal and external factors that are either favorable or unfavorable in achieving project goals.

Vector Data

Data stored and represented by coordinates for vertices defining the shape of the feature. Typically referred to as a “shapefile” within GIS terminology, vector data can be stored as points, lines, or polygons that can be digitized on-screen and used in mapping and analysis processes.
EXECUTIVE SUMMARY

This report presents the results of a study to identify and assess potential tools or processes that can be used to evaluate the cumulative benefits of infrastructure projects proposed for the North Slope region of Alaska. ASRC Energy Services Alaska, Inc. and Resource Development Inc. conducted this study on behalf of the State of Alaska Department of Natural Resources (DNR) in conjunction with the Arctic Strategic Transportation and Resources Project (ASTAR).

The purpose of the ASTAR project is to identify, evaluate, and advance opportunities to enhance the quality of life and economic opportunities in North Slope communities through responsible infrastructure development. In partnership with the North Slope Borough (NSB), DNR seeks to collaborate with area communities and other stakeholders in an effort to identify community infrastructure and regional connectivity projects that offer the greatest cumulative benefits for the region.

Objectives for cumulative benefits analysis tools include:

- Must be informed by stakeholder input
- Must define a methodology to identify the best projects (or project areas) with greatest benefits
- Must be able to analyze projects for benefits (including benefits associated with minimizing cultural, social, and environmental impacts)
- Must be user friendly – can’t be overly elaborate or complicated
- Must allow for spatial and non-spatial inputs (e.g. important or sensitive cultural, social, environmental, and cost data) that define constraints, factors, and benefits of potential infrastructure projects
- Must include input from subject matter experts
- Must include factors to rank and weight evaluation criteria based on perceived degree of importance and stakeholder viewpoints

The scope of work for this study involved (1) convening a workshop for project kickoff; (2) performing a literature review to identify potential sources of information on decision-making processes or software tools to support benefits analysis (3) compiling potentially relevant publications and media into a digital library, and developing annotated bibliographies for each entry; (4) preparing a report to describe the work activities performed, the literature and media identified, and initial recommendations for tools to support ASTAR’s cumulative benefits analysis (CBA); and (5) providing a summary presentation on findings to ADNR representatives.

The literature review provided insight into a number of issues regarding development of a CBA tool. No single, readily available tool was identified that could comprehensively meet the ASTAR objectives. However, a project framework, along with a number of individual tools and methods to support the framework, was distilled out from the research. The goal of the framework is to establish a process that inherently identifies project areas with the most benefits and local support as project areas analysis moves to further stages of refinement, essentially resulting in project areas that offer the most cumulative benefit rising to the top of the list. The ASTAR project framework is composed of four distinct stages as illustrated and described below.
Stage 1 - Identify Infrastructure Projects through Stakeholder Engagement. The initial stage of the project framework seeks to solicit stakeholder input and preferences; identify infrastructure projects to meet those preferences; and gather information relevant for later project evaluation.

Stage 2 - Identify Project Areas that Offer the Most Cumulative Benefit Potential. Successful stakeholder engagement will result in hundreds of projects identified in Stage 1. Given ASTAR’s goal of identifying project areas with the most cumulative benefit potential and community support, project areas will need to be evaluated to identify which areas have the potential to benefit the greatest number of stakeholders. Accordingly, Stage 2 involves prioritizing areas to be advanced for additional analysis in Stage 3. Project areas moved to Stage 3 will be those determined to offer the most potential cumulative benefit for regional stakeholders; have local support; and demonstrate that they will provide benefits to a wide spectrum of stakeholders.

Stage 3 - Define and Analyze Priority Project Areas Identified in Stage 2. Project areas advanced to Stage 3 are exposed to more rigorous desktop analysis by subject matter experts to characterize the project, describe or quantify expected benefits, and identify feasible alternatives, important constraints, data gaps, and other key factors affecting project success. This involves analyzing the priority projects in detail to adopt an analysis strategy; further define factors and constraints; select scoring criteria and weighting methods; and perform alternatives analysis.

Stage 4 - Collect relevant field data for priority Project Areas. Collect relevant field data (i.e. gravel surveys, Lidar, lake surveys) that will help communities better understand the opportunities and constraints of future infrastructure development. Data collected from these efforts should live long beyond the ASTAR project.

More than twenty different tools and decision-making processes were considered during the course of the research, and of those, ten were considered potentially applicable to meet ASTAR project objectives. Potentially applicable tools and processes included:

- Stakeholder Survey Form with Likert Scales
- Multi-Criteria Decision Analysis (MCDA)
- Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis
- Decision Matrix Method
- Project Ranking by Advisory Group Decision Method
- Weighted Decision Matrix
• Pairwise Comparison of Inputs
• Analytical Hierarchy Process
• Subject Matter Expert (SME) Consultation
• Geographic Information System (GIS) Analysis (including ModelBuilder®, MCDA, Overlay Analysis, Least-Cost Path Analysis, and GeoPlanner®)

The research is summarized in this report along with initial conclusions and recommendations for next steps. The recommendations were reviewed by ADNR staff, who provided feedback and engaged ESRI to provide information on custom software products that could be useful. Based on the input from ADNR and ESRI, the following tools were identified for supporting the ASTAR CBA:

Stage 1: Stakeholder Survey Forms with Likert Scales using ESRI Survey 123®

Stage 2: Analytical Hierarchy Process

Stage 3: MCDA utilizing GIS, SME consultation, and decision matrices
1.0 Introduction

This report presents the results of a study to identify and assess potential tools or processes that can be used to evaluate the cumulative benefits of infrastructure projects proposed for the North Slope region of Alaska. This study was conducted by ASRC Energy Services Alaska, Inc. (AES Alaska) and Resource Development Inc. (RDI) for the State of Alaska Department of Natural Resources (ADNR) in conjunction with the Arctic Strategic Transportation and Resources Project (ASTAR).

1.1 Background and Key Messages

The purpose of the ASTAR project “is to identify, evaluate, and advance opportunities to enhance the quality of life and economic opportunities in North Slope communities through responsible infrastructure development” (ADNR, 2018). In partnership with the North Slope Borough (NSB), ADNR seeks to collaborate with area communities and other stakeholders in an effort to identify community infrastructure and regional connectivity projects that offer the greatest cumulative benefits for the region. ASTAR key messages include:

- ASTAR is operating under a formal partnership agreement that established a working relationship and open dialogue between ADNR and the NSB. This partnership helps to ensure the needs of the people and communities within the borough are reflected in ASTAR’s outcomes.

- Desired outcomes for the ASTAR project include increased cultural connectivity, reduced cost of living in area communities, decreased rehabilitation costs for the National Petroleum Reserve – Alaska (NPR-A) legacy wells, greater opportunities for the development of natural resources, and increased economic activity providing job opportunities for the region.

- Unlike previous infrastructure projects, ASTAR's review will encompass the entire North Slope region, including the NPR-A, Arctic National Wildlife Refuge, and other federal lands and waters. Potential community infrastructure and regional connectivity projects may include port and other marine facilities.

- ASTAR will use a cumulative benefits analysis - advancing projects that seek to provide the greatest benefits to North Slope people and communities - rather than using the standard federal approach of assessing projects for their potential impacts (cumulative impacts analysis), which often focus on negative rather than positive outcomes.

- By identifying tangible cumulative benefits for specific infrastructure projects, ASTAR will significantly inform state and local discussions with federal agencies regarding their land management activities in the region.

- Projects that may provide the greatest cumulative benefits and receive local support will be covered in the greatest detail. This includes identifying potential funding sources, project sponsors, obstacles and challenges, and analyzing permitting and data gaps.

- Deliverables include a strategic plan with identified and detailed infrastructure projects, a cumulative benefits analysis tool, the identification of information gaps, gap-filling studies such as the construction materials survey within a subset of the NPR-A, and the health baseline summary report.
1.2 Scope of Study

The overall scope of this study is to identify, summarize, and assess possible tools and feasible options for cumulative benefits analysis, and provide recommendations for next steps. The scope of work for this study was subdivided into the tasks listed in Exhibit 1. Study requirements included identifying potential tools or processes that incorporate:

- Spatial and non-spatial inputs (e.g. important or sensitive cultural, social, environmental, and cost analysis data) that define constraints, factors, and benefits of potential infrastructure projects
- Evaluation criteria and a methodology involving both qualitative and quantitative analysis as appropriate
- Factors to rank and weight evaluation criteria based on perceived degree of importance and stakeholder viewpoints

Exhibit 1: Scope of Work for Assessment of Potential Tools for Cumulative Benefits Analysis

- **Workshop** – Convene a workshop to kick off the project with AES Alaska, RDI, and ADNR team members. Discuss and review the scope of work, sequence of activities, and potential sources of information.  
  *The workshop was held on May 22, 2018. A copy of the PowerPoint presentation delivered at the workshop is included as Appendix A of this report.*

- **Literature Search and Applicability Review** – Conduct an online search of publications to identify potentially relevant literature on Multi-Criteria Decision Analysis (MCDA), Multi-Criteria Evaluation (MCE), and Rapid Ecological Assessment tools and processes, as well as available Environmental Systems Research Institute (ESRI®) tools and products (e.g. GeoPlanner, ModelBuilder).  
  *A summary of the Literature Search and Applicability Review is presented in Section 3 of this report.*

- **Digital Library, Annotated Bibliography, and Summaries** – Compile potentially relevant publications into a digital library. Develop an annotated bibliography of publications and media reviewed during the literature search.  
  *The digital library was delivered to ADNR on June 22, 2018. The annotated bibliography and executive summaries are included in Appendices B and C of this report.*

- **Report with Preliminary Recommendation** – Prepare a report to describe the work activities performed, the literature identified and media reviewed, their potential applicability to the ASTAR project, and a preliminary recommendation for tool(s) and process(es) to meet the ASTAR project objectives for cumulative benefits analysis.

- **Summary Presentation Development** – Develop a presentation to summarize the research performed for this study, the potential tools and processes identified, and the recommendation for tool(s) and process(es) for ASTAR’s cumulative benefits analysis.

- **Summary Presentation Delivery** – Following completion of this report, deliver the Summary Presentation to ADNR representatives.

- **Project Management** – Throughout this study, perform routine project management duties including project setup in Oracle accounting system, subcontracting with RDI to guide their involvement, monitoring budget and expenditures on a weekly basis, and compiling schedule, progress, and cost information into a biweekly progress reporting structure.
1.3 Study Limitations

This study constitutes preliminary research for cumulative benefits analysis (CBA). The work effort was limited to review of 15 to 20 publications to identify potential tools and processes, evaluating their suitability and application to the ASTAR project, and providing recommendations for further investigation, testing, and refinement in subsequent phases of work. The analysis and conclusions in this study are preliminary in nature and are not intended to represent a comprehensive analysis. Further work may be necessary to refine the identified tools or processes for application to the ASTAR project.
2.0 Objectives for Cumulative Benefits Analysis Tools and Processes

Based on our understanding of ASTAR Key Messages and on discussions with ADNR, the objectives for the CBA tool(s) or process(es) are as follows:

- Must be informed by stakeholder input
- Must define a methodology to select the best projects with greatest benefits
- Must be able to analyze projects for benefits (while not ignoring impacts)
- Must be user friendly – can’t be overly elaborate or complicated
- Must allow for spatial and non-spatial inputs (e.g. important or sensitive cultural, social, environmental, and cost data) that define constraints, factors, and benefits of potential infrastructure projects
- Must include input from subject matter experts (SMEs)
- Must include evaluation criteria and methodology involving both qualitative and quantitative analysis
- Must include factors to rank and weight evaluation criteria based on perceived degree of importance and stakeholder viewpoints
3.0 Literature Search

AES Alaska and RDI conducted a literature search to identify publications and media with information on potential tools and processes that could be applied to ASTAR CBA. Exhibit 2 provides a list of the publications and media reviewed, and Appendix B provides an annotated bibliography for each entry. An executive summary for each entry is provided in Appendix C.

Exhibit 2: Publications and Media Reviewed During Literature Search

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<th>Author or Source</th>
<th>Title</th>
<th>Tool or Process</th>
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<td>Atkinson, David M., Peter Deadman, Douglas Dudycha, and Stephen Traynor</td>
<td>Multi-Criteria Evaluation and Least Cost Path Analysis for an Arctic All-Weather Road</td>
<td>GIS, least-cost path analysis (LCPA), multi-criteria analysis, weighted criteria, pair-wise comparison</td>
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<tr>
<td>Council on Environmental Quality, Executive Office of the President</td>
<td>Considering Cumulative Effects Under the National Environmental Policy Act</td>
<td>National Environmental Policy Act Cumulative Effects Analysis</td>
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<tr>
<td>Hastie, Reid, and Tatsuya Kameda</td>
<td>The Robust Beauty of Majority Rules in Group Decisions</td>
<td>Group decision making</td>
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<tr>
<td>Joshi, Ankur, Saket Kale, Satish Chandel, and Dinesh Pal</td>
<td>Likert Scale: Explored and Explained</td>
<td>Likert Scale</td>
</tr>
<tr>
<td>YouTube Video presented at Soma City Workshop for Planning and Restoration</td>
<td>Using Environmental Systems Research Institute (ESRI) GeoPlanner for ArcGIS as a Framework for Geodesign</td>
<td>GIS, SME value inputs, GeoPlanner for ArcGIS</td>
</tr>
<tr>
<td>Majumder, M</td>
<td>Multi Criteria Decision Making</td>
<td>Multi-Criteria Decision Making (MCDM), Analytic Hierarchy Process (AHP), and Fuzzy Logic Decision Making</td>
</tr>
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<td>Meerman, Jan, and Oswaldo Sabido</td>
<td>Methodology to Conduct Rapid Ecological Assessments of the Impacts of Hurricane Damage to Forests and Watersheds</td>
<td>Rapid Ecological Assessment, stakeholder engagement questionnaires, stakeholder workshops</td>
</tr>
<tr>
<td>Muller, Leena, Joseph D. Rouse, and Shahram Khosrowpanah</td>
<td>GIS-Based Screening for Cumulative and Secondary Impacts from Development Projects in Northern Guam</td>
<td>GIS, SME value inputs, Interviews, Questionnaires, Checklists, Matrices, Network and System Diagrams, Modeling, Trend analysis</td>
</tr>
<tr>
<td>Perzina, Radomir, and Jurajislav Ramik</td>
<td>Microsoft Excel as a Tool for Solving Multi-Criteria Decision Problems</td>
<td>Decision Analysis Module for Excel</td>
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</table>
This literature review provided insight into a number of issues regarding the development of a CBA tool. No single, readily available tool was identified that could comprehensively meet the ASTAR objectives. However, a project framework, along with a number of individual tools and methods to support this framework, was distilled out from the research and is presented in Sections 4 and 5. The goal of this proposed framework is to establish a process that inherently advances projects with the most benefits and local support as project selection moves to further stages of refinement, essentially resulting in the best projects rising to the top of the list.

Ultimately, this review served to highlight the innovative nature of the ASTAR approach in seeking to develop a methodology for identifying and prioritizing projects that offer the greatest cumulative benefits.

Among the conclusions of this literature review is that very little research has been conducted in the analysis of infrastructure projects to determine their overall benefits to stakeholder groups. Most research and established processes (both analytical and regulatory) focus on identifying and assessing negative impacts and proposing ways to avoid or mitigate long-term effects of infrastructure development on the environment. Much attention is placed on constraints to development rather than on the understanding of cumulative benefits.

Although GIS will likely play a significant role in ASTAR project and alternatives evaluation, many of the GIS-based approaches can only address the issue of benefits analysis once specific benefits are quantified and transformed for use in established geoprocessing environments. Current GIS tools and modeling processes will be helpful in the spatial analysis of certain infrastructure types in which spatial factors play a significant role, such as road construction and facility siting. However, the applicability of GIS will be greatly enhanced by inputs from other non-spatial data or methods (e.g., weighting exercises and SME judgments) whose results can be collaboratively incorporated into the spatial regime.

Difficulty in consistently defining “benefits” seems to be an underlying impediment to including such factors in most analyses. Apparent limitations are also imposed when seeking a reliable way in which to incorporate human judgment and the preferences of stakeholder groups with competing interests. Clearly, assimilating the concept of
benefits as defined for the ASTAR project will need further thought and development beyond that contained in current literature.

When ASTAR project development is considered from a decision-making standpoint, several methods and tools that address inclusion of stakeholder input and ways to quantify SME judgments begin to surface for consideration. Much of the reviewed literature centered on tools and methods for making well-informed and comprehensive decisions that were both transparent and defensible, so it seems prudent to adopt a paradigm that incorporates many existing tools and analytical methods that fit the decision-making framework presented in Section 5.

Other key takeaways from the literature review include:

- Thorough consideration of stakeholder and SME inputs is vital but requires carefully designed tools to “tease out” preferences and reduce or eliminate bias in order to provide valid, quantified inputs to further analysis.
- SME inputs are often not as reliable as expected due to bias and limited experience, but proven tools are available to reduce or eliminate bias.
- Valid weighting of inputs is important but must be subjected to consistency evaluation to provide reliable and defensible results. Good weighting methods are available and should be employed at appropriate steps within the framework.
- Spatial and non-spatial inputs often require vastly different methods and skill sets in order to feed good quality data into the analysis but can be brought together cohesively within a proper framework.
- Initial project identification and evaluation can often be performed with fewer computer-based tools, but the information gathered can be critical in future stages.

As a result of this literature research and review, a number of specific tools and processes have been identified as having potential application in CBA for the ASTAR project. The following is a list of these tools and processes, each of which is described more fully in Section 5.

- Stakeholder questionnaires, surveys, and interviews
- Group decision making
- Weighting methods such as matrix development, pairwise comparison, and Analytic Hierarchy Process (AHP)
- SWOT Analysis
- GIS-based geoprocessing methods, such as Least-Cost Path Analysis and Weighted Overlay Techniques
- SME inputs and interviews
- GIS tools such as ESRI’s ModelBuilder and GeoPlanner
• Multi-Criteria Decision Making (MCDM), alternatively known as Multi-Criteria Decision Analysis (MCDA) or Multi-Criteria Evaluation

• Decision Analysis Module for Excel
4.0 Project Framework

CBA is part of a broader ASTAR project framework that incorporates distinct stages and decision points through which increasingly refined elements are passed along to reach successful project implementation. This framework provides for systematic progression from broad consideration of how to meet various needs to evaluation, selection, and advancement of infrastructure projects that meet those needs and provide the most cumulative benefits to stakeholders. Exhibit 3 illustrates this framework, and further explanation of each stage is provided below.

Exhibit 3: ASTAR Project Stages

Stage 1: Identify Infrastructure Projects through Stakeholder Engagement

The initial stage of the project framework seeks to solicit stakeholder input and preferences; identify infrastructure projects to meet those preferences; and gather information relevant for later project evaluation. This stage can be broken down as follows:

- **Identify needs of stakeholders** – Through direct interaction and utilizing prepared materials (such as interviews and surveys), stakeholders are engaged to identify needs that align with the goals and objectives of ASTAR for potential infrastructure project development. These needs may be apparent, meaning there is an obvious lack of specific infrastructure required for delivery of services, business development, employment opportunities, access to healthcare, or some other specific need; or they may be perceived necessities that are difficult to define or for which a coherent solution may not be readily apparent. This stage seeks to clarify these types of issues so they can more easily assimilate into project evaluation.
• **Solicit input and infrastructure project ideas from stakeholders to meet needs** – It is important in this stage to acknowledge stakeholder input provided during previous outreach campaigns (e.g., the NSB Comprehensive Planning process) while also soliciting new input from stakeholders about specific projects or project types related to ASTAR that may, in their view, meet needs for cultural connectivity, reduced cost of living, and increased economic opportunities. These projects may be local or regional in scope. Stakeholders can also identify the benefits they think would be provided by the projects and provide feedback whether a project would have broad local support, which is a critical indicator for project success.

• **Solicit input on important criteria for project evaluation** – Project evaluation requires defined criteria by which analysis can take place. It is important during stakeholder engagement to request input on benefits and other criteria that stakeholders perceive as important in project evaluation. These inputs are often based on human judgement but, nonetheless, can be valuable for use in scoring or weighting variables and further refining analysis processes.

Early identification of, and engagement with stakeholders will be vital in order to leverage their unique viewpoints and experience for project analysis, as well as build rapport and enhance community understanding and support for infrastructure development. Within this framework, some CBA processes and tool development can be integrated with stakeholder engagement strategies and modes set forth in Section 4.3 of the ASTAR Stakeholder Engagement Plan (AES Alaska and UMIAQ 2018). It is suggested that scheduled engagement events or activities be utilized for Stage 1 information gathering as described above.

**Stage 2: Screen and Prioritize Projects**

Successful stakeholder engagement could result in tens or even hundreds of projects identified in Stage 1. Given budget limitations and ASTAR’s goal of prioritizing projects with the most benefits and support, the list of projects may need to be pared down. Accordingly, Stage 2 will involve initial screening of projects for those that should either be eliminated or passed along for additional analysis in Stage 3. Those passed forward to Stage 3 will be determined to best meet needs, goals, and objectives; have local support; and demonstrate that they will provide benefits to a wide spectrum of stakeholders. This stage can be broken down as follows:

• **Screen** – Potential projects are now sifted to identify those that best meet the needs of stakeholders and align with the goals and objectives of ASTAR and which can be viably analyzed in subsequent stages.

• **Prioritize** – Projects advanced beyond initial screening can then be prioritized in order of those that provide the greatest perceived benefits identified by regional stakeholders through quantifying survey results and ranking projects accordingly. Prioritizing at this stage can also aid in later decisions related to available ASTAR funds, based on quantified preferences among projects and/or by establishing a “cut line” for project advancement.

**Stage 3: Define and Analyze Priority Projects**

Projects advanced to Stage 3 are now exposed to more rigorous desktop analysis by SMEs to characterize the project scope, describe or quantify expected benefits, and identify feasible alternatives, important constraints, data gaps, and other key factors affecting project success. This involves analyzing the priority projects in detail to adopt an analysis strategy; further define factors and constraints; select scoring criteria and weighting methods; and perform alternatives analysis.

• **Define Factors and Constraints** – The unique factors and constraints relevant to each project are identified for use in analysis.
• **Select Criteria for Analysis** – Standards or parameters used to make judgments or decisions about factors and constraints analysis are selected.

• **Select weighting methods for analysis** – Appropriate importance – or “weights” – can be calculated and applied to the various evaluation criteria.

• **Identify and Fill Data Gaps** – Once a set of needed factors and constraints is inventoried and available data is readied for analysis, gaps existing between needed and available data must be filled if possible or the analytical plan must be modified to accommodate irreconcilable gaps. The majority of these gaps can likely be filled from the desktop, and will be whenever possible, but some may require fieldwork to gather needed information.

• **Determine Alternatives** – A robust and comprehensive analysis requires consideration of alternatives that can be compared and scored to rank and defensibly make recommendations for a preferred project alternative to be advanced.

• **Perform Analysis** – Analysis is then performed for each alternative. Each alternative is scored and ranked, and the preferred alternative is recommended for advancement as appropriate.

**Stage 4: Advance Projects**

Projects passing the screening and analysis of prior stages are now advanced for approval and identification of sponsors and funding sources.
5.0 Potentially Applicable Tools

This section presents a summary of potential tools and processes applicable to the ASTAR project during each stage of the project framework. Tools generally refer to custom or off-the-shelf computer software, while processes generally refer to systematic engagement with stakeholders, advisory groups, and SMEs. Both tools and processes work in conjunction to support the project framework and are collectively referred to as tools. Section 5.1 describes potential tools relevant for Stage 1 Project Identification; Section 5.2 describes tools relevant to Stage 2 Project Screening and Prioritization; Section 5.3 describes tools relevant to Stage 3 Project Definition and Analysis; and Section 5.4 describes tools relevant to Stage 4 Project Advancement.

Many of the tools described are complex and it is beyond the scope of this report to provide a full explanation of each one. For additional information, the reader is referred to the sources listed in Exhibit 2 and Appendix B.

5.1 Stage 1 Infrastructure Project Identification Tools for Stakeholder Engagement

Stage 1 Goal: The goal of Stage 1 is to solicit stakeholder input and preferences; identify infrastructure projects to meet those preferences; and gather information relevant for later project evaluation.

Stage 1 Potential Tools: Potential tools considered for Stage 1 are listed below. These tools would be employed in the context of stakeholder engagement meetings or workshops:

- Stakeholder Survey Form with Likert-Type Scale Response Anchors
- SWOT Analysis

These tools are described below and are evaluated for potential application during the ASTAR project.

5.1.1 Stakeholder Survey Form with Likert-Type Scales

Description. Stakeholder survey forms incorporating Likert scales are widely used to measure attitudes and opinions with a greater degree of nuance than a simple “yes/no” question. By definition, Likert scales are survey questions that offer a range of answer options – from one extreme attitude to another, like “extremely likely” to “not at all likely.” Typically, Likert scales should be designed with an odd number of values, allowing for a neutral midpoint. Likert scales help uncover greater detail and degrees of opinion that could significantly improve the understanding of stakeholder feedback that is received. A sample list of Likert-Type Scales is included in Appendix D, and an example Likert scale is provided in Exhibit 4. Dawes (2008) reported that scales with five or seven levels tend to produce better results than scales using nine or more levels.

Exhibit 4: Example of Likert Scales

<table>
<thead>
<tr>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Strongly disagree</td>
</tr>
<tr>
<td>2 – Disagree</td>
</tr>
<tr>
<td>3 – Somewhat disagree</td>
</tr>
<tr>
<td>4 – Neither agree or disagree</td>
</tr>
<tr>
<td>5 – Somewhat agree</td>
</tr>
<tr>
<td>6 – Agree</td>
</tr>
<tr>
<td>7 – Strongly agree</td>
</tr>
</tbody>
</table>
Using Likert scales can help avoid some common pitfalls of survey design, like creating overly broad questions that respondents may find too difficult to think about or articulate. This could lead to frustration and short responses that spoil the quality of information received.

Since 2015, the NSB has successfully used Likert scales to gauge respondent’s awareness and understanding of topics related to the Comprehensive Planning project.

**Evaluation.** A carefully designed stakeholder questionnaire for ASTAR will help identify stakeholder needs, infrastructure projects that could fill those needs, the benefits provided by those projects, and which projects would offer the most benefits and receive broad local support. If the questionnaire includes Likert scale responses, the quality of responses will be improved, and the questionnaires can be more easily compared and evaluated to identify potential projects that should receive more detailed analysis. With proper design, these surveys can also serve as inputs to Stage 2 tools such as pairwise comparison and AHP. Appendix E presents a sample Stakeholder Survey Form for ASTAR using Likert scale Level of Agreement anchors.

### 5.1.2 SWOT Analysis

**Description.** SWOT analysis is typically an examination of an organization’s internal strengths and weaknesses, its opportunities for growth and improvement, and the threats the external environment presents to its survival. The internal analysis is used to identify resources, capabilities, core competencies, and competitive advantages inherent to an organization. The external analysis identifies market opportunities and threats by looking at a competitor’s resources, the industry environment, and the general environment. Exhibit 5 presents a typical matrix used to record information gathered during a SWOT analysis.

Inputs for the SWOT are typically gathered and synthesized in a workshop environment for placement in the appropriate category within the matrix (S, W, O, or T). The results are then discussed among the group and strategies are subsequently developed to maintain or build upon strengths, overcome or compensate for weaknesses, capitalize on opportunities, and mitigate threats.

**Exhibit 5: Typical SWOT Analysis Matrix**

For the ongoing NSB comprehensive planning project, the planning team used SWOT analyses in a series of workshops with residents and community leaders to identify the strengths, weaknesses, opportunities, and threats
for each North Slope community. Results of these SWOT analyses helped establish an understanding of each community’s unique needs, some of which involved infrastructure projects. Appendix F summarizes the outcome of the SWOT analyses for each community.

**Evaluation.** SWOT analysis is normally focused on analyzing business performance and the business environment; however, as demonstrated by the NSB planning project, it can be used to help identify community infrastructure needs, and may be a useful tool to employ during Stage 1 stakeholder engagement.

### 5.2 Stage 2 Project Screening and Prioritization Tools

**Stage 2 Goal:** The goal of Stage 2 is to provide initial screening and prioritizing of projects to identify those that should either be eliminated or passed along for additional analysis in Stage 3. Assuming the ASTAR stakeholder engagement process is effective, tens, or even hundreds of potential projects could be identified during Stage 1 stakeholder engagement. With ASTAR’s limited budget and timeline, not every project that is identified can be advanced for further consideration.

**Stage 2 Potential Tools:** Potential tools considered for Stage 2 include:

- Project Ranking by Advisory Group Decision Method
- Pairwise Comparison of Inputs
- Analytic Hierarchy Process

Each of these is described below and is evaluated for potential application during the ASTAR project.

#### 5.2.1 Project Ranking by Advisory Group Decision Method

**Description.** Group decision making involves individuals collectively making a choice or choices from the alternatives before them. The decision is then no longer attributable to any single individual who is a member of the Group. The decisions made by groups are often different from those made by individuals and are generally more representative of broad consensus.

Social decision schemes are methods used by a group to combine individual responses to come up with a single group decision. Types of social decision schemes include delegation; averaging; plurality; unanimity; and random. Plurality is the most consistent technique, and it involves the least amount of effort (Hastie and Kameda 2005). For plurality, group members vote on their preferences, either privately or publicly. These votes are then used to select a decision, by either simple majority, supermajority, or other more or less complicated voting system.

For cases where group decisions involve selection of a short list of options from a much larger list, ranking is a valuable technique. Asking group members to rank the options either before or during the meeting will allow alternatives that show the most promise to be identified. More than one round of ranking may be necessary to achieve consensus and converge on a short list.

As an example of group decision making, the current NSB comprehensive planning effort includes a stakeholder advisory group whose role is to provide guidance and recommendations on the comprehensive planning team’s planning efforts and contractual compliance. This advisory group, called the Quality Improvement Team (QIT), was established specifically for the comprehensive planning effort. The group meets quarterly and decision-making is achieved through discussion and consensus building. As listed in Exhibit 6, the group currently consists of 13 stakeholder representatives from each of the eight North Slope communities, the NSB, Arctic Slope Regional...
Corporation (ASRC), and Ukpiagvik Inupiat Corporation (UIC). ADNR could engage this QIT Team or establish a similar advisory group to assist with initial project screening and ranking for ASTAR.

**Exhibit 6: Quality Improvement Team Advisory Group for NSB Comprehensive Planning**

<table>
<thead>
<tr>
<th>QIT Stakeholder Representatives</th>
<th>Village Representatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Executive Members</strong></td>
<td><strong>Village Representatives</strong></td>
</tr>
<tr>
<td>Forrest “Deano” Olemaun, NSB</td>
<td>Ida Angasan, Kaktovik</td>
</tr>
<tr>
<td>Ken Robbins, NSB Assistant to the Mayor</td>
<td>Bob Harcharek, Utqiagvik</td>
</tr>
<tr>
<td>Gordon Brower, NSB Planning Director</td>
<td>John Hopson, Jr., Wainwright</td>
</tr>
<tr>
<td>Colleen Abad, ASRC</td>
<td>Susan Mekiana-Morry, Anaktuvuk Pass</td>
</tr>
<tr>
<td>Richard Reich, ASRC</td>
<td>Alzred Steve Oomittuk, Point Hope</td>
</tr>
<tr>
<td>Nagruk Harcharek, UIC</td>
<td>George Sielak, Nuiqsut</td>
</tr>
<tr>
<td>Jason Bergerson, NSB</td>
<td>Bill Tracey, Point Lay</td>
</tr>
<tr>
<td></td>
<td>Doug Whiteman, Atqasuk</td>
</tr>
</tbody>
</table>

**Evaluation.** Given the potential for a large number of suggested projects to emerge from Stage 1, project ranking by group decision with an Advisory Group appears to be an effective method to pare down the number of potential projects, by only nominating the top projects for each community or stakeholder group that offer the most perceived benefits and receive broad local support.

### 5.2.2 Pairwise Comparison of Inputs

**Description.** Pairwise Comparison of Inputs is a process of comparing analytical input factors in pairs to judge which factor is preferred, or has a greater amount of some quantitative property, or whether the two factors are identical. The method of pairwise comparison can also express the relative importance of one factor over another. Pairwise comparisons are performed using proven mathematical techniques involving reciprocal matrices that show factor preferences and importance. Within the ASTAR project, these matrices can then be used within the AHP method to evaluate project factors against overall objectives of connectivity, local support, and cumulative benefits.

**Evaluation.** Pairwise comparisons can make use of information gathered in Stage 1 surveys to help determine preferred project types or demonstrate the relative importance of factors or projects to different stakeholder groups. This is an explicitly mathematical process and, combined with AHP, pairwise comparison could aid in ranking projects for advancement to more rigorous project analysis in Stage 3.

### 5.2.3 Analytic Hierarchy Process

**Description.** AHP is an increasingly popular decision-making tool that utilizes mathematics and psychology to structure and evaluate complex problems within or between groups that have multiple criteria to consider. AHP helps to find a decision that best suits the goals and objectives of a problem, by organizing problem elements into a hierarchy that can be easily understood and quantified. The hierarchy breaks the overall problem (or goals and objectives) into levels of sub-problems that can be compared to one another and across levels. AHP uses pairwise comparison of problem elements, which can be either discrete data or human judgments about the meaning and importance of the elements. Ultimately, the goal is to evaluate these sub-problems against the overall goals and provide quantifiable results to allow for evaluation of alternatives, some of which may not be apparent at process initiation.
Using AHP, analysis inputs are converted to numerical values that can be calculated and compared over the entire hierarchy. Numerical weights, (variously referred to as priorities or preferences), are derived and presented in a matrix such that preferred alternatives can be determined. A Consistency Ratio is also calculated to evaluate how reasonable the outcomes are based on the nature of the inputs. AHP allows for diverse, and seemingly incomparable, inputs or problems to be compared rationally and to provide a defensible decision to be made.

**Evaluation.** AHP is a rigorous method that requires mathematical skills and thoughtful construction of pairwise comparison matrices. The calculations can be performed in an Excel spreadsheet or existing software packages can be utilized. AHP can be modified for simple or complex problem hierarchies, so it is adaptable for use in Stage 2 project screening, or for more complex project alternative analysis in Stage 3.

### 5.3 Stage 3 Analytical Tools to Define and Analyze Priority Projects

**Stage 3 Goal:** The goal of Stage 3 is to analyze priority projects promoted from Stage 2 in greater detail and to advance projects with the most benefits for approval and identification of sponsors and funding sources.

Evaluation of alternatives for a given project concept is often a requirement in many regulatory processes, but is also considered a best practice prior to decisions on costly investments in terms of money and time. Alternatives analysis often helps generate local support by demonstrating to stakeholders the logic of one alternative over another while also showing due consideration of the potential effects on the environment and culture.

In order to meet ASTAR objectives, it necessary to examine alternatives to identify the optimal balance of cost-effectiveness, cultural sensitivity, local support, environmental soundness, and overall benefits to the project area. In consideration of this, Stage 3 requires identification of alternatives for each project.

Also in this stage, clearly defined criteria must be established and supporting data prepared to enable project alternatives analysis. This will require appropriate tools and SME input in order to establish a rational and defensible evaluation of proposed projects.

**Stage 3 Potential Tools:** Potential tools considered for Stage 3 include:

- SME Consultation
- Decision Matrix Method
- Weighted Decision Matrix
- Multi-Criteria Decision Analysis
- Pairwise Comparison of Inputs
- Analytic Hierarchy Process
- GIS Analysis

### 5.3.1 Subject Matter Expert Consultation

**Description.** Consultation with SMEs will be necessary to identify inputs to analyses and inform the weights of various factors identified criteria to these analyses. SME Consultation enables analysts to select appropriate spatial and non-spatial data as well as to help decide the best approach for codifying value judgments about these data.
SMEs will be consulted to ascertain this input. This information will then be used in the analytical processes described in the following sections.

**Evaluation.** SME consultation is vital for successful completion of Stage 3 project analysis. Depending on the particular project, SME’s may be needed for land tenure, wetlands, fish and wildlife, cultural and paleontological resources, hydrology, subsistence, economics/socioeconomics, geology, engineering, construction methods, regulatory, contaminated sites, or other areas of expertise.

### 5.3.2 Decision Matrix Method

**Description.** The decision-matrix method is a technique used to rank the multi-dimensional options of an option set. It is frequently used in engineering for making design decisions but can also be used to rank investment options, vendor options, product options, or any other set of multidimensional entities. The method is also referred to as the Pugh Method, Pugh Concept Selection, Criteria Scoring Method, Criteria Ranking Method, and other similar names.

The advantage of the decision-making matrix is that subjective opinions about one alternative versus another are made more objective by incorporating multiple criteria in the decision making process. Another advantage of this method is that sensitivity studies can be performed. An example of this might be to see how much opinions would have to change in order for a lower-ranked alternative to outrank a competing alternative.

Examples of projects using the decision matrix method include the Foothills West Transportation Access project (Alaska Department of Transportation and Public Facilities [ADOT&PF] 2009), the Ambler Mining District Access Summary Report (DOWL HKM 2011), and the Alaska Deep-Draft Arctic Port System Study (USACE 2013). AES Alaska has also used the decision-matrix method to compare options for confidential North Slope pipeline and road routing studies for Shell Exploration and Production Company.

Exhibit 7 provides an example of the decision matrix used for the Foothills West Transportation Access project. In this example, alternate routes for a road to Umiat were analyzed according to nine primary criteria: project purpose; construction cost; engineering considerations; hydrologic considerations; geologic and geotechnical considerations; land ownership; environmental considerations; maintenance costs; and subsistence. Each of these primary evaluation criteria were supported by a host of spatial data presented in GIS, and non-spatial data such as construction cost estimates and engineering criteria. After the data were assembled and each alternative was defined in an alternatives analysis report, the five route alternatives were assigned scores from 0 to 5 for each criterion, with 0 representing the least desirable option for a given criterion, to 5 representing the most desirable. The scores were then summed to identify a preferred alternative.
**Exhibit 7: Example Decision Matrix – Foothills West Transportation Access Project**

<table>
<thead>
<tr>
<th>Criteria Scores for Corridors</th>
<th>Franklin Bluffs</th>
<th>Pump Station 2</th>
<th>Pump Station 3</th>
<th>Galbraith</th>
<th>Galbraith West Alternate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Purpose</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Engineering Considerations</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Hydrologic Considerations</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Geologic and Geotechnical Considerations</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Land Ownership</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Considerations</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Maintenance Costs</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Subsistence</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>23</td>
<td>24</td>
<td>24</td>
<td>35</td>
<td>29</td>
</tr>
</tbody>
</table>

**Evaluation.** Decision matrices are a widely accepted tool for evaluation of project alternatives, and would be useful in Stage 3 for contrasting and comparing alternative routes or locations for infrastructure with respect to selected criteria. For ASTAR, evaluation criteria must include benefits in addition to impacts. For example, primary criteria can be developed that are similar to the list in Exhibit 8.

**Exhibit 8: Example Primary Evaluation Criteria for ASTAR**

<table>
<thead>
<tr>
<th>Primary Criterion</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benefits-Related Criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Minimization</td>
<td>Minimize environmental and undesirable socio-cultural impacts</td>
</tr>
<tr>
<td>Co-Location</td>
<td>Co-locate infrastructure or new development to reduce environmental footprint</td>
</tr>
<tr>
<td>Jobs/Economic Opportunity</td>
<td>Improve socio-economic conditions and job opportunities for local residents</td>
</tr>
<tr>
<td>Enabler</td>
<td>Improve economics for other marginal or currently uneconomic projects. Increase the life of the Trans-Alaska Pipeline and other oil and gas infrastructure already in place</td>
</tr>
<tr>
<td>Lower Cost Goods and Services</td>
<td>Lower the cost of energy, basic goods, utilities, and other services</td>
</tr>
<tr>
<td>Health and Safety</td>
<td>Improve basic public safety. Enhance logistics to perform remediation at legacy well sites or other contaminated sites</td>
</tr>
<tr>
<td>Connectivity and Sustainability</td>
<td>Improve infrastructure to provide basic community connectivity and sustainability</td>
</tr>
<tr>
<td><strong>Constraints-Related Criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Ecological</td>
<td>Environmental inputs (e.g. wetlands, high-value wildlife habitat, calving areas, etc.)</td>
</tr>
<tr>
<td>Sociocultural</td>
<td>Cultural resources, subsistence resources, stakeholder input</td>
</tr>
<tr>
<td>Engineering</td>
<td>Engineering constraints (e.g. slope aspect, geologic materials, water crossings, etc.)</td>
</tr>
<tr>
<td>Financial</td>
<td>Preliminary cost estimates</td>
</tr>
<tr>
<td>Regulatory</td>
<td>Regulatory constraints (e.g. offsets, restricted/protected areas, etc.)</td>
</tr>
<tr>
<td>Land Tenure</td>
<td>Land ownership, leases, rights-of-way, etc.</td>
</tr>
</tbody>
</table>
5.3.3 Weighted Decision Matrix

**Description.** A weighted decision matrix operates in the same way as the basic decision matrix described above but introduces the concept of weighting the criteria in order of importance. The resultant scores provide a better reflection of decision makers’ perceived relative importance of criteria involved in the process. The more important the criteria, the higher the assigned weighting.

Weighting can also be used to account for different societal viewpoints concerning a given criteria. For example, in the case of routing a fiber optic system, the primary objective of a communications company might be cost-effective construction, whereas the primary objective of an environmental group would likely be environmental protection. The relative importance of routing criteria considered could be quite different. Each party faces the challenge of assessing and clearly articulating the relative importance of the criteria affecting the decision. Weights for criteria can be generated through the pairwise comparison process described in Section 5.2.2., or through discussion with an informed multidisciplinary group operating in an as objective manner as possible.

Examples of projects that used weighted decision matrices include the Foothills West Transportation Access project (ADOT&PF 2009) and confidential North Slope pipeline and road routing studies for Shell Exploration and Production Company. Exhibit 9 shows an example of criteria weighting used for the Foothills West Transportation Access project. Each criteria was weighted by its importance in decision-making based on a range of viewpoints typically expressed in public input processes. Five different viewpoints were selected: State, Community, Environmental, Engineering, and Industry. Each criterion was then evaluated based on its importance to each specific viewpoint, assigning a score from 0 to 4, with 0 identifying a criterion as least important to a specific viewpoint, and a 4 inferring a criterion as most important to a viewpoint. Viewpoint importance rankings for each criteria were then averaged to model a spectrum of input opinion and a final, averaged decisional weight for each criteria was determined. Preliminary weightings for each viewpoint were generated in as objective a manner as possible by a multidisciplinary group of ADOT&PF staff.

**Exhibit 9: Example Criteria Weighting for Stakeholder Viewpoints – Foothills West Transportation Access Project**

<table>
<thead>
<tr>
<th></th>
<th>State</th>
<th>Community</th>
<th>Environmental</th>
<th>Engineering</th>
<th>Industry</th>
<th>Average Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Purpose</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>2.8</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>Engineering</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>Hydrologic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2.4</td>
</tr>
<tr>
<td>Geologic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>Land Ownership</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2.6</td>
</tr>
<tr>
<td>Environmental</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>Maintenance</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2.2</td>
</tr>
<tr>
<td>Subsistence</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Exhibit 10 shows the result of applying the average weights derived in Exhibit 9 to the criteria scores summarized in Exhibit 7. The result indicates the Galbraith Route was the most advantageous corridor based on the 9 primary weighted criteria.

**Exhibit 10: Example Weighted Decision Matrix – Foothills West Transportation Access Project**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Weight</th>
<th>Franklin Bluffs</th>
<th>Pump Station 2</th>
<th>Pump Station 3</th>
<th>Galbraith</th>
<th>Galbraith West Alternate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Purpose</td>
<td>2.8</td>
<td>8.4</td>
<td>2.8</td>
<td>5.6</td>
<td>11.2</td>
<td>14</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>1.8</td>
<td>5.4</td>
<td>3.6</td>
<td>1.8</td>
<td>9</td>
<td>7.2</td>
</tr>
<tr>
<td>Engineering Considerations</td>
<td>2.4</td>
<td>2.4</td>
<td>4.8</td>
<td>9.6</td>
<td>12</td>
<td>7.2</td>
</tr>
<tr>
<td>Hydrologic Considerations</td>
<td>2.4</td>
<td>2.4</td>
<td>4.8</td>
<td>7.2</td>
<td>12</td>
<td>9.6</td>
</tr>
<tr>
<td>Geologic and Geotechnical Considerations</td>
<td>2.4</td>
<td>2.4</td>
<td>4.8</td>
<td>7.2</td>
<td>12</td>
<td>9.6</td>
</tr>
<tr>
<td>Land Ownership</td>
<td>2.6</td>
<td>13</td>
<td>10.4</td>
<td>7.8</td>
<td>5.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Environmental Considerations</td>
<td>2.8</td>
<td>2.8</td>
<td>5.6</td>
<td>8.4</td>
<td>14</td>
<td>11.2</td>
</tr>
<tr>
<td>Maintenance Costs</td>
<td>2.2</td>
<td>11</td>
<td>8.8</td>
<td>2.2</td>
<td>6.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Subsistence</td>
<td>2.4</td>
<td>7.2</td>
<td>12</td>
<td>9.6</td>
<td>2.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Totals</td>
<td>55.0</td>
<td>57.6</td>
<td>59.4</td>
<td>84.4</td>
<td>70.6</td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation.** Implementing a weighted matrix into ASTAR Stage 3 would meet the objective of including factors to rank and weight evaluation criteria based on perceived degree of importance and stakeholder viewpoints.

### 5.3.4 Multi-Criteria Decision Analysis

**Description.** MCDA provides a method to support decision-making within a framework that integrates multiple stakeholder viewpoints with analytical input factors and constraints. These inputs can be weighted according to preference or importance and used to select the most suitable course of action. Consensus is thereby sought from stakeholder inputs to identify project priorities or preferences. MCDA can be applied to many different project types, from infrastructure and land use planning to socioeconomic development. Other tools mentioned in this section, such as decision matrices, pairwise comparisons, and AHP, all fit within the concept of MCDA. A full example of using MCDA is too lengthy and complex to include in this report. However, a good example is provided in *GIS-based multi-criteria analysis for land use suitability assessment in City of Regina* available at [https://link.springer.com/article/10.1186/2193-2697-3-13](https://link.springer.com/article/10.1186/2193-2697-3-13).

**Evaluation.** MCDA could be applicable to Stage 3 as a means to integrate many different stakeholder viewpoints and varied analytical inputs that may be encountered during project evaluation.

### 5.3.5 Pairwise Comparison of Inputs

**Description.** Refer to section 5.2.2 for a discussion of Pairwise Comparison of Inputs.
Evaluation. Pairwise comparison could be useful in Stage 3 for determining proper weighting of input factors and constraints in GIS applications.

5.3.6 Analytic Hierarchy Process

Description. Refer to section 5.2.3 for a discussion on AHP. Its applicability in Stage 3 centers on its usefulness for evaluation of alternatives within projects to achieve the decision most appropriate to overall ASTAR goals.

Evaluation. AHP could be applicable for Stage 3 project alternatives analysis.

5.3.7 Geographic Information Systems Analysis

Description. GIS is a computer-based system designed to capture, store, manipulate, analyze, manage, and display spatial data. Mappable features can be digitized as points, lines, or polygons (commonly referred to as vector data) and have associated attribute tables containing information about these features. These tables may contain both spatial (e.g., location coordinates or acreage) and non-spatial (e.g., ownership or zoning type) data that can be displayed in specific ways on maps or as inputs to analysis. GIS can also utilize data stored in raster files or pull additional information from tabular sources in a variety of formats.

GIS analysis can range from simple techniques, such as simple map presentation of related features, to complex processes involving custom programming and geoprocessing tools. GIS tools identified for use in CBA development for ASTAR are described below:

- **MCDA Description.** Within GIS analysis, MCDA is a process that seeks to aid in decision-making by structuring problems through analyses that incorporate both spatial and non-spatial inputs, as well as value judgments about those inputs. These value judgments, often determined by consultation with SMEs, are used to quantify inputs and provide weighting values (or degree of importance) for each layer of information. MCDA makes use of, or can be incorporated within, the geoprocessing tools described below.

  Evaluation. MCDA is well suited for implementation in Stage 3, but careful design of analyses will be needed to make full use of its concepts. Some GIS tools, such as GeoPlanner, may impose limitations on its applicability.

- **Overlay Analysis Description.** This method is a common approach to solving multi-criteria problems, such as project site selection and resource use suitability. Overlay analysis employs GIS tools to define the problem and break it into sub-problems or models; determine the significant input layers for use in the model; reclassify the data layers to a common scale for meaningful analysis; weight the input layers; add or combine the layers; and then analyze the results of the process. The process seeks to identify an optimal solution (e.g., best project site) based on the aggregated results. ESRI’s ArcGIS desktop software contains the tools to perform these analyses.

  Evaluation. Overlay Analysis could be useful in Stage 3 alternatives analysis, especially when evaluation of site selection or best resource use is necessary.

- **Least-Cost Path Analysis Description.** LCPA is a common method for use in routing, such as determining optimal road alignment based on multiple criteria. It seeks to find the path with “least cost” from an origin to a destination. “Cost” in LCPA is usually understood as the level-of-effort required to transit an area, whether in terms of physical obstacles like terrain, river crossings, and material resources or in terms of environmental or human constraints, such as land use restrictions or culturally-sensitive
areas. These costs can be a function of time, distance, or essentially any other criteria that can be defined as important in the analysis.

This method is raster-based and thus often requires steps to transform vector data to this format before it can be used in analysis. LCPA employs techniques similar to Overlay Analysis but requires the creation of rasters for the source (the location to which the path from each raster cell is calculated); the cost (the user-defined impedance for moving through each cell); and the cost distance (the effort needed to travel between neighborhood nodes as calculated within the raster). Once these are created, an algorithm derives the least-cost path from the source to user-defined destination(s).

**Evaluation.** LCPA could be useful in Stage 3 alternatives analysis, notably in examining linear features, such as road alignments, where multiple alignments and degree of infrastructure connectivity can be evaluated.

- **ModelBuilder Description.** ModelBuilder is a visual programming language for building geoprocessing workflows. It can include any combination of out of the box ESRI toolbox tools or custom geoprocessing tools. It can consume and output spatial and non-spatial data. ModelBuilder can iteratively process many scenarios in a single execution, or portions of the model can be run systematically. There are a large selection (hundreds) of tools from ESRI’s toolbox that allow for flexibility in arranging and utilizing those tools. It can also be exported as a Python script and be further refined by more experienced developers if necessary, since Python is a powerful scripting language.

**Evaluation.** With regard to ASTAR, some benefits to using ModelBuilder are that the developed model could be exported as a distinct tool. Another potential benefit for the ASTAR project is that outputs from ModelBuilder can be easily imported into other online tools, so if the cumulative benefits analysis is a framework of tools/applications, then ModelBuilder would be applicable in various places within the GIS portion of that framework. In comparison to GeoPlanner, ModelBuilder does not provide any kind of user interface, dashboard, or key performance indicators; if required by the ASTAR project team, these would need to be developed separately.

- **GeoPlanner Description.** GeoPlanner is a web-based application that has tools to support land use planning and business intelligence. It runs analytics on the fly as users create and edit spatial and non-spatial data and metrics about development projects. It provides a collaborative ability for teams to create and evaluate different scenarios and project alternatives. The tool allows users to create and share designs, key performance indicators, data, projects, dashboards, and maps across the organization or with the public. If the out-of-the-box model is not fit for purpose, the analysis can be customized from within the GeoPlanner platform. It includes pre-developed tools to assess site suitability and conditions using weighted raster overlay and spatial analytics. Criteria are established that include spatial features representing opportunities, risks, and constraints. Weighted values can be set against the chosen criteria. The model is run and an output raster is created whose cells are color coded to reveal areas most suitable for the alternative being evaluated. Additionally, GeoPlanner includes evaluation tools that help visualize the degree of stakeholder consensus in land use alternatives – thus could assist in understanding which projects or project alternatives would receive local support.

**Evaluation.** GeoPlanner provides a suite of pre-established models to achieve many of the desktop analytic activities in Stage 3 of the ASTAR project framework. The weighted raster overlay analysis allows the user to assign weight to attributes to established factors and constraints. However, it requires that the criteria be represented as spatial features, which may not represent a problem in Stage 3. It includes canned (out-of-the-box) analytics tools that would help determine alternatives: find hot spots, derive new locations, create travel time areas, calculate density, create buffers, and aggregate points. One
drawback is the methodology and algorithms in the various off-the-shelf models and tools is not well
documented, and while GeoPlanner does provide the ability to customize the analytics, it is unclear to
what level they could be customized and whether a robust methodology like MCDA could be employed.

**Evaluation.** GIS Analysis is an effective tool for use in Stage 3 where project analysis has a spatial component. It would not be necessary if no new infrastructure were being considered, such as in enhancements to existing facilities wherein the benefits would be determined on a socioeconomic, rather than spatial, basis.

### 5.4 Stage 4 Project Advancement Tools

**Stage 4 Goal:** The goal of Stage 4 is to advance projects with the most benefits for approval and identification of sponsors and funding sources.

**Stage 4 Potential Tools:** No tools are necessary for Stage 4.
6.0 Conclusions and Recommendations

This section presents our conclusions and recommendations for assessment of potential tools for ASTAR CBA. Section 6.1 presents a list of our general conclusions from the study, and Section 6.2 presents our recommendations for each distinct stage of the project framework.

6.1 Conclusions

- Our Literature Search (Section 3) did not identify a singular comprehensive tool that achieves all of the goals and objectives of ASTAR.

- Achieving the ASTAR goals and objectives identified in the “Key Messages” (Section 1.1) and summarized in Section 2.0 Objectives, requires a process with distinct stages and various tools employed at each stage. We have defined this process in Section 4.0, Project Framework, and it is summarized in Exhibit 11 below. We believe the methodology is rational and defensible, without being overly complex or unnecessarily expensive to implement.

- Some flexibility in the process and in the application of tools may be needed, depending on the projects identified, especially in Stage 3.

Exhibit 11: Summary of ASTAR Stages, Potential Tools, and Criteria for Analysis

<table>
<thead>
<tr>
<th>Stage</th>
<th>No. Projects Considered</th>
<th>Potential Tools</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 – Project Identification</td>
<td>10’s to 100’s</td>
<td>◦ Likert-Type Scales ◦ SWOT Analysis</td>
<td>◦ Benefits ◦ Local Support</td>
</tr>
<tr>
<td>Stage 2 – Project Screening and Prioritization</td>
<td>10’s</td>
<td>◦ Project Ranking by Advisory Group Decision Method ◦ Pairwise Comparison ◦ Analytical Hierarchy Process</td>
<td>◦ Benefits ◦ Local Support</td>
</tr>
<tr>
<td>State 3 – Project Definition and Analysis</td>
<td>10 or as funding allows</td>
<td>◦ SME Consultation ◦ Decision Matrix Method ◦ Weighted Decision Matrix ◦ Multi-Criteria Decision Analysis ◦ Pairwise Comparison of Inputs ◦ Analytic Hierarchy Process ◦ GIS Analysis</td>
<td>◦ Benefits-Related Criteria ◦ Constraints-Related Criteria ◦ See Exhibit 8</td>
</tr>
<tr>
<td>Stage 4 – Project Advancement</td>
<td>10 or as funding allows</td>
<td>◦ Potential Funding Sources ◦ Project Sponsors</td>
<td>◦ Not Applicable</td>
</tr>
</tbody>
</table>

6.2 Recommendations

6.2.1 Recommendations for Stage 1 - Project Identification

For Stage 1 Project Identification, we recommend distributing carefully designed stakeholder questionnaires in each stakeholder engagement meeting. The questionnaires will help identify stakeholder needs, infrastructure projects that could fill those needs, the benefits provided by those projects, and which projects would offer the most benefits and receive broad local support. Design of the questionnaire should be a collaborative effort between
ADNR and ASTAR team members from Group 3 – Stakeholder Outreach and Coordination and Group 2 - Data Integration and Analysis to ensure the questions are structured in a manner that allows the feedback to flow into future analytics and screening efforts. We recommend that Likert-type scales be used to collect information on perceived benefits and local support. Refer to the sample survey form in Appendix E. We also recommend soliciting input on potential new infrastructure projects while acknowledging prior stakeholder inputs on potential projects by showing the list of from the NSB Community Comprehensive Plans. For the NSB comprehensive planning projects, the planning team used SWOT analyses in a series of workshops with residents and community leaders to identify the strengths, weaknesses, opportunities, and threats for each North Slope community. Results of these SWOT analyses helped establish an understanding of each community’s unique needs, some of which involved infrastructure projects. This recommendation of using the results of the community planning team and further refining stakeholder needs using carefully crafted questionnaires combines the two best practice methodologies identified in the literature search.

Exhibit 12 is a flow chart that depicts the process we recommend for Stage 1 Project Identification.

**Exhibit 12: Flow Chart for Stage 1 – Project Identification**

As an option, SWOT analyses could be used to solicit new infrastructure project ideas, particularly if SWOT analysis is the preference of a particular community. However, we view SWOT analyses as more time-intensive and possibly less effective than the Likert-type surveys described above.

### 6.2.2 Recommendations for Stage 2 - Project Screening and Prioritization

For Stage 2 Project Screening and Prioritization, we recommend scoring and ranking potential projects using the Advisory Group Decision Method.

The first step involves establishing an Advisory Panel. ADNR could engage the existing QIT, or establish a separate group strictly for ASTAR. We recommend establishing a separate group of 5 to 9 members called the ASTAR Advisory Committee. At a minimum, we envision the Advisory Panel to include the members listed in Exhibit 13.
Exhibit 13: Recommended Members of ASTAR Advisory Committee

<table>
<thead>
<tr>
<th>Member</th>
<th>Representing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. One member from NSB Planning Commission</td>
<td>North Slope Communities</td>
</tr>
<tr>
<td>2. One member from NSB Assembly</td>
<td>North Slope Communities</td>
</tr>
<tr>
<td>3. One member from ADNR</td>
<td>ASTAR Sponsoring Agency</td>
</tr>
<tr>
<td>4. One member from NSB Planning</td>
<td>ASTAR Cooperative Agency</td>
</tr>
<tr>
<td>5. One member from Resource Development Council Board</td>
<td>North Slope Resource Industry</td>
</tr>
</tbody>
</table>

For Stage 2 Project Screening and Prioritization, the committee would follow the process outlined in Exhibit 14.

Exhibit 14: Flow Chart for Stage 2 – Project Screening and Prioritization

6.2.3 Recommendations for Stage 3 – Project Definition and Analysis

For Stage 3 Project Definition and Analysis, we recommend using a variety of tools as appropriate for a given infrastructure project. These include SME Consultation; GIS Analysis; Decision Matrix Method; Weighted Decision Matrix; MCDA; Pairwise Comparison of Inputs; and AHP. Exhibit 15 is a flow chart that depicts the process we recommend for Stage 3 Project Definition and Analysis.
Exhibit 15: Flow Chart for Stage 3 – Project Definition and Analysis

Evaluation factors and criteria may vary from project to project, however, we recommend starting with the criteria listed in Exhibit 8. For weighting, we recommend incorporating consulting SMEs from the following range of societal stakeholder viewpoints:

- State of Alaska
- Federal
- Local Community
- NSB
- Regional Corporation
- Industry
- Environmental

6.2.4 Recommendations for Stage 4 – Project Advancement

For Stage 4 Project Advancement, we recommend identifying potential funding sources that could apply to each project analyzed in Stage 3, and investigating the requisite criteria for utilizing those sources. Sources showing the most promise can be paired with the appropriate projects to set the stage for advancing them to subsequent phases of design, permitting, and construction. The Economics/Socioeconomics Digital Library prepared by AES Alaska and Northern Economics Inc. (2018) introduces potential funding sources that can be further evaluated.

After investigating funding, each project should be presented to potential sponsors who show interest in advancing the projects forward. Exhibit 16 is a flow chart that depicts the process we recommend for Stage 4 – Project Advancement.

Exhibit 16: Flow Chart for Stage 4 – Project Advancement
6.2.5 Next Steps

Assuming ADNR approves the framework and tools described above, we recommend identifying and analyzing a sample project to test this methodology. This will allow the team to make ASTAR-specific refinements and further develop the toolset described in Stage 3.
7.0 References


Alaska Department of Transportation and Public Facilities (ADOT&PF). Draft Interim Corridor Analysis / Decisional Matrix, Foothills West Transportation Access, Project No. 62210. (September 2009).

AES Alaska and UMIAQ. Draft Final Stakeholder Engagement Plan, Arctic Strategic Transportation and Resources Project, North Slope, Alaska. (July 2018).

AES Alaska and Northern Economics, Inc. Arctic Strategic Transportation and Resources Project, Economics/Socioeconomics Digital Library, North Slope, Alaska. (June 2018).


DOWL HKM. Ambler Mining District Access Summary Report, AKSAS 63812. (September 2011).


APPENDIX A
May 22, 2018 Project Kickoff Workshop
PowerPoint Presentation – Identify, summarize, and address possible tools and feasible options for cumulative benefits analysis
APPENDIX B
Annotated Bibliography of Literature and Media Reviewed
APPENDIX C
Executive Summaries of Literature and Media Reviewed
APPENDIX D
Likert-Type Scale Response Anchors
APPENDIX E
Sample Stakeholder Survey
APPENDIX F
North Slope Borough Comprehensive Plan SWOT Analysis Summaries