Final Technical Report
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North Slope Decision Support for Water Resource Planning and Management

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Disclaimer

Abstract

The objective of this project was to enhance the water resource decision-making process with respect to oil and gas exploration/production activities on Alaska's North Slope. To this end, a web-based software tool was developed to allow stakeholders to assemble, evaluate, and communicate relevant information between and amongst themselves. The software, termed North Slope Decision Support System (NSDSS), is a visually-referenced database that provides a platform for running complex natural system, planning, and optimization models. The NSDSS design was based upon community input garnered during a series of stakeholder workshops, and the end product software is freely available to all stakeholders via the project website. The tool now resides on servers hosted by the UAF Water and Environmental Research Center, and will remain accessible and free-of-charge for all interested stakeholders. The development of the tool fostered new advances in the area of data evaluation and decision support technologies, and the finished product is envisioned to enhance water resource planning activities on Alaska's North Slope.

Table of Contents

Executive Summary

Ice roads and ice pads provide a cost-effective means of oil and gas exploration on Alaska's North Slope with minimal impact to the sensitive underlying tundra. Consequently, oil and gas exploration in this region is confined to the winter season, when the underlying soils are sufficiently frozen and snow covered to safely bear heavy loads without significant or lasting damage. Due to the fundamental role of fresh water in support of exploration activities, in addition to myriad other environmental and human demands, successful management of this resource is indeed essential to the broader issue of environmental protection and responsible energy development on the North Slope.

The objective of this project was to enhance the water resource decision-making process with respect to oil and gas exploration/production activities on Alaska's North Slope. To this end, a web-based software tool was developed to allow stakeholders to assemble, evaluate, and communicate relevant information between and amongst themselves. The software, termed North Slope Decision Support System (NSDSS), is a visually-referenced database that provides a platform for running complex natural system, planning, and optimization models. The NSDSS design was based upon community input garnered during a series of stakeholder workshops, and the end product software is freely available to all stakeholders via the project website. The project website contains a project summary, supporting literature, and access to the decision support tool itself at the following url: http://nsdss.ine.uaf.edu/index.html . The NSDSS is also available as a stand-alone tool at the following url: http://nsdss.net/ .

Development of the NSDSS was an iterative process conducted between the research team and regional stakeholders. The project held four stakeholder workshops over the course of the study, and information garnered from each workshop was used to develop the subsequent iterations of the tool.

Stakeholder Workshop #1 was held on January 20-21, 2009, in Anchorage, AK. After introducing stakeholders to the project objectives, attendees participated in working groups to identify water resource information gaps, desired decision support features, and propose problem solution approaches. A detailed water balance and water withdrawal permitting usage scenario was presented to the group as an initial step. Participants were invited to contribute to modifications and refinement to this usage scenario based on their prior experience and collective knowledge. Minimum information system and model requirements were then identified based on the results of the group usage exercise. Later, participants divided into working groups to develop additional usage scenarios and associated system requirements. The information gained during this project kickoff workshop allowed the project team to begin development of a product specifically tailored to the expressed needs of the stakeholder groups.

Stakeholder Workshop #2 was held on November 9-10, 2009, in Fairbanks, AK. The second workshop began with a presentation describing the scope, history, and objectives of the project. This was followed by a live demonstration of the prototype system, then an afternoon session in which stakeholders completed hands-on exercises with the system. The meeting concluded with a discussion of development and desired system specifications. As with the first workshop, the greatest stakeholder interest centered around the ice road planning module and development of a water supply analysis tools. The information gained at this workshop allowed the research team to prioritize system capabilities during the full scale development phase over the ensuing two-year period.

Stakeholder Workshop #3 was held on April 27-28, 2011, in Fairbanks, AK. A significant outcome arising from Workshop #3 was a list of five potential case studies to be developed during the final phase of product development. The case studies were intended to emulate scenarios in which the NSDSS would be used, test the system functionality under realistic conditions, demonstrate its utility for various stakeholder tasks, and to allow intensive user evaluation of the system for final refinements and error correction. During the final year of the project, two of these case studies were selected for further development.

Stakeholder Workshop #4 was held on September 19, 2012 in Fairbanks AK, and September 20, 2012 in Anchorage AK. As described, Workshop #4 was organized around two case studies. Case Study #1 was titled "Utilizing the NSDSS for Ice Road Planning." For this case study, the NSDSS Ice Road Planning module was employed to develop a simulated plan for Chevron's 2007 White Hills Ice Road. The study was centered around a comparison of an ice road route developed by the NSDSS route selection module to the actual route proposed in the submitted permit application. Case Study #2 was titled "Evaluating Regional Suitability for Ice Road Development". In this case study, the NSDSS was employed to evaluate the suitability of a proposed linear transportation corridor for future ice road development. This case study was intended to address an existing need for agencies to evaluate the ice road related water resources along competing planned North Slope transportation corridors.

The final product resulting from these iterative development and outreach activities is an operable and relevant online decision support tool capable of facilitating management decisions regarding the use of fresh water for ice road development on Alaska's North Slope. The NSDSS is readily accessible on the web, and available free of charge to all stakeholders interested in employing its numerous functions. This final report summarizes the capabilities of the system.

Project History and Overview

Introduction

The objective of this project was to enhance the water resource decision-making process with respect to oil and gas exploration/production activities on Alaska's North Slope. To this end, a web-based software tool was developed to allow stakeholders to assemble, evaluate, and communicate relevant information between and amongst themselves. The software, termed North Slope Decision Support System (NSDSS), is a visually-referenced database that provides a platform for running complex natural system, planning, and optimization models. The NSDSS design was based upon community input garnered during a series of stakeholder workshops, and the end product software is freely available to all stakeholders via the project website.

This project was intended to benefit all stakeholders interested in producing collaborative mutually-beneficial, well-informed management decisions regarding North Slope freshwater resources. While the tool was designed to focus on ice road-related issues, the resulting framework is capable of supporting a wide variety of other uses including scientific research and municipal planning. With respect to oil and gas activities on the North Slope, the project is expected to result in optimized water use strategies designed to maximize accessibility while minimizing environmental impacts. By providing a common platform by which developers can originate and communicate water use plans early in the permitting process, regulatory agencies and other interested stakeholders can more readily share and evaluate information, thus resulting in a more streamlined permitting process.

Background / Problem Statement

Alaska's Arctic Slope, or North Slope as it is commonly known, hosts a phenomenal wealth of natural, cultural, and economic resources. It represents a complex system, not only in terms of the biophysical system and its global importance but also from the standpoint of its social dynamic. The energy resources on the North Slope represent an important domestic energy source, yet the differential costs and benefits to various stakeholders are sometimes at odds. A major challenge at the forefront of domestic energy development on the North Slope is the need for best management practices that will ensure benefits for all stakeholders. To do so requires stakeholder cooperation that enables cost-effective development strategies that fit within a broader context of long term cultural, economic, and environmental sustainability.

Water is an essential component of the North Slope environment, influencing the energy balance and nutrient cycling, creating habitat for aquatic and terrestrial flora and fauna, and meeting a variety of human needs. Local communities use lakes and rivers for access to subsistence resources and to sustain those same resources and requisite habitat. As well, energy development in the region is inextricably tied to water resources. Oil and gas exploration and development require a great deal of freshwater to support ice road and ice pad construction, for drilling muds, domestic water supply, and to implement emerging enhanced oil recovery (EOR) methods, such as British Petroleum's LoSal ™ technology.

Due to the fundamental role of water in natural and human systems, successful management of this resource is indeed essential to the broader issue of environmental protection and responsible energy development on the North Slope. The challenges of developing best management practices for water resources include the following: resource planning and management for efficient and sustainable water use; understanding and explicitly considering environmental impacts and protection; and developing and implementing effective participatory management strategies with representative stakeholder participation from all sectors.

Ice roads and ice pads provide a cost-effective means of oil and gas exploration with minimal impact to the sensitive underlying tundra. Consequently, such ice structures have become integral to oil and gas exploration activities on the North Slope. Their widespread use represents a challenge to water resource managers, however, due to the amount of water necessary to construct and maintain them. As the proximity of available fresh water sources has a significant impact on the planned location of ice roads and ice pads, changes in water resource management strategies could significantly impact oil and gas exploration activities. At present, water withdrawals require lake-specific permits that specify the maximum volume of water that may be pumped from each lake. Withdrawal limits on state lands are set by the Alaska Department of Natural Resources (ADNR), often in consultation with the Alaska Department of Fish & Game (ADF&G), and depend on the presence and species of fish, total lake storage, and under-ice volume at the time of maximum ice thickness.

Additional water withdrawal considerations include the potential for water withdrawals to impact the annual and interannual lake water balance. Such changes could in turn impact local and regional wildlife habitat, permafrost thermal balance, or other biophysical systems. Moreover, the placement of exploration structures themselves can potentially impact wildlife in other ways, including crossing preferred migration routes, or disrupting important denning, calving, and nesting sites.

How can we identify and select among the best exploration scenarios that optimize water access and use to minimize exploration costs, environmental impact, and economic/environmental risk? Limited data is generally understood to be the greatest impediment to tackling problems such as this. Indeed, there are relatively few observational data available for the North Slope to support resource planning and management. This is due to the vast area of the region as well as the extreme, logistically-challenging climate. The majority of data that does exist has evolved over decades of individual and disjointed research efforts undertaken by various agencies, researchers, and private companies. The overwhelming effort required to locate, let alone retrieve, these data is prohibitive to its use and has greatly diminished its effective value. Moreover, drawing conclusions from and basing decisions upon only a small fraction of the available data fundamentally increases uncertainty and risk. Therefore, the problem of best management practices inherently includes the problem of locating as much existing data as possible and making it readily accessible. This is also a necessary first step to prioritizing investment in additional data.

The overarching challenge addressed in this work relates to North Slope water resource management. Specifically, we developed a water resources management strategy in support of oil and gas exploration that explicitly considers optimal water use, direct and cumulative environmental impacts, and multiple objectives and values among stakeholders. We anticipate that the tools developed in this work will not only be applicable to the water management issues considered here, but will also be applicable to broader environmental management issues, industrial development applications, and scientific inquiry.

Project Timeline

The project, an iterative software development process conducted between the research team and regional stakeholders, spanned the period from Fall 2008 through Spring 2013. A general timeline describing the major project phases is presented below:

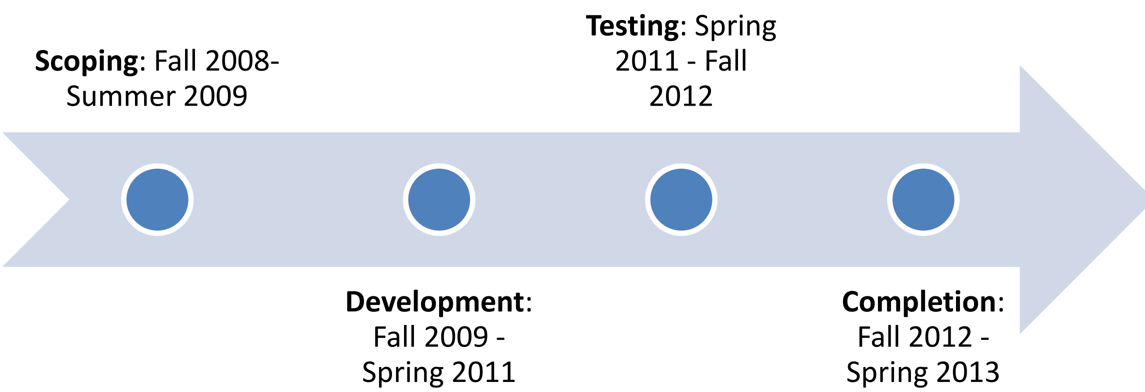

Figure 1: NSDSS Project Timeline

Outreach Activities / Workshops

Formal outreach activities between the research team and North Slope stakeholders were spearheaded by a series of stakeholder workshops held throughout the course of the project. These workshops were designed to ensure that stakeholder input was garnered in the initial scoping phase of the decision support system, throughout the development and beta testing phases, and finally, in the rollout of the final project.

Stakeholder Workshop #1 was held on January 20-21, 2009, in Anchorage. Representatives from local, state, and federal agencies, the oil and gas industry, and non-governmental organizations were invited to participate in this project kick-off workshop. Ultimately, a group of 45 individuals attended the meeting, representing entities including ADNR, ADF&G, ADOT&PF, North Slope Borough, BLM, USFWS, USGS, DOE, North Slope Science Initiative, Conoco Philips Alaska, British Petroleum, UAF, and the Nature Conservancy.

After introducing stakeholders to the project objectives, attendees participated in working groups to identify water resource information gaps, desired decision support features, and

propose problem solution approaches. A detailed water balance and water withdrawal permitting usage scenario was presented to the group as an initial step. Participants were invited to contribute to modifications and refinement to this usage scenario based on their prior experience and collective knowledge. Minimum information system and model requirements were then identified based on the results of the group usage exercise. Later, participants divided into working groups to develop additional usage scenarios and associated system requirements.
The information gained during this project kickoff workshop allowed the project team to begin development of a product specifically tailored to the expressed needs of the stakeholder groups.

Stakeholder Workshop #2 was held on November 9-10, 2009, in Fairbanks. The workshop objectives were to provide stakeholders with a project status report; introduce participants to the newly-developed prototype DSS; work with stakeholders to refine the system specifications; and identify Year 2 tool development priorities. Attendees included representatives from ADF&G, ADNR, BLM, USFWS, DOE, North Slope Science Initiative, and UAF. Neither Conoco Philips nor British Petroleum were able to send representatives to the meeting, but both entities responded to the invitation and requested updates on the project.

The second workshop began with a presentation describing the scope, history, and objectives of the project. This was followed by a live demonstration of the prototype system, then an afternoon session in which stakeholders completed hands-on exercises with the system. The meeting concluded with a discussion of development and desired system specifications. As with the first workshop, the greatest stakeholder interest centered around the ice road planning module and development of a water supply analysis tools.

Stakeholder Workshop #3 was held on April 27-28, 2011, in Fairbanks. The objectives of this workshop were to present a nearly complete version of the DSS, solicit observations and input from stakeholders, and formulate a list of potential case studies to be performed with the technology during the final year of the project. Similar to Workshop #2, this workshop included multiple hands-on sessions intended to provide technology training for potential users. Attendees included representatives from ADF&G, ADNR, ADOT&PF, USFWS, BLM, DOE, Conoco Philips, ExxonMobil, and UAF.

A significant outcome arising from Workshop #3 was a list of five potential case studies to be developed during the final phase of product development. The case studies were intended to emulate scenarios in which the DSS would be used, test the system functionality under realistic conditions, demonstrate its utility for various stakeholder tasks, and to allow intensive user evaluation of the system for final refinements and error correction. During the final year of the project, two of these case studies were selected for further development.

Stakeholder Workshop #4 was held on September 19, 2012 in Fairbanks and September 20, 2012 in Anchorage. The goal of the final workshop was to present the two selected case studies to audiences in both locations, conduct additional hands-on training with the stakeholders, and solicit final recommendations for completion and future work with the DSS. Attendees included delegations from ADOT&PF, ADNR, USFWS, British Petroleum, Conoco Philips, ExxonMobil, PND Consulting, and UAF.

As described, Workshop #4 was organized around two case studies. Case Study #1 was titled "Utilizing the NSDSS for Ice Road Planning". For this case study, the NSDSS Ice Road Planning module was employed to develop a simulated plan for Chevron's 2007 White Hills Ice Road. The study was centered around a comparison of an ice road route developed by the NSDSS route selection module to the actual route proposed in the submitted permit application. Case Study #2 was titled "Evaluating Regional Suitability for Ice Road Development". In this case study, the NSDSS was employed to evaluate the suitability of a proposed linear transportation corridor for future ice road development. This case study was intended to address an existing need for agencies to evaluate the ice road related water resources along competing planned North Slope transportation corridors.

Stakeholder responses to Workshop #4 were positive. Comments and recommendations regarding the tool were centered around ways in which the tool could be used in the future. For example, attendees at the Fairbanks workshop recommended that the tool should be used in the EIS process for a proposed transportation corridor to Umiat (known within the state as the Foothills West project). Attendees at the Anchorage workshop concluded that the tool could be useful for helping agencies track ice road-related water use of a shared set of lakes by multiple industrial entities. Anchorage attendees also suggested that the tool would be a helpful planning tool for emerging companies with scant North Slope ice road experience. These and other recommendations were taken into consideration during the final phase of project development, testing, and documentation.

Website

The NSDSS project website is the primary point of access for the web tool, databases, project description, software documentation, and all ancillary project information. The website is available at the following url: http://nsdss.ine.uaf.edu/

Description of Software

The NSDSS system developed in this project is a prototype, and all methods used within it are the product of novel research. As such, the tool should be used with this knowledge in mind. Users of the system should not base their ice road plans on NSDSS results alone. Rather, it should be used as a planning tool in the initial stages of ice road design and permitting.

A detailed description of the system design, functionality, and use is available on the project website in a pdf titled NSDSS Requirements and Design Document. This section provides a general summary derived from information presented in that design document. A link that that document is contained in the following url:
http://nsdss.ine.uaf.edu/docs/NSDSS_RequirementandDesign.pdf

Prototype Development
The software developed in this project is termed a rich prototype. The prototype is referred to as "rich" because it is a fully operational and deployed version of the eventual production NSDSS, which can be developed as a follow on from this project. A rich prototype was developed to fully reveal the detailed requirements for the NSDSS tool and cyberinfrastructure, and to essentially prove the concept that the NSDSS would be a viable tool for ice road planning.

Due to the complex nature of the project, prototyping was very extensive and explored innovations in technology, novel natural systems modeling methods, and new optimization techniques applied to ice road planning. Below is a summary of the methods and associated algorithms developed, as well as a summary of the technology developed to implement them.

Optimal Ice Road Planning:
An array of methods for planning ice roads was developed by the research team that was based on the foraging behavior of ants. This behavior was converted into a computer algorithm for finding the best route for an ice road to take given uneven terrain, sources of water, avoidance of sensitive vegetation and endangered species, and, of course, a goal to minimize cost of construction and operation. With a basic algorithm developed for finding optimal routes, further algorithms were developed for more sophisticated ice road planning. The full suite of algorithms included:

- Basic Start Point to End Point Ice Roads – where a set of best roads is found that minimize 1) construction time, 2) travel time, and 3) construction duration, while avoiding sensitive vegetation and possible habitat for endangered and at risk animals.

- Best Start Point Search – where an entire road is specified as a range of possible starting points, and the best starting point is found from the road.

- Multiple Start Points and End Point Search – where an entire road is specified as a range of possible starting points, and multiple target end points are specified that the route must reach.

- Landscape Ice Road Suitability Analysis – where a permanent road is specified as the starting point, and the landscape is evaluated for suitability for ice road construction from the permanent road.

The reader is referred to descriptive papers within the Ice Road planning section of the literature page of the NSDSS web site for more detail on the Ice Road optimization algorithms. http://nsdss.ine.uaf.edu/literature.html

Natural System Modeling:

The following models were developed as part of the assessment of natural system effect on the ice road planning process:

- Lake Water Budget Model: This model allows the user to select a lake on the North Slope and model the water budget of the lake either using a historical time frame, or using General Circulation models to produce a forecast of the major drivers of the model. This model is documented at the NSDSS web site, at: http://nsdss.ine.uaf.edu/NaturalSystemModeling/WhitePapers/WhitePaper_NSDSS_Lake_Water_Budget_Modeling.pdf

- Lake Dissolved Oxygen Model: This model allows the user to select a lake on the North Slope and model the reduction in dissolved oxygen over the winter as it is depleted due to freeze up. This model is documented at the NSDSS website, at: http://nsdss.ine.uaf.edu/docs/NSDSS_Lake_Dissolved_Oxygen_Model.pdf

- Snow Fence Model: This model is an addition to the water budget model. It adds the ability to add a snow fence to the lake watershed, which collects snow that can augment the lake water supply at Spring Thaw. The NSDSS snow fence model, and related snow fence design research documentation, can be found at the NSDSS web site, at: http://nsdss.ine.uaf.edu/docs/NSDSS_IncorporatingSnowFencesIntoWaterBudgetModel.pdf

Integration of Natural System Models in Ice Road Planning:

The primary goal of developing the various natural systems models was to understand the availability of water on the North Slope, as it is the building material for ice roads. Simply quantifying available water was the first challenge. Next, understanding how the water supply varies both historically, and under climate change were tackled.

The ice road planning tool within the NSDSS makes very good use of the water budget, snow fence, and dissolved oxygen (DO) models to shed light on the amount of water that will be used in each planned ice road, and the effect the water use will have on lake volume and water quality. Specifically, as stakeholders create ice road plans, they are required to indicate the lakes they plan to use in the ice road construction. Ideally, they will have created water budget and DO models for these lakes ahead of time. Then, when the ice road plan is being developed, it quantifies the water to be used at each lake, and the resulting drop in volume and DO over the winter time.

Given the inputs (rain and snow), and the outputs (evaporation and sublimation) are all uncertain, and vary each year, the NSDSS uses an ensemble of years (either historical or from a forecast) to quantify the uncertainty in the water supply for the lake, and the risk of depleting the lake to unacceptable levels.

NSDSS System Architecture

The NSDSS system architecture consists of a cyberinfrastructure and web application. Figure 2 illustrates the general system architecture.

The web application (http://nsdss.net/) is a Microsoft Silverlight based web application that employs a workbench user experience. The workbench concept presents the user with a series of widgets (tools) that sit on top of the primary work surface. In the case of NSDSS, the work surface is a map of the North Slope of Alaska. The cyberinfrastructure is a collection of databases that store meteorological and hydrologic observation data, gridded output data from General Circulation Models (GCMs), and GIS data on lakes, topography, hydrology, vegetative cover, previously built ice roads, and animal habitat. Each database has a web service that serves the data to the web application. A key element of the cyberinfrastructure is a catalog service, which stores metadata on all of the data in the cyberinfrastructure and responds to the web applications requests for data with instructions on which service to go to for the data it is seeking.

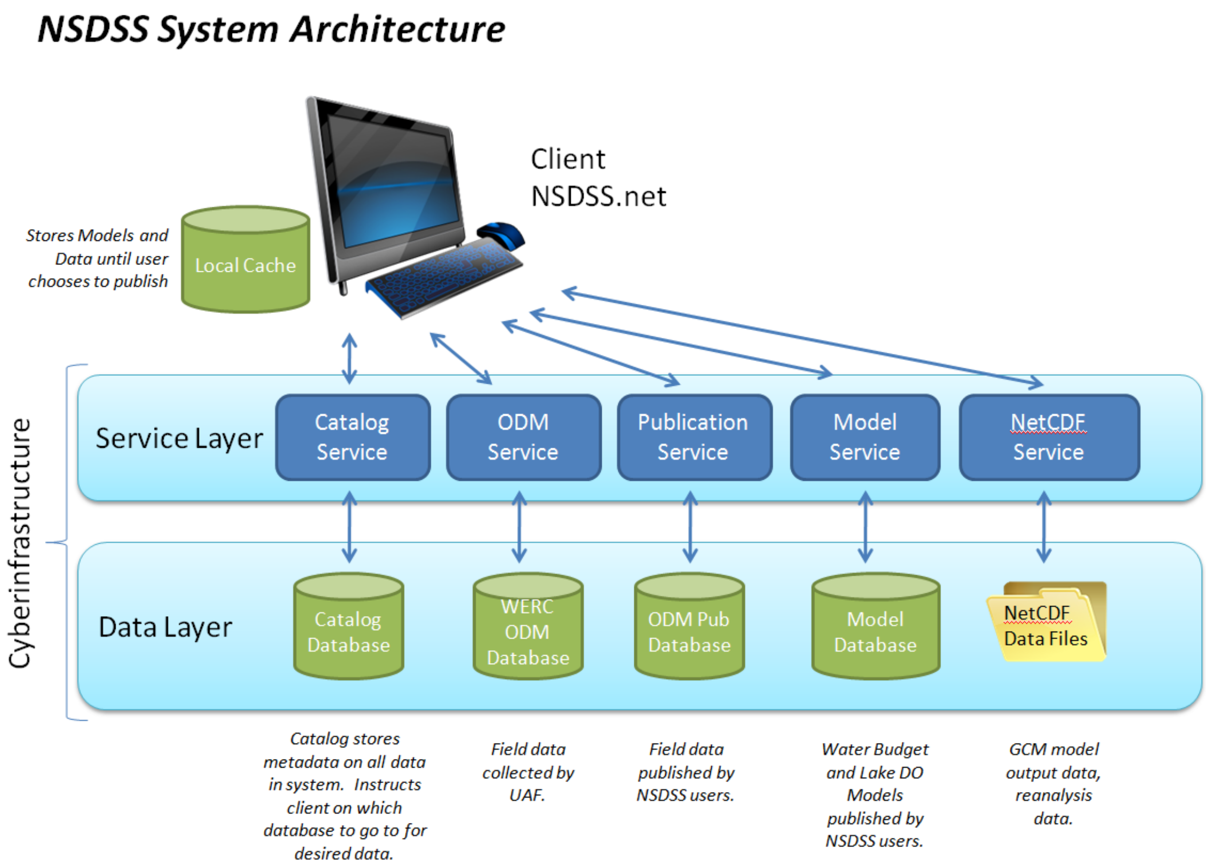

Figure 2: NSDSS System Architecture

The catalog service uses semantic mediation to interpret translate requests from the web application for a specific variable (eg. rain) into all of their synonyms (eg. precipitation, R, P, etc.), so that data throughout the cyberinfrastructure isn't overlooked because the exact name isn't provided in the search. An array of white papers documenting the various algorithms, case studies, and findings developed during the project can be found at the project website: http://nsdss.ine.uaf.edu/literature.html

NSDSS System Functionality

The web application (NSDSS.net, see Figure 3 below) is a Microsoft Silverlight based web application that employs a workbench user experience. The workbench presents the user with a series of widgets (tools) that sit on top of the primary work surface. The work surface is a map of the North Slope of Alaska.

The main screen contains a simple home bar, which floats over the map in the upper left corner of the screen. The home bar contains controls for searching and opening the four widgets (explained below). There are also buttons on the right side of the bar to show and control the legend for the map, to open a box that provides information about NSDSS, and to clear the map if a user has been drawing on it.

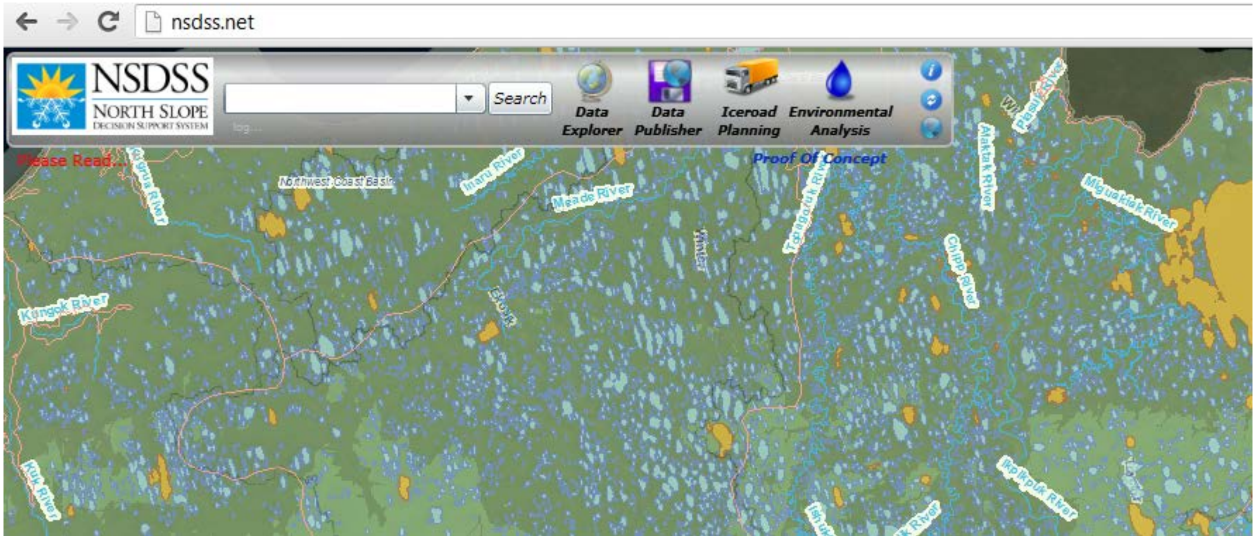

Figure 3: The NSDSS Home Bar

The NSDSS employs four primary mechanisms to work with data, termed “widgets”:

Widget #1 Data Explorer

This widget provides the results of searches that are conducted with the search box in the home bar. A user can enter a search term either by typing in the search box, or by selecting a term from the list of variables, species, and other searches in the drop down. After the search button is clicked, the data explorer widget appears and presents the results of the search. The search is focused on the area of the map that has been zoomed to, and the search term that was entered. In the case of Figure 4 below, a search for rain has been conducted. Both data collected at sites (red dots) and gridded data (represented in the list with a grid icon) are presented.

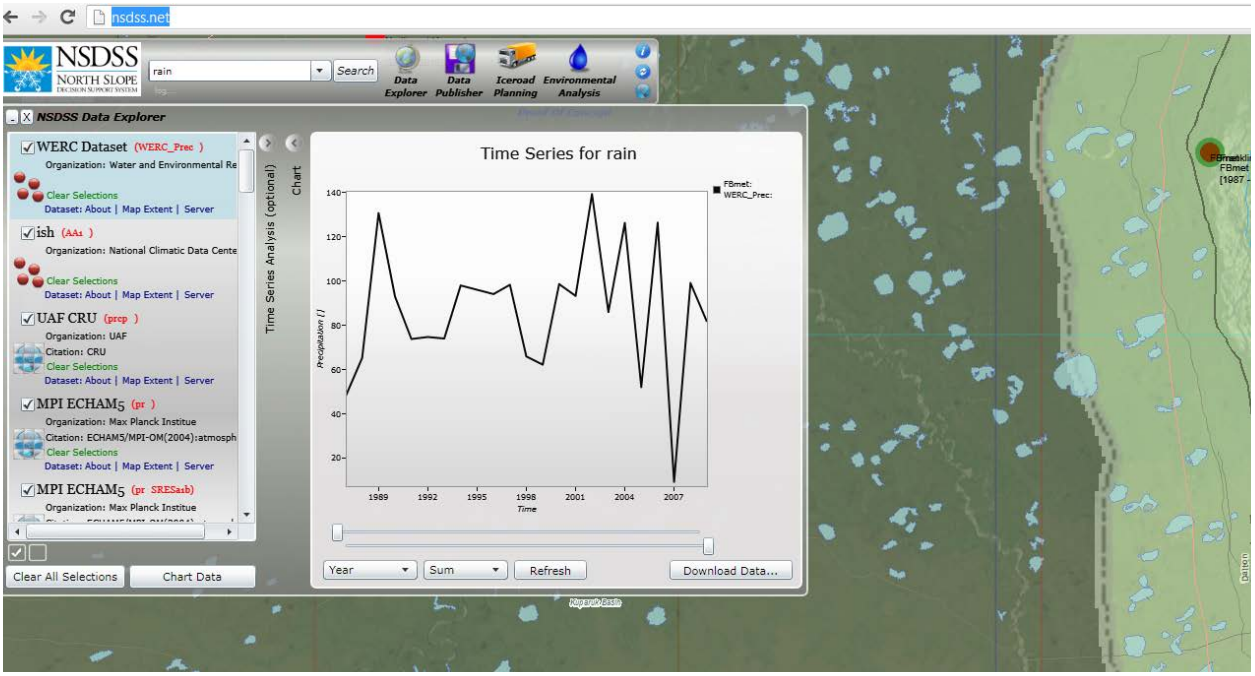

Figure 4: Searching and the Data Explorer Widget.

Widget #2 Data Publisher

The NSDSS allows users to add their own data to the system. The data publisher widget provides this functionality. The data publisher is opened by clicking its icon in the home bar. The publisher widget will appear under the home bar. Figure 5 shows the publisher widget.

The data publisher allows users to add site-based data to the NSDSS publisher database. The publisher database is one of the databases in the cyberinfrastructure. It is a CUAHSI ODM database, which is designed to hold time series of observations measured at specific geographic points. CUAHSI is the Consortium of Universities for the Advancement of Hydrologic Science, Inc, a group of universities that has set up standards-based approaches to storing and sharing observations data. ODM is the Observations Data Model, which is a specific database design for storing observations. CUAHSI provides tools for establishing ODM databases and the related web services to serve them. The NSDSS has used ODM databases for the publisher database, as well as the historic dataset that UAF's WERC has collected over the last several decades.

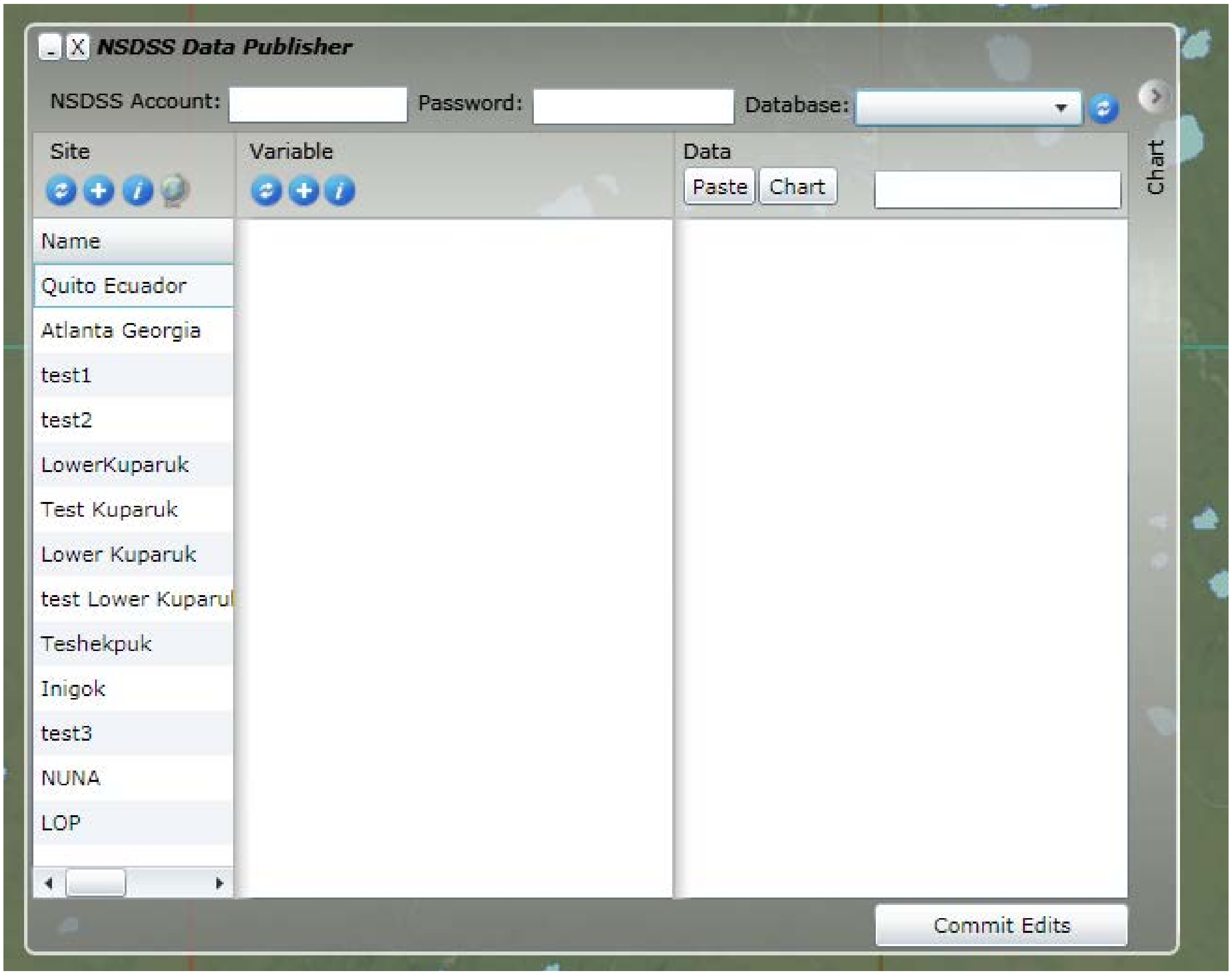

Figure 5: Data Publisher Widget allows you to add data to the NSDSS system.

Widget #3 Ice Road Planner

The NSDSS ice road planner widget provides all functionality for designing ice roads. The widget is opened by clicking the Ice Road Planning icon in the home bar. The widget will open below the home bar (Figure 6).

The Ice Road planner widget allows users to perform two primary workflows, accessed via the drop down menu in the top left of the widget screen (Figure 6). Using the Create Ice Road workflow, the user can create basic ice roads with user-defined start and end points, identify optimal start points for an ice road leading to a specified end point, and create ice road networks. Using the Create Landscape Ice Road Suitability Analysis workflow, the user can evaluate competing permanent (paved or gravel) road routes in light of their ability to suitability to support connecting ice roads.

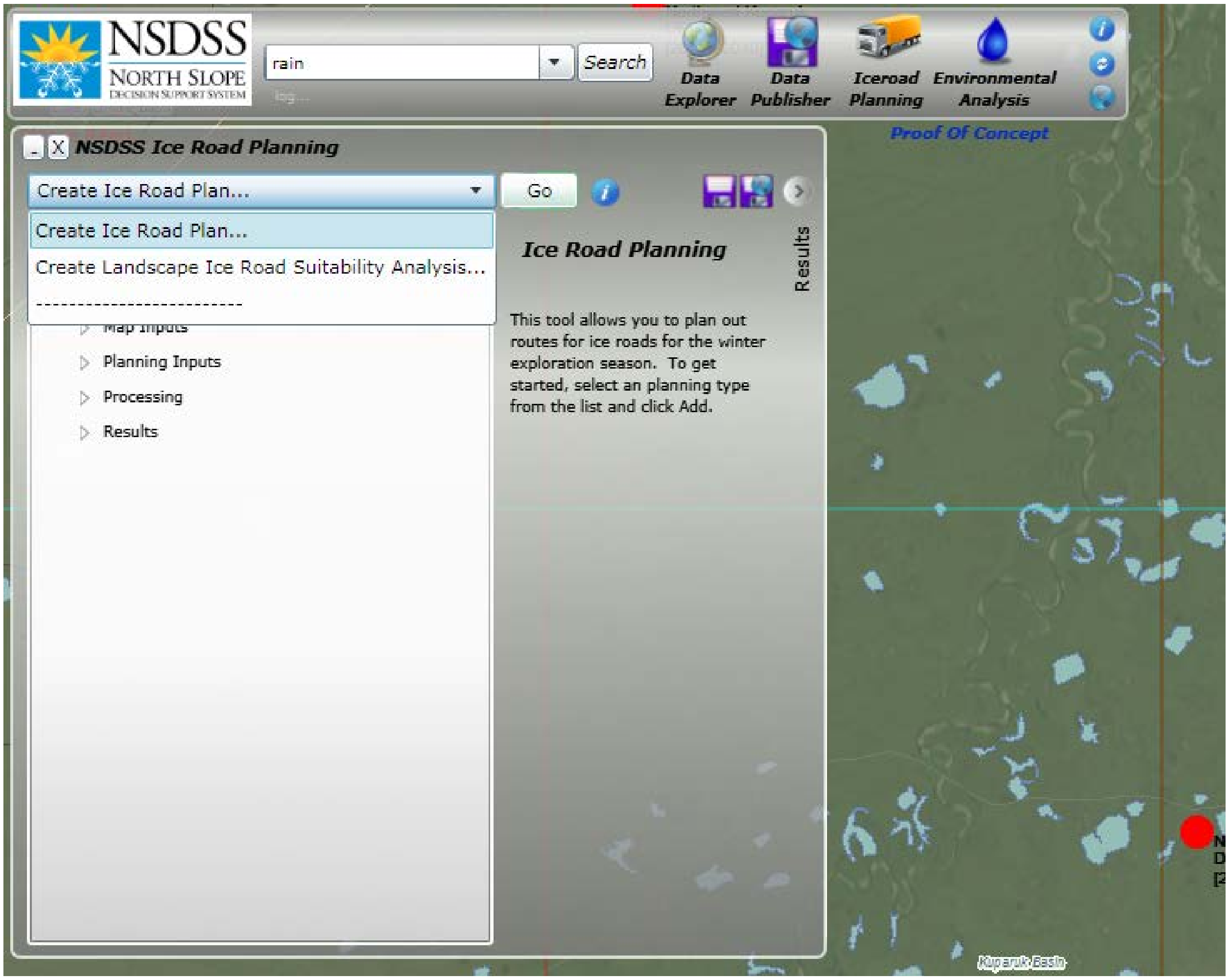

Figure 6: Ice Road Planning Widget

Widget #4 Environmental Analyst

The environmental analyst widget contains tools for natural systems modeling, including water budget modeling and dissolved oxygen modeling. To open the widget, click the Environmental Analyst Icon in the home bar. The widget will open below the home bar. A screen shot of the Environmental Analyst is provided in Figure 7.

The Environmental Analyst widget provides two general workflows. With the Create Lake Water Budget Model, a user can select any lake in the North Slope Lakes database and create a 2010-2040 water budget that forecasts the amount of water in the lake and the amount available for extraction for use in ice road construction under current regulations. The forecast can be used in an ice road plan (see section on ice road planning) to assess if sufficient water will be available in the coming season for the planned ice road. This water budget model has the capacity to incorporate man-made changes to the water budget resulting from pumping or the application of snow fences. Using the Create Lake Dissolved Oxygen workflow, a user can select any lake in the North Slope Lakes database and create a winter season dissolved oxygen model to understand how water quality may be affected by removal of water for use on ice roads.

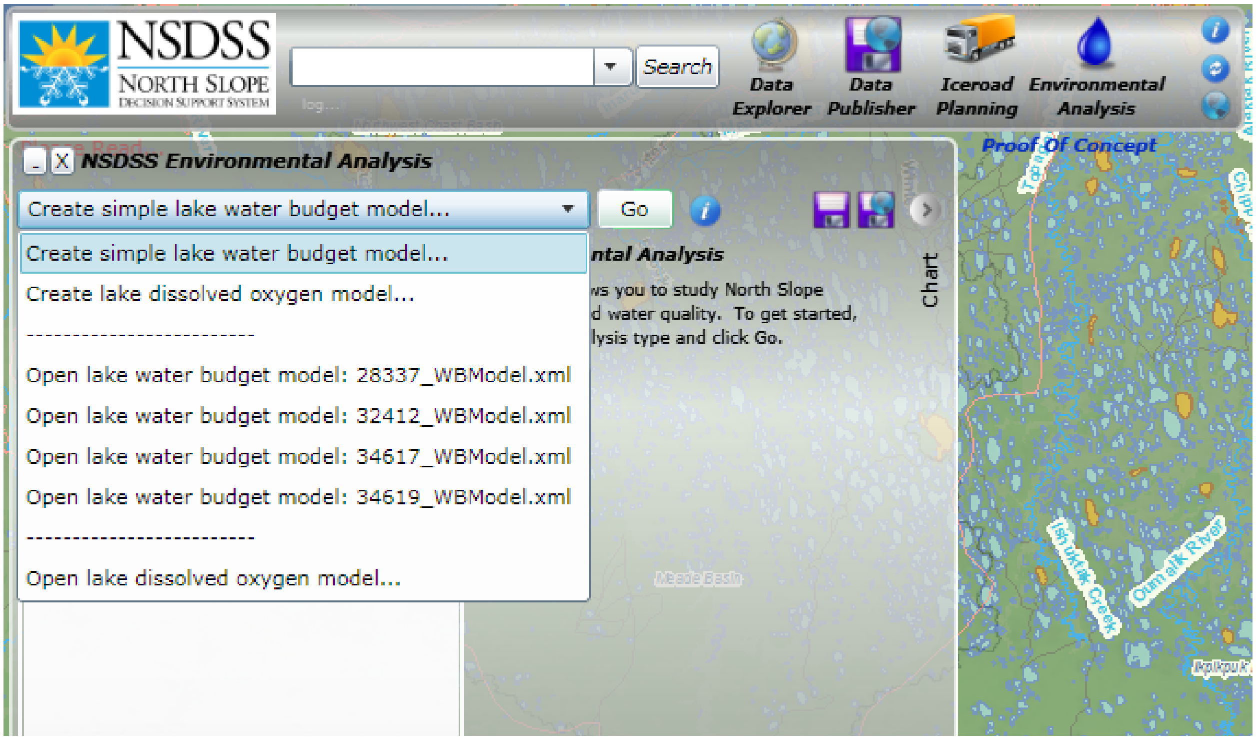

Figure 7: Environmental Analyst Widget

Case Studies – Demonstrations of Software Functionality

Two case studies were employed to demonstrate the utility of the NSDSS to stakeholders during Workshop #4 and beyond. The objectives of the case studies were to:

- Provide real-world examples that allowed stakeholders to see how the NSDSS tools can be used.
- Illustrate to specific stakeholders the value of the tools.
- Act as a ground-truthing exercise for the NSDSS tool and underlying methods.
- Illustrate where the NSDSS databases and tools could be extended and enhanced.

In the first case study, the NSDSS was utilized to develop an ice road plan for an ice road that had already been permitted and constructed. In this case study, the team utilized the White Hills ice road, used by Chevron for oil and gas exploration in winter 2007-2008. The purpose of the case study was to evaluate how an ice road designed via the NSDSS toolkit might differ from an ice road designed in the traditional fashion. The case study included:

- An ice road planning exercise to assess how similar the NSDSS recommended route was to the designed Chevron route.
- A water budget model conducted on one of the source lakes, to assess the availability of water for ice road use.
- A lake dissolved oxygen model, to assess if water quality would be unacceptably impacted by water extraction.

The second case study was focused on ice road landscape suitability analysis. The purpose of this case study was to evaluate whether the landscape surrounding a hypothetical gravel road extending from the Dalton Highway to Kavik Camp would support extensive ice road development. The case study was intended to be analogous to existing discussions regarding various proposed routes for a gravel road leading to Umiat. In the case study, the NSDSS landscape suitability analysis tool was used to create a road to Kavik Camp, located on the Coastal Plain approximately 50 km from the Dalton Highway. Hypothetical ice road routes were created from starting points at approximately 10 mile intervals along the proposed road alignment. The cost-effectiveness and environmental suitability of each route was evaluated to understand which sections of the landscape were most and least suitable for ice road construction.

The case studies are described in detail on the literature page of the project website. Please find a link to the case studies at the following url: http://nsdss.ine.uaf.edu/literature.html

Summary/Conclusions

This project fostered the development of a web-based tool intended to provide data, evaluation, and modeling tools necessary to support and communicate decisions regarding water resources on Alaska's North Slope, especially with respect to ice road construction and maintenance. The tool was developed in an iterative process involving the research team and regional stakeholders including the industrial, regulatory, scientific/engineering, and non-profit communities. The tool now resides on servers hosted by the UAF Water and Environmental Research Center, and will remain accessible and free-of-charge for all who care to use it. The creation of the tool itself fostered new advances in the area of data evaluation and decision support technologies. We intend to seek continued support for further expansion and development of the tool, and will continue our outreach efforts to regional stakeholders.

This report was intended to provide a general summary of the objectives, development, and functionality of the NSDSS tool. However, the tool is intended to be a resource for stakeholders, and as a consequence, a comprehensive website has been established to provide users with detailed information regarding NSDSS functionality, background, and a link to the tool itself. Readers of this final report are encouraged to visit the NSDSS website to fully evaluate the valuable resource that was established with the generous funding provided by this project: http://nsdss.ine.uaf.edu/

List of Acronyms and Abbreviations

ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
CUAHSI	Consotium of Universities for Advancement of Hydrologic Science
DO	Dissolved Oxygen
EOR	Enhanced Oil Recovery
GCM	General Circulation Model
GIS	Geographic Information System
NetCDF	Network Common Data Form
NSDSS	North Slope Decision Support System
ODM	Observations Data Model