Final Project Report: Development of an NHD Stewardship Strategy and National Hydrography Data for the National Park Service Alaska Region

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Final Project Report: Development of an NHD Stewardship Strategy and National Hydrography Data for the National Park Service Alaska Region

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About the Cover: Revised NHD for Bering Land Bridge National Park and Preserve. Updated shoreline is shown in red, streams and rivers are in dark blue and lakes are in light blue. All data presented over recently acquired SPOT5 true-color orthorectified satellite imagery. Map graphic courtesy of Saint Mary's University of Minnesota, GeoSpatial Services.

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List of Acronyms

ANIA – Aniakchak National Monument

BELA – Bearing Land Bridge National Preserve

CAKR – Cape Krusenstern National Monument

DENA – Denali National Park and Preserve

EVS – NOAA Extracted Vector Shoreline

ENC – NOAA Electronic Navigational Chart Shoreline

FGDC – Federal Geographic Data Committee

GIS – Geographic Information Systems

GLBA – Glacier Bay National Park and Preserve

GNIS – Geographic Names Information System

IfSAR – Interferometric Synthetic Aperture Radar

KEFJ – Kenai Fjords National Park

LACL – Lake Clark National Park and Preserve

MHW – Mean High Water Level

NHD – National Hydrography Dataset

NOAA – National Oceanic and Atmospheric Administration

NPS – United States National Park Service

NWI – National Wetland Inventory Program

SPOT5 – SPOT5 Satellite

SDMI – Alaska Statewide Digital Mapping Initiative

USGS – United States Geological Survey

USFWS – United States Fish and Wildlife Service

WALCC – Western Alaska Landscape Conservation Cooperative

Abstract

The National Hydrography Dataset (NHD) is one of the key layers in the National Map and is a primary spatial database utilized by the National Park Service (NPS) for research, management and administration of Alaska Region NPS Units. The creation and revision of NHD for the United States is governed by a comprehensive data model, editing procedures, validation rules and upload processes designed and managed by the United States Geological Survey (USGS). As part of the data management process, USGS has implemented a state by state data stewardship program to provide structured processing and submission of new and revised data. To date, there has been no formally designated state steward for NHD in Alaska which has resulted in lack of coordination in the NHD update process. In addition, original NHD for the state is in need of update as it was created primarily from 1950's era aerial image interpretation and a low resolution digital elevation model.

In an effort to initiate the process of updating NHD data for Alaska National Park Units, NPS developed this cooperative project in conjunction with Saint Mary's University of Minnesota GeoSpatial Services (SMUMN). The initial purpose of the project was to jointly develop an NHD stewardship strategy for NPS Units in Alaska and then to apply that strategy in the development of updated NHD data for several Parks. As NHD stewardship activities outside of NPS in Alaska gained momentum, this project was modified to include additional objectives. These included: initial development and testing of automated methods for NHD data conflation using newly acquired, high resolution IfSAR digital elevation models; development and application of NHD data revision protocols for interior (non-coastal) NPS Units; and, NHD data revisions following the new AK Hydro stewardship model. Each of these project activities has resulted in the preparation of draft editing procedures and standards which are included as Appendices in this report as well as updated NHD data for various NPS Units which has been submitted to the National Map.

Acknowledgements

Introduction

The rugged and complex Alaskan landscape is a case study in extremes. Often over short linear distances, the terrain in this state varies from high alpine mountain peaks to extremely flat arctic plains, with numerous ecological units in between. It is also a landscape that is characterized by standing and flowing water. Alaska's water resources account for nearly 40 percent of the nation's surface water and include: more than 12,000 named streams and rivers stretching nearly 1,370,000 km (850,000 miles); three million mapped lakes; 75,600 km (47,000 miles) of mapped coastline; expansive snowfields; and an estimated 100,000 glaciers scattered across the state. The state's largest river, the Yukon, is the third longest river in the nation, and measures nearly 2000 miles rising from headwaters in Canada to a massive delta that empties into the Bering Sea. As a result of the abundant water resources, the ruggedness and vast size of the state, it has proven to be a significant challenge to maintain modern, accurate hydrography datasets.

The National Hydrography Dataset (NHD) is the surface water component of The National Map and is a digital vector dataset maintained by the United States Geological Survey (USGS) using geographic information systems (GIS) technology. It is a comprehensive set of digital spatial data representing the surface water of the United States using common features such as lakes, ponds, streams, rivers, canals, dams and oceans. These data are designed to be used in general mapping and in the analysis of surface-water systems using geographic information systems (GIS). These data are important to help understand hydrologic functions and their relationships to other natural and cultural resources.

While consistently mapped at 1:24,000 or better in the contiguous U.S., the NHD in Alaska was taken from 1950s-era USGS Historical Topographic Maps at 1:63,360-scale, and has seen few improvements or enhancements over the years. The dataset contains many errors including streams outside their channels, misrepresentations of flowlines, disconnected streams and omission of existing streams. Harsh terrain, remote locations, rapidly changing landscapes and coastlines, seasonal extremes, dense cloud cover, tidal ranges, complex braided channels, expansive wetlands, and subsurface flow further challenge efforts to map the state's water.

As one of the largest land and resource managers in Alaska, the National Park Service has a mandate to create and update spatial data in support of management decisions and activities across regional park units. The NHD dataset for these areas is a key spatial data layer that supports a variety of activities including: delineation of unit boundaries; base inventory of fish and wildlife habitat; analysis of the impact of natural and anthropogenic disturbances; longitudinal studies involving response to climatic variations; infrastructure development; and, user experiences. As a result, it is important for NPS to have a protocol in place for the creation and maintenance of hydrography data that complies with Federal standards and results in the availability of a core data set that supports the management mission of the Agency.

This project was a collaborative effort between the NPS Alaska Region and Saint Mary's University of Minnesota (SMUMN) to develop a stewardship strategy for creating and updating NHD data, and to implement that strategy and create a USGS compliant NHD database for Alaska's National Parks. The first phase of the project was focused on development of an NHD stewardship strategy which included the following: differentiating and describing the specific roles and responsibilities for both NPS and SMUMN in the NHD development and editing process; describing workflow processes utilizing standard USGS NHD editing processes and quality assurance tools; specifying USGS data

checkout procedures to ensure compliance and national data conformity; procedures for including Alaska NHD data into the national NHD database; describing NPS workflow processes to ensure staff expertise and local knowledge is fully captured in making editing decisions; and describing project management, coordination, and production task and workflow definitions. The second phase of the project was to implement this strategy to establish an NPS NHD stewardship production program in partnership with SMUMN and USGS.

Over the course of this project, a variety of NHD data acquisition and maintenance activities were tested and documented through the development of draft protocols. Specific tasks that were addressed included:

1. Development and implementation of a stewardship strategy and draft protocol document for acquisition of nationally compliant NHD shoreline data by NPS units and their partners;
2. Development of a prototype process for the automation of NHD updates using recently acquired SPOT5 satellite imagery and IfSAR elevation models from the Alaska Statewide Digital Mapping Initiative (SDMI);
3. Development of editing protocols for updating interior NHD in Denali National Park and Preserve (DENA), Bering Land Bridge National Preserve (BELA); and Cape Krusenstern National Monument (CAKR) in response to data needs for the USGS U.S. Topo update program; and,
4. Implementation of NHD data update, densification and submission processes for Glacier Bay National Park and Preserve (GLBA) utilizing the interim Alaska hydrography stewardship process and AK Hydro data model.

The following sections of this report document the activities that were undertaken to address the tasks listed above.

Stewardship Strategy Development

Background

The current National Hydrography Dataset was designed and populated by a large consortium of agencies involved in hydrography across the United States. The effort was led by the U.S. Geological Survey, the U.S. Environmental Protection Agency (EPA), and the Natural Resources Conservation Service (NRCS). The high-resolution NHD dataset, completed in 2007, is based on the USGS 7.5-minute series topographic maps at a scale of 1:24,000 in the lower 48 states and 1:63,360 series topographic maps in Alaska. There are now 26 million features in the NHD representing a 7.5 million mile stream network with over 6.5 million water bodies.

Ongoing maintenance of the NHD is essential for improving these datasets to meet the ever increasing demand for currency, additional detail, and more significant attribution. The best source of information about changes in local hydrography are users closest to the data, such as State and local governments, as well as Federal land management agencies, and other users of the data. The need for local knowledge has led to the creation of a collaborative data stewardship process to revise and maintain the NHD.

The stewardship program of the NHD provides an opportunity for local users who are knowledgeable about the hydrography to update the data. The NHD is an authoritative data source and the steward of the data must represent an authority in terms of technical skill and an impartial approach to portraying hydrography over a given area. The principal steward is the primary point of contact between the USGS and the state's NHD maintenance efforts. The steward is also responsible for promoting the NHD and for making the data publically available in the state. The USGS is responsible for standards, data management, quality assurance, and distribution. The USGS provides partner support with a point of contact assigned to the state. Further, the USGS is also responsible for providing the training and resources needed to manage the editing process. The NHD Update Tools guide the steward through each step of the editing workflow. They also help ensure that a steward enforces the rules of the NHD database and provides a complete quality control process to manage data integrity.

Currently, there is no State Stewardship Coordinator for NHD in Alaska. As a result, hydrography editors from multiple agencies are scattered across a vast and diverse state, each working to fulfill their agency's business needs, but not necessarily working to adopt or enhance the NHD through coordinated stewardship. This has resulted in numerous statewide, regional and local hydrography datasets being created, managed, distributed and used over a number of years. Given the current hydrography situation in Alaska, there is a pressing need in the state to correct these issues and improve the NHD to meet the needs of federal, state, and local agency partners. Current efforts are bringing together key partners and consolidating efforts, but a lot of work remains to effectively and accurately map Alaska's water. Updating the NHD in Alaska is too large a task for any single entity. Success requires coordinating the efforts of local, state, federal and NGO partners.

The most comprehensive effort to date that is focused on joint agency coordination for NHD updates is the Alaska Hydrography Technical Working Group (AHTWG). AHTWG is a statewide cooperative that addresses and guides NHD development on behalf of all groups in Alaska. AHTWG adopted the Alaska Hydrography Database (AK Hydro) as the preferred method to update hydrography. AK Hydro is a hydrography editing and stewardship model including a custom

database based on a proven and award-winning project - the Southeast Alaska Hydrography Database.

AHTWG promotes a strategic vision that supports the maintenance, stewardship, and use of common hydrography datasets for state, federal and other partners. Specifically, the AHWTG:

- Promotes the implementation of a Statewide Stewardship Model
- Coordinates statewide hydrography editing standard operating procedures, standards and editing workflows
- Facilitates development of feature level metadata standards
- Provides input to improving the NHD data model and tools
- Communicates hydrography issues to leadership and technical staff
- Benefits all digital hydrography editors and users in Alaska

Membership in AHTWG is comprised of agency members who are actively involved in hydrography data editing and coordination and a representative from the Alaska Hydrography Database (AK Hydro) program at the University of Alaska. AHTWG is governed by a steering committee. This core group functions as the decision making body of AHTWG and carries out the core business of the group. The steering committee consist of a representative from the following Federal agencies: Bureau of Land Management, National Oceanic and Atmospheric Administration, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, U.S. Geological Survey and the following State entities: Alaska Department of Environmental Conservation, Alaska Department of Fish and Game, Alaska Department of Natural Resources, University of Alaska and the Alaska Hydrography Database.

The Steering Committee is advised by an ad hoc group of Technical Advisors as well as focus groups as needed. This group is composed of representatives from the geospatial and water resources community and provides guidance to AHTWG to meet the group's mission.

The development and organization of an NHD stewardship model for Alaska remains very much a work in progress. Much of the recent stewardship efforts described above have evolved over the period in which the project documented in this report has taken place. Results from editing approaches and protocol development efforts undertaken by NPS and SMUMN have helped to guide the development of editing standards for AK Hydro and have contributed to the knowledge of hydrography editors in other state and Federal agencies.

Methods
The primary purpose of the first task in this project was to cooperatively prepare an NHD data development strategy for the NPS Alaska Region.   Work on this strategy was structured so that the processes developed addressed NPS hydrography data needs, adopted current NPS hydrography data knowledge and were compliant with current USGS data and editing standards which ensured eligibility for inclusion of the data in the National Map. Early in the project scoping process, it was agreed that the best way to develop the strategy was to do so within the context of an actual NHD data development exercise so that issues and problems could be immediately resolved and documented within the editing protocol. Since NPS had an immediate need to update NHD shoreline data for five coastal park units in Alaska, this project was chosen as the test case for the development

of NHD data editing processes and the preparation of a comprehensive draft NHD update protocol document for the Alaska Region.

In many parts of the United States and particularly Alaska, shoreline features in the NHD are both ambiguous and imprecise. The Alaska shoreline features present in much of the current NHD database were developed from the original 1950's era topographic mapping of the state using traditional, small scale aerial photography and photo interpretation techniques. These demarcations were often indicative of: drift lines; vegetation edges; visible tidal lines; and other observable features. However, since the initial compilation of shoreline features occurred in coastal Alaska, scientific investigations have substantially increased understanding of the tidal datum and natural coastal processes affecting the region. Greater scientific understanding coupled with new techniques and improved technology; as well as a collection of newer imagery revisions were combined in this project to update the NHD shoreline of the following NPS units: Cape Krusenstern (CAKR), Bering Land Bridge (BELA), Aniakchak (ANIA), Lake Clark (LACL), and Kenai Fjords (KEFJ).

Throughout Alaska the most accurate digital representation of the mean high water (MHW) shoreline is NOAA's extracted vector shoreline (EVS) and electronic navigational chart (ENC) data. Where EVS and ENC data are unavailable, shoreline data from the USGS NHD remains the best historical representation of approximate MHW shoreline. In those areas where imagery has been acquired at the time of MHW image interpretation can be completed to fill in areas lacking the EVS and ENC data. By integrating EVS, ENC, USGS NHD and image interpretation using newly acquired tidally referenced imagery bases, revisions to and updates of the NHD shoreline were possible for this project.

Updates to the National Hydrography Dataset (NHD) were conducted using a series of data edit steps which included; data acquisition, data development and processing, and data model validation using the USGS ArcGIS NHD Edit Tools. These steps effectively moved compiled coastline data (EVS, ENC, historical USGS NHD data, and image interpreted coastline) to the NHD data schema for use as target data in the NHD Edit Tools.

Data acquisition and selection was completed using a combination of locating and downloading EVS and ENC data on the NOAA web site, acquiring USGS NHD which was readily available from the USGS National Map, and, where applicable, image interpretation of shoreline from tidally referenced orthorectified imagery acquired by the National Park Service.

Database development or processing of the shoreline data included the importing of the datasets into a USGS NHD compliant schema and edge matching the shoreline ends to one another. Preparation involved validation and compiling the linear shoreline into one shoreline feature class for the assigned project area. The various datasets were brought into ArcMap and validated against the highest quality verifiable digital orthorectified imagery available and the most current, large scale NOAA marine charts prior to acceptance. The validated shorelines were then snapped to the ends of one another to create a shoreline without breaks. A final quality control and assessment process involved careful attention to ensure that there were no topological errors in the shoreline when transitioning from one data source to another. Topological checks were run to identify and repair; overlaps, self-overlaps, intersects, self-intersects, and no dangles. A complete list of processes can be found in the Appendix A.

Data model validation and uploading of the shoreline data to the USGS National Map utilized the USGS NHD Edit Tools through ESRI's ArcMap environment. A template was downloaded from the

USGS and the previously processed shoreline data was imported into the template. Within the NHD Edit Tools this template was run through a series of quality control checks to ensure the newly added shoreline was compliant with the USGS NHD feature rules. Upon successful passing of all quality control checks the template was then uploaded to the USGS for inclusion into the National Map.

Quality control checks required any geometric errors to be repaired according to established topological standards. Following the repair of any geometric issues, a series of individual QC checks were conducted to further repair the dataset. When all issues had been addressed, a final quality control check was executed prior to the data becoming eligible for upload to the National Map.

Results

Completion of this project task resulted in the update of approximately 2,855 miles of shoreline within five different NPS Alaska Region coastal park units; KEFJ (606 miles), LACL (411 miles), ANIA (108 miles), BELA (1,560 miles) and CAKR (170 miles). Shoreline features were updated using the best available data representing mean high water from three different sources: NOAA extracted vector shoreline, NOAA electronic navigational chart data and, where EVS and ENC data were unavailable, existing shoreline data from USGS NHD. As an additional update mechanism, original image interpretation of shoreline features was also conducted for a portion of the Seward Peninsula shoreline within the BELA Preserve boundary. This was made possible by the availability of tidally referenced, high resolution aerial imagery for that section of coast. Once completed, these data edits were validated using the USGS NHD Edit Tools and submitted to the National Map as the current shoreline for the five park units in the project.

In addition to the data edits, this project task also resulted in the development of a draft protocol for the compilation of accurate and contemporary digital shoreline for Alaska coastal parks (Appendix A). This protocol represents a collaborative effort between SMUMN and NPS to document the data sources, editing process, decision points, quality assurance steps and review requirements required for successful shoreline updates in Alaska. This document is intended to provide guidance for future shoreline update projects by advising practitioners on appropriate workflow processes and interactions for data editing and validation.

Research conducted for the development of this mapping protocol established that the update of shoreline features for Alaska's parks is a collaborative process. Where data editing was being conducted by an organization outside of NPS, it was important that Service staff be involved with initial data acquisition (NOAA, imagery, existing NHD etc.) and then be available for consultation on shoreline mapping decision points throughout the editing process. During testing of the editing process for this project, it was also determined that having a contact within each park unit who was knowledgeable about shoreline features and tides added considerable value to decisions and data review. Following completion of the edits, it was important to have NPS staff conduct a thorough review of the draft data with the intent of identifying features that should be modified or re-visited.

Following the final data review, it was critical that someone knowledgeable with NHD data model, geometric networking and the NHD Edit and Conflation tools assumed responsibility for the submission to USGS and the National Map. The final editing processes involved considerable decision making related to topological structure; geometric network integrity; and, feature attribution. The tools that were required to run in order to process and validate the data prior to submission were complex and unstable. Consultation with NHD professionals at USGS was often required to resolve

data editing and processing issues. Responsibility for that step resided with an individual or organization that was completely conversant with the NHD data submission process.

Conclusions

The research conducted for this project task supported the following conclusions:

1. NHD updates must be a collaborative process given that many decisions are required regarding feature permanence and configuration.
2. Compliance with the NHD data model is critical from the start and can be insured by adopting either the AK Hydro or NHD data schema as the editing framework at project start
3. NPS involvement is required at the following times: project inception; acquisition of initial primary (NOAA and NHD) and collateral (imagery, soils, hydrology etc.) data sources; during activity editing for consultation; and, for QAQC review prior to data submission.
4. If available, validation of final data by visual review should be conducted by a knowledgeable park specialist prior to final processing.
5. Once a final stewardship strategy and data model are in place for Alaska, involvement of designated data steward and USGS technical staff is required during final data validation and submission of the data to the National Map.
6. Data editing and validation tools, available from both AK Hydro and USGS NHD, are available and should be employed to ensure data compliance with both Alaska and National standards.
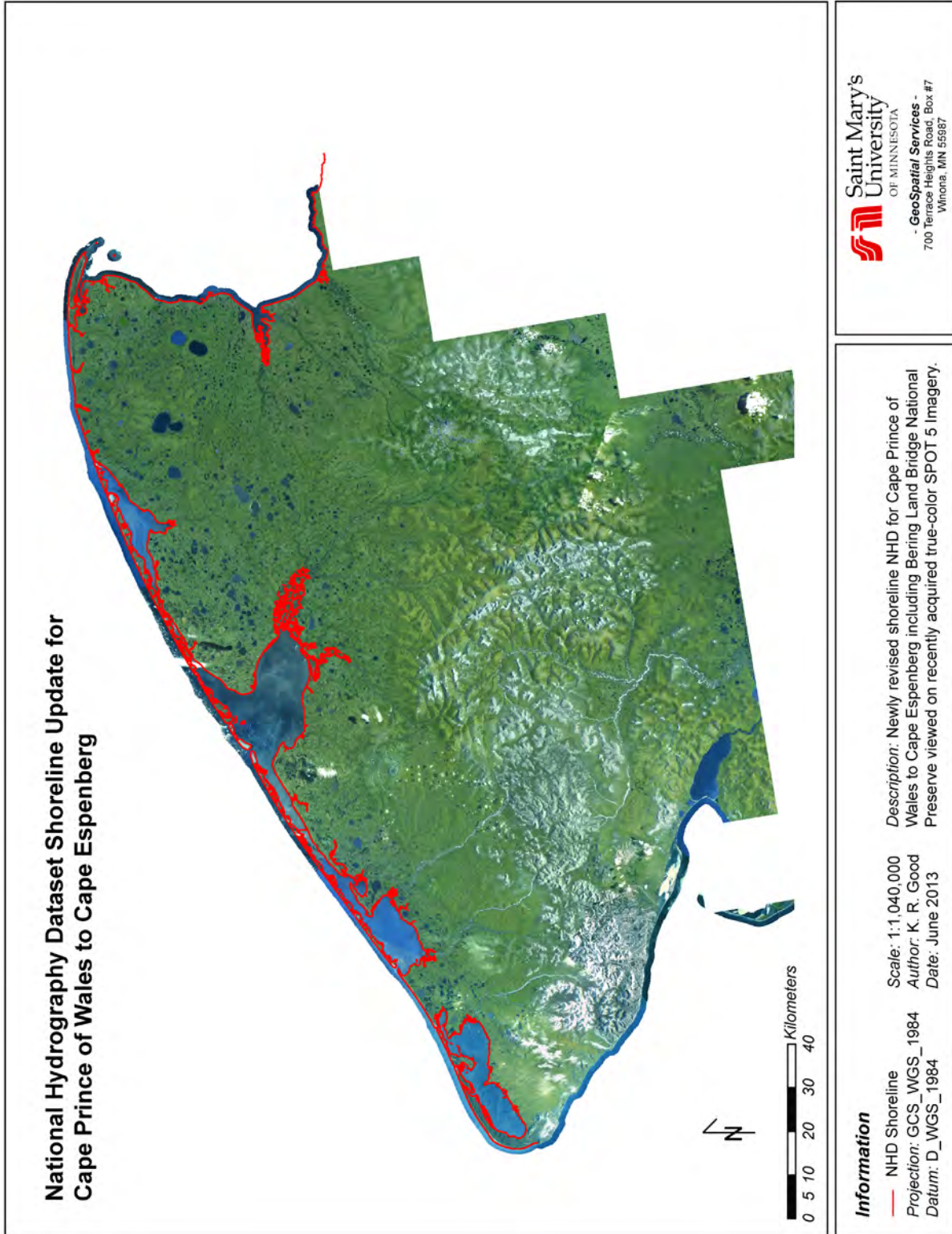
Figure 1. Map of final comprehensive shoreline NHD update for Cape Prince of Wales to Cape Espenberg. Location: Western Alaska, Seward Peninsula including Bering Land Bridge National Preserve
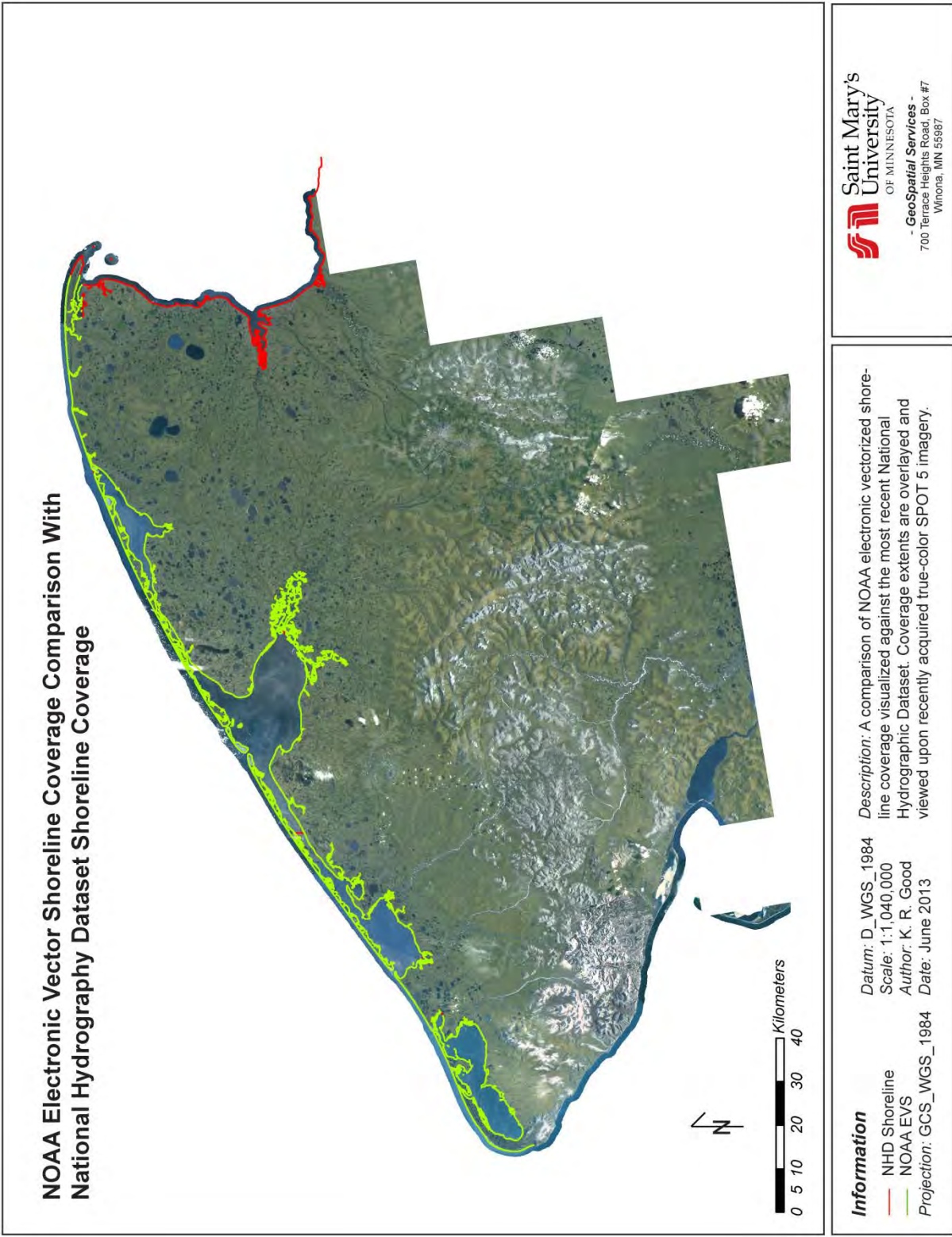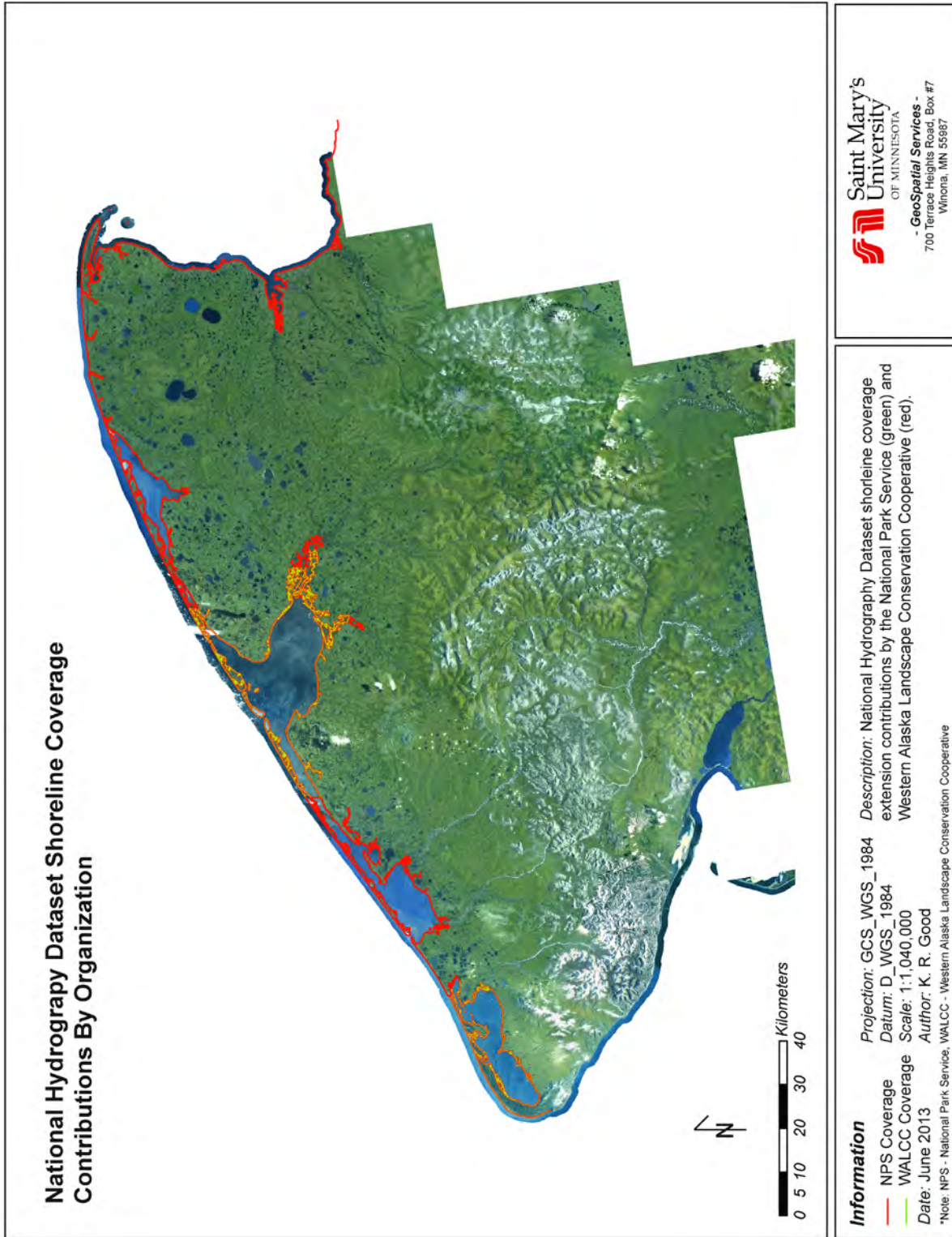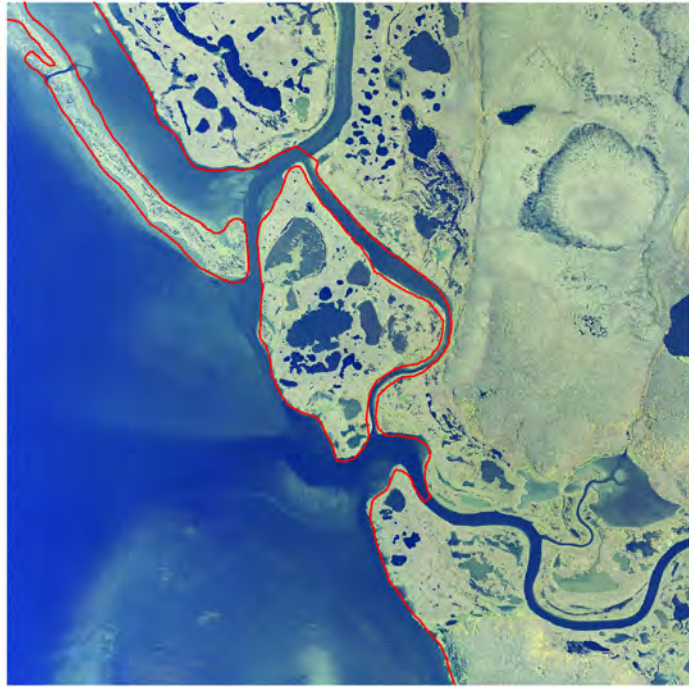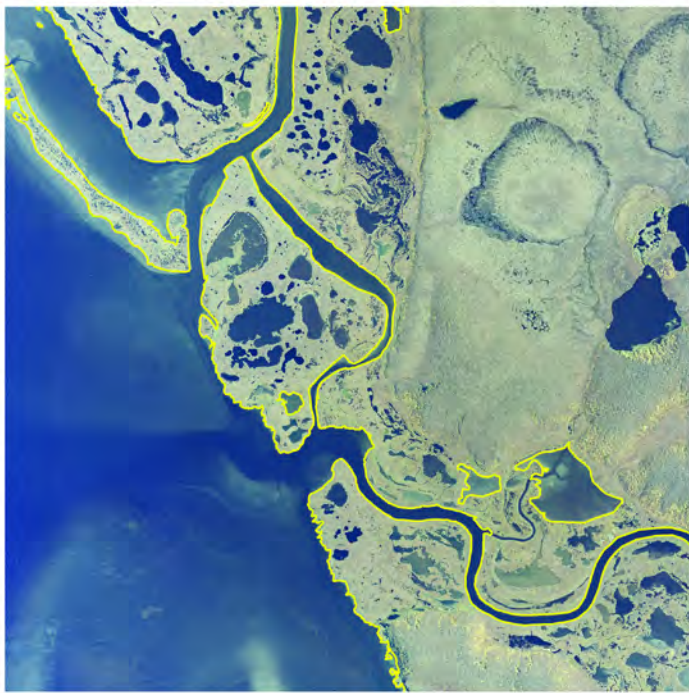
Figure 2: Revised shoreline NHD coverage.

Figure 3. Contributions to revised shoreline NHD coverage by organization.

Figure 4. Historical comparison of 1950's era and 2003 National Hydrologic Dataset.

NHD Automation Process

Background

In the first part of this project, NOAA EVS and ENC data were utilized to update NHD shoreline features in five coastal parks. These two sources represented the best available spatial data for coastal work; however, they provided minimal, if any, data for use in updating interior NHD such as rivers, lakes and other water bodies. As a result, the second task in this NHD stewardship investigation was focused on the development and testing of automated methods for updating interior hydrography.

Over the past several years the Alaska Statewide Digital Mapping Initiative (SDMI) has been in the process of acquiring new digital elevation models (DEMs) derived from IfSAR (interferometric synthetic aperture radar) sensors. These data were initially collected over large areas that included several Alaska NPS units and will ultimately be available for the entire state. The models are hydrologically enforced and suitable for application in the automated generation of both linear (1D) and polygonal (2D) hydrography which can then be used as input for automated updates of interior (non-coastal) NHD. In fact, IfSAR derived DEM data has already been tested by the Bureau of Land Management (BLM) in the National Petroleum Reserve Alaska (NPRA). The derived hydrography in NPRA had several limitations, including a lack of NHD attribution; however, it appeared to be an accurate representation of surface water flow paths and basins that had the potential to provide initial input to NHD updates.

The availability of accurate elevation data for use in the NHD updates provided the opportunity to investigate methods that were focused on the development of processes and tools by which hydrography could be updated using automation techniques based on IfSAR DEMs and existing NHD. This investigation was the focus of the second task in this project and, while it did not actually create updated NHD data, the task evaluated and documented the various techniques and the associated estimates of quality assurance and manual editing required for automating NHD data updates using IfSAR. This addition to the stewardship strategy for Alaska was a very important step for moving forward with a cost effective and accurate NHD update process.

Methods

As mentioned previously, most of the current NHD residing in the National Map for Alaska was based on hydrography interpreted from circa 1950's aerial imagery and stereoplotter derived 60 meter resolution digital elevation models. As a result of the methods used to create this original data and to a lesser extent the landscape changes that have occurred over time, much of this original data suffers from poor spatial referencing and does not accurately represent hydrography extent and connectivity. With the acquisition of more accurate digital elevation data and satellite imagery through the Alaska SDMI program, it was possible to measurably improve the representation of surface hydrography and the spatial accuracy of these data related to both location and flow. The purpose of this investigation, therefore, was to investigate automated techniques for generation of both linear and polygonal hydrography from new digital elevation data and then, using existing NHD as a starting point, conflate the new data to USGS NHD data model for loading into the National Map.

This research was guided by several assumptions that were established cooperatively at the outset of the project. These included:

1. The density of the new hydrography was to be approximately equivalent to the existing NHD for the project study area.
2. The process compared hydrography derived from SDMI IfSAR elevation data to existing NHD and then matched feature attribution through a proximity analysis process.
3. The process of creating a geometric network from the updated hydrography was not part of the tools developed but resided with the NHD Edit tools.
4. Python scripts that interacted with ArcGIS tools were used for the automation process and final processes were grouped together in an ArcGIS Toolbox implementation.
5. Output from processing was an ArcGIS file geodatabase and no multi-part features were allowed in the final data.
6. Processing of hydrography data was contained within specific HUC-8 units. If an area of interest included more than one HUC-8 then multiple tool runs were required.
7. Input hydrography data for this process was derived from IfSAR elevation data using established ArcGIS tools and processes for flowline (streams) and basin (ponds and lakes) generation.

These assumptions were incorporated into the development of a generalized workflow process that was used to guide the tool development and procedures (Figure 5). The primary steps in this workflow included: preparation of input data for assessment; loading of input data into a file geodatabase structured according to NHD schema requirements; conflation of the polygonal hydrography; conflation of the linear hydrography; and, report conflation statistics, errors and flags to the tool user for investigation and resolution.

Preparation of Input Data
This step in the workflow process involved acquisition (check-out) of existing NHD data from the National Map for the project area of interest (AOI). It also included the generation of new hydrography (flowlines and basins) for the AOI from the IfSAR elevation data. As mentioned above, generation of new hydrography was conducted using standard tools in ArcGIS and was managed so that the density of the derived hydrography was roughly equivalent to the linear and polygonal hydrography density in the original NHD.

Once an AOI had been selected for testing the NHD automation process, existing NHD data for the area was checked out from the National Map using the USGS procedures available on the NHD Stewardship Website found at http://usgs-mrs.cr.usgs.gov/stewweb/. Checkouts were available on a HUC-8 basis only and multiple checkouts were required for AOIs that crossed HUC-8 boundaries. Where the extent of the AOI was smaller than the HUC-8, it was possible to edit only the data for the AOI as long as it was integrated with the surrounding, unedited data before finalization and check-in.

The next step in preparing the input data was to generate new hydrography from the IfSAR elevation model. Two types of hydrography were required for the conflation process; lines or one-dimensional (1D) features and polygons or two-dimensional features (2D). The NHD data model fully described the types of features that fit in each of these categories and also provided information on feature attribution and description.
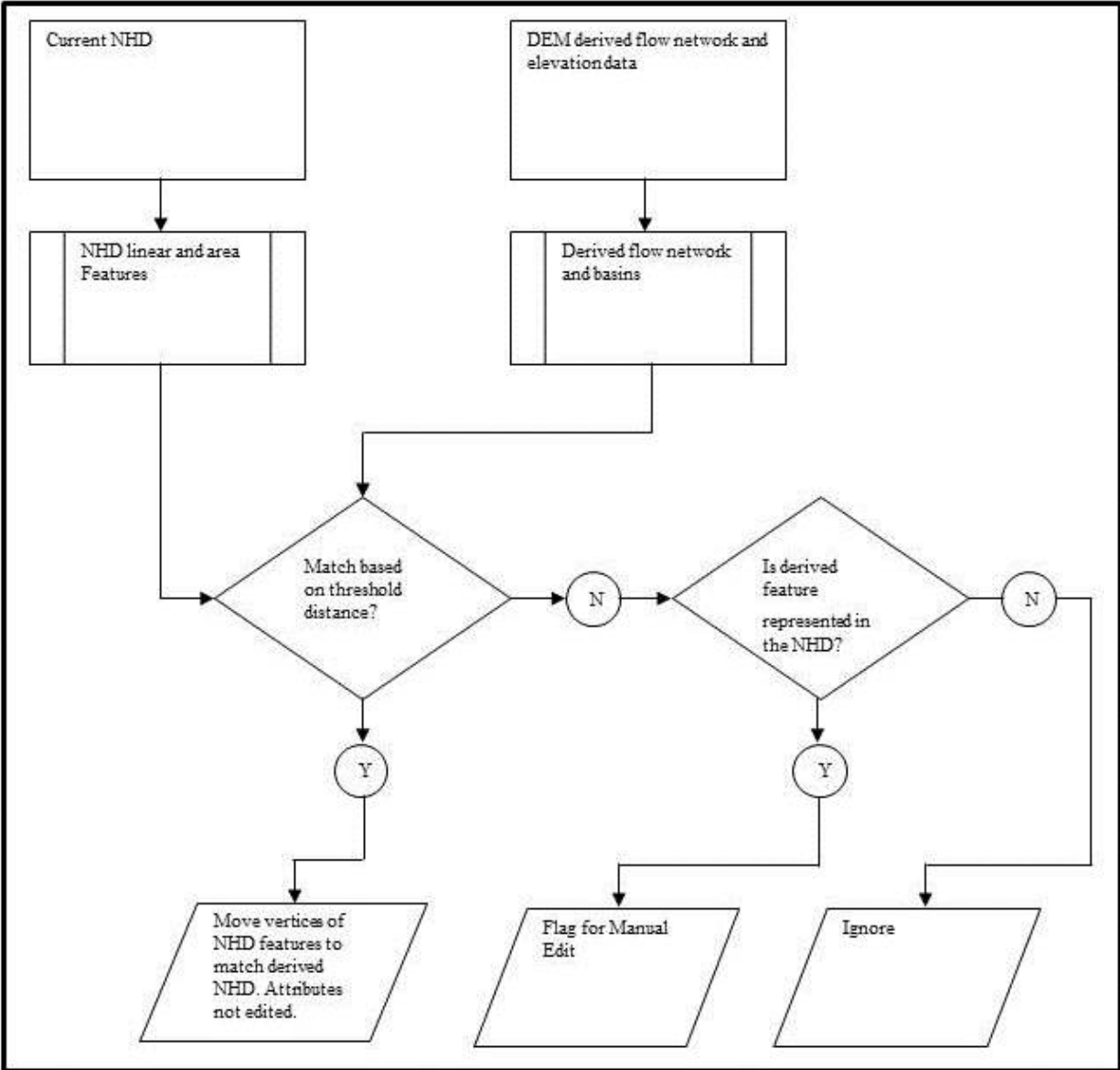
Figure 5. Schematic representation of automation workflow process.

In the workflow process for this project, researchers chose to begin by generating 2D features or open water basins including lakes, ponds, and large rivers. The minimum mapping unit selected for lakes and ponds was two acres (0.8 hectares) and mapping of 2D rivers started at sixty feet (20 meters) in width. Any features smaller than those limits were discarded from further processing. Initial processing of the DEM involved creating a depressionless DEM using the ArcGIS Spatial Analyst *Fill* tool. In the context of this project, the fill process located and identified areas in the landscape that trapped water and raised the elevation of those cells within the identified area so there were no depressions or sinks in the DEM. The *Slope* command was then executed to create a raster containing the slope of each cell. The areas that were depressions in the original DEM had no slope (slope = 0) following this processing.

Using this value, the ArcGIS raster calculator was then used to generate a raster where all areas with no slope are set to a value of 1 and all areas with slope are set to 0. This binary raster was then

vectorized to create a polygon shapefile defining the basin geometry; that is to say all groups of cells with a value of 1 became basins. The shapefile was then imported into a geodatabase feature class to create the basins data which was used as open water or lake/pond features in the NHD.

The DEM was then further analyzed to generate 1D features or the hydrologic flow network. This was done using the ArcGIS Spatial Analyst *Flow Accumulation* tool. This procedure identified those areas where water had the potential to flow across the landscape based on topography in the DEM; it did not necessarily mean that there was actually water present in those areas.

The first step in the process was to generate a flow direction raster based on the filled DEM derived during 2D processing (Figure 6). The next step was to use the flow direction raster as an input to the *Flow Accumulation* tool. Output from this tool was a raster that contained cell values that were simply the number of cells contributing to or flowing into that particular cell. The raster calculator was then used to extract the flow network based on a threshold cell value. Depending on the size of the dataset, the cell values had the potential to become extremely large. The high end of the values, however, was not the issue. The issue was determining what threshold cell value on the low end was meaningful to qualify a cell for inclusion in the flow network. Selection of too high a threshold value and the flow network was too sparse; too low a threshold and the flow network was extremely dense and did not represent reality.
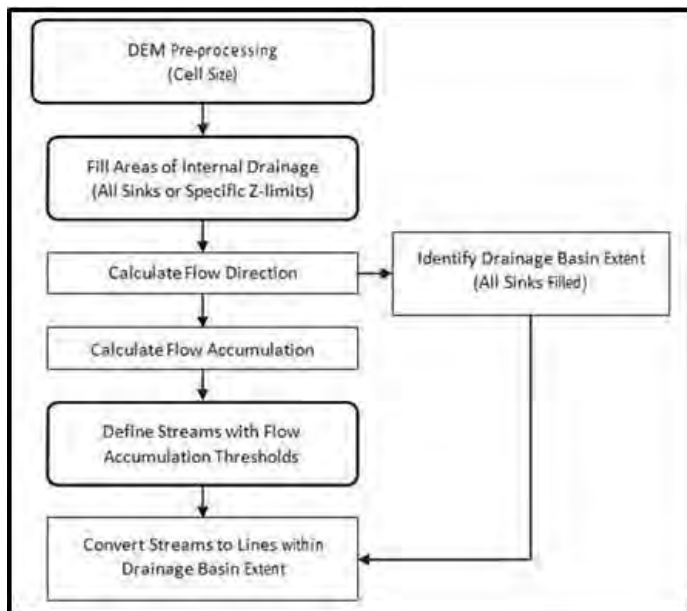
Figure 6. Schematic representation of 1D hydrography generation in ArcGIS.

Determination of the threshold value was best accomplished by a trial and error comparison of flow network results at various accumulation values with the stream features on USGS 1:24,000 scale topographic maps and existing USGS NHD data. The USGS topographic maps were considered to represent the minimum number of features that were derived from automated generation and it was concluded that it was better to include too many features in the model rather than too few. Local knowledge was also beneficial in making this determination. Once a threshold value was determined and a flow network raster was calculated, it was then vectorized to provide input into the conflation tool processing. The final 1D and 2D derived hydrography was loaded into an empty file geodatabase created using the NHD data model schema.

Conflation of Polygonal Hydrography

The next step in the automation process was the conflation of derived polygonal hydrography to NHD format. Within this process, raw basin geometry derived from the IfSAR elevation model was assessed to identify features that matched existing data within the original NHD water body layer. This process copied the raw basin geometry to a new geodatabase and applied selected NHD attributes through conflation. The tool flagged any NHD features that couldn't be processed for later review by an analyst.

The process employed a radius tool to match raw basin geometry to the most likely original NHD water body. If there were no raw basins that intersected with an original NHD water body, the original feature was flagged for manual review. Where the process identified more than one polygon in the raw basin geometry that matched the existing NHD, it compared the area of all the features found and assigned the geometry and attribution of the polygon to the area closest to the area of the original NHD feature.

The steps in the conflation process were as follows:

1. **Setting up or preprocessing the working geodatabase:**
   Prior to running the Step1 Script the user creates an empty file geodatabase. The analyst can make several copies of this geodatabase to do multiple runs of the tools at different geometry search radius values. For example the analyst could have a geodatabase copy for each radius that would hold each tool run of 20, 30, 40 meters. If the analyst is unsure how many runs to perform, it is prudent to retain an empty copy of the results from the first step, this way if further multiple runs are decided upon, the analyst doesn't have to repeat this step.
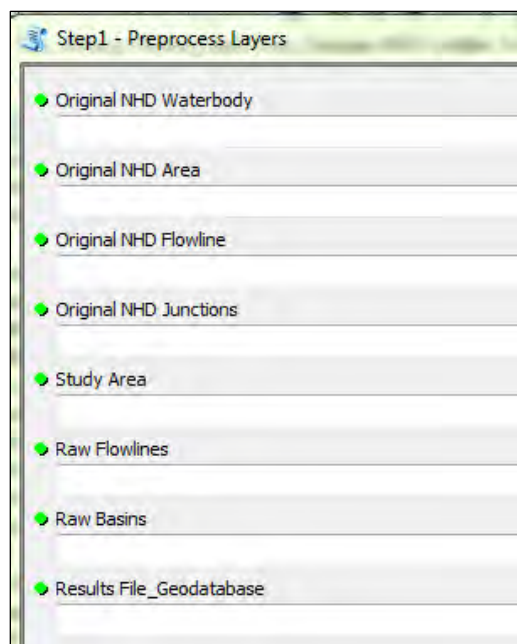
Figure 7: Conflation tool Step 1- data input screen

This process creates layers that hold the features within or crossing the border of the given area of interest. It also creates empty layers that the tool will use to hold the final results of the conflation processes.

2. **Conflate Waterbody Polygons**

Enter the path to the results file geodatabase location that will contain the saved results. Enter the Geometry Search Radius for this run of the tool; the radius must be in meters.
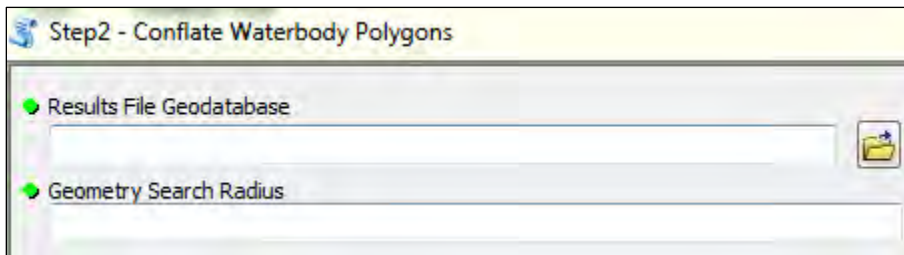
Figure 8: Conflation tool Step 2 – data input screen

a. The tool processes every feature in the original NHD water body layer. It searches for derived features that are either within or intersect each original NHD feature. If no features are returned from the derived basins, the tool then searches for features that are within the specified search radius. If there are multiple returns from the search process, the tool then compares the area of each selected feature with the derived hydrography features returned. The feature that has a total area that has the smallest difference to the original NHD feature is the geometry that is selected as matched with the attribution of the resulting feature and is saved to the final conflation layer. Those original NHD features with no selected derived hydrography for either search are flagged for manual review by an image analyst. These original NHD features will need evaluation by an analyst to determine if they should be kept, deleted, and/or reshaped.

b. Each derived hydrography feature that has its geometry matched to an original NHD water body is flagged as being assigned in the feature geodatabase. Those derived features that do not have their geometry assigned are left out of the final conflation layer. Derived hydrography features that are not assigned a match are flagged as null for later review by an image analyst.

c. The analyst must clean flagged basins in the conflation layer and, if chosen, they can also add derived hydrography features that were not processed but have been validated visually by reviewing remotely sensed imagery. This is done by copying over the unprocessed features from the derived hydrography layer to the conflation layer and manually populating the required NHD attributes. Once all the issues are addressed the analyst can "clean" the fields in the conflation layer by applying Null to the review fields and "N" to the fields that indicate a feature has not been matched.

```
--------------------
Polygon Conflation Processing Completed.
To get accurate results evaluate all features flaged before
starting the next step.
--------------------
WaterBodies Processed: 327
Polygons Conflated: 110
Polygons with No Matching Waterbodies: 217
Polygons Flaged for Analyst: 217
Completed script 2ndConflatePolygons...
Succeeded at Mon Jan 20 11:06:50 2014 (Elapsed Time: 10
minutes 16 seconds)
```

Figure 9: Conflation Tool – water body processing results screen

3. **Artificial Paths Script**

Artificial paths are linear hydrography features that pass through polygonal hydrography in order to maintain flow network connectivity through the NHD database. For this process, the analyst enters the path to the results file geodatabase location that will contain the save results. They also enter the Geometry Search Radius for this run of the tool; the radius must be in meters.
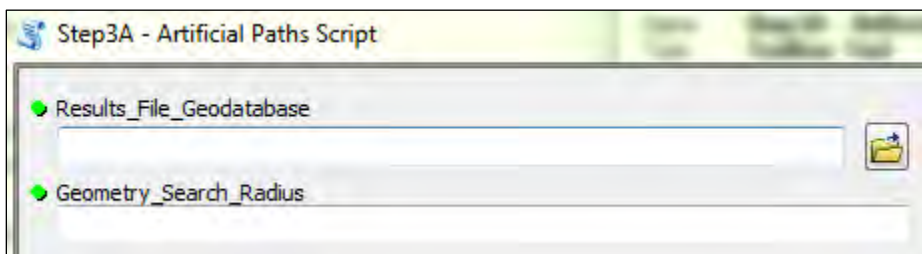
Figure 10: Conflation Tool Step 3A - artificial path data input screen

Derived flowlines are required as input to this process and are clipped using both the conflated water body polygons that are the output from Step 2 above and the original NHD water body layer in order to create artificial paths that can be conflated from the original NHD to the derived hydrography. The tool attempts to match original artificial paths to the clipped segments of the derived flowlines segments. The tool flags features for analysis if there is no match found. The window will display the number of linear features flagged for the analyst to review. This step requires no cleaning by the analyst.

```
Close this dialog when completed successfully

Executing: 3rdConflateArtificialPaths P:\NPS
\Conflate_Tool_Working\Working\Barb\Results.gdb 25
Start Time: Mon Jan 20 13:18:56 2014
Running script 3rdConflateArtificialPaths...
--------------------
NHD Flowline Artificial Lines Processing Completeted.
--------------------
Polylines Processed: 106
Polylines Flaged for Analyst: 106
Completed script 3rdConflateArtificialPaths...
Succeeded at Mon Jan 20 13:22:09 2014 (Elapsed Time: 3
minutes 13 seconds)
```

Figure 11: Conflation Tool – artificial path processing results screen

Conflation of Linear Hydrography

The next step in the automation process was the conflation of derived linear hydrography to new NHD format. This process matched raw flowlines with NHD streams that were within a given search radius and saved the geometry. The radius was applied to derived hydrography and searched for the closest corresponding NHD vector. Once a match had been selected then vertices forming the existing NHD line were snapped to the derived geometry and feature attribution was copied over. Those points that were not within the search radius were processed separately and flagged as needing analyst evaluation. Various radii were tested including 10, 20, 50 and 80 meters. The tool default was set to 20 meters; however, the radius parameter was set to be user defined so that the tool was adaptable to varying hydrography densities.

The steps in the conflation process were as follows:

1. **Spatial Preparation for Conflation**

    This step is required to prepare the storage locations for data created by the hydrography conflation process. Prior to completing this step, the user must have already created a geodatabase that will hold the processing results. Additional geodatabases will be created during tool processing to hold derived hydrography that is not an artificial path and points derived from original NHD hydrography that will be used to conflate attribution to new geometry. For both layers the analyst will need to navigate to the geodatabase that the data is to be created in, give them names prior to running the. The analyst will need to point to the same layers to run the next tool.
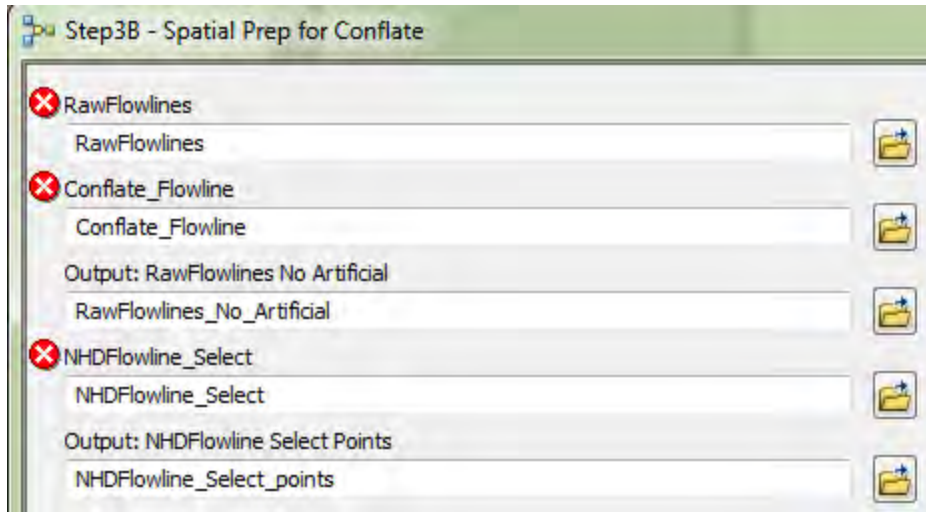
Figure 12: Conflation Tool Step 3B – preparation of spatial data for conflation

This step requires no cleaning by the analyst.

2. **Conflate Lines Script**

   Enter the path to the results file geodatabase location that will contain the saved results. Enter the Geometry Search Radius for this run of the tool; the radius must be in meters. The text boxes for RawFlowlines_No_Artificial and NHDFlowline_Select_points are the layers created from the spatial preparation step above. For both layers the analyst will need to navigate to the geodatabase and choose the layers that were previously created.
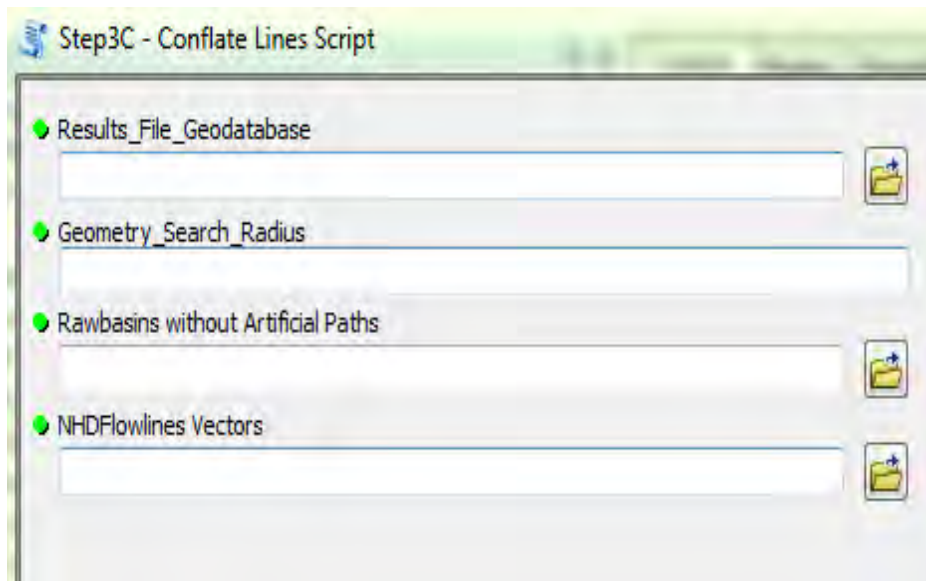
Figure 13: Conflation Tool Step 3C – conflate lines data input screen

The tool then performs the following tasks:

a) NHD features which are within the geometry search radius to the derived flowlines that are not artificial paths. Two layers are created representing points that are successfully snapped and those that are not. The layer containing points that are not snapped represents those features that are outside the geometry search radius. These points will be used later in the process to find original NHD features with no matching derived hydrography.

b) Selects the derived hydrography that has one point from the original NHD layer snapped to it and saves the selection in a layer signifying that it has been matched.

c) Snaps junction points within the geometry search radius to the matched layer and saves the snapped points into an output junction layer for later processing.

d) Splits the features in the matched layer using junction points from the junction layer and creates a layer of flowlines that have snapped junctions.

e) Splits the junction layer using the points in the successfully snapped layer from Step a) above.

f) Verifies that only one set of original NHD attributes are represented by the snapped points for each feature in the split junction layer. If there is only one set, it copies the attributes from the points to the new geometry and saves the feature in the final flow line conflation layer. If more than one set of attributes are found the tool flags the feature for analyst review and applies the attribution set that is associated with the greatest number of points along the line.

  - Each feature that has multiple attribution returns is flagged for review by an analyst using a database field set to 'Y' and a description field set to "More than one NHD feature's attribute was matched to this feature. Verify correct attributes recorded".
  - Each derived flow line that has had its geometry assigned to an original NHD feature is flagged as assigned successfully. Those derived flow lines that do not have their geometry assigned are left out of the final conflation layer. These missing flowlines are flagged for review by an analyst.
  - Each flow line that has been properly selected is flagged as successful. Those features that were not successfully attributed are flagged for analyst review.

g) Searches for all original NHD hydrography that has not been successfully assigned to a derived feature and intersects these with features from the derived hydrography that have not yet been successfully assigned and NHD points that have not been snapped. For each feature that intersects, the tool copies the feature and its attribution to the final conflation layer but flags it for review by an analyst.

```
--------------------
Flowline Conflation Processing Completed.
--------------------
Polylines Processed: 142
Polylines Flaged for Analyst: 52
Completed script 2ndPrepConflate2...
Succeeded at Wed Jan 22 15:56:19 2014 (Elapsed Time: 5 minutes 41 seconds)
```

Figure 14: Conflation Tool – flowline conflation reporting screen.

Analyst Review and Final Editing

Once the tool is finished processing an analyst will need to evaluate each flagged feature. For those with multiple attributes, the analyst may need to split the lines and manually copy over the correct attribution from the original NHD hydrography layer. For NHD lines that didn't have any matches in the derived hydrography, the analyst may need to evaluate to keep and/or reshape the lines so they properly match up with those flowlines whose geometry has been updated. Some of the artificial paths created may need to be removed from the from the final conflation layer as they cross basins that are isolated ponds that are not connected to the surface hydrography network. Advanced editing decisions may be required to resolve some of the match issues and current remotely sensed imagery is required to support those decisions as well as to validate the NHD conflation assignments made by the tool.

Results

Completion of this task resulted in the development of an ArcGIS based tool for the conflation of existing NHD data to updated geometry derived from basin and flow line modeling of IfSAR digital elevation models. The tool was written using a combination of Python scripting (Appendix B) and ArcGIS Model Builder and the final version resided within an ArcGIS Toolbox for simplification of user implementation.

The primary purpose of this task was to generate new NHD geometry from updated digital elevation data at approximately the same density of features as the historic NHD data for the project area of interest and then conflate the original NHD attribution to the new geometry. The workflow processes were developed to handle both 1D and 2D hydrography conflation.   Although not part of the original goals for this project, procedures for NHD data densification were also tested. A key goal in the development of these workflow processes was to minimize manual intervention and decision making in the NHD data development process.

The tools were developed and tested within a 55,000 acre area of interest with Denali National Park and Preserve. This area was chosen for a variety of reasons including: the availability of SDMI IfSAR elevation data and SPOT5 imagery; the topographic variation of the landscape; the importance of this location as part of the USGS 2013 US Topo update schedule; and, analysts familiarity with existing NHD data in this area.

Data Preparation

Development of 1D hydrography using the flow accumulation process defined above yielded reasonable results for input into the conflation tool processing. Two different algorithms for flow accumulation were tested, the D8 algorithm within ArcGIS and the D-infinity algorithm within the TauDEM software package.   For this study area, both algorithms yielded similar results so researchers decided to proceed with the ArcGIS processing tools in order to standardize the final tools within one software platform. Through a trial and error process, a flow accumulation value of 18,000 square meters (4.5 acres) was established as the appropriate contributing area for stream

initiation that resulted in approximately the same hydrography density as the original NHD within the project area of interest.

Basin development from the DEM fill process also yielded reasonable results for generating 2D hydrography; however, not all of the basins actually contained water nor did the boundaries fully match the presence or absence of water on the landscape when reviewed with recent imagery. In a process to improve the accuracy of basin generation, three approaches were tested: incorporating hydrography masks prepared during the IfSAR data acquisition; automated classification of basin features using eCognition (remote sensing tool for feature recognition and image classification) software applied to the IfSAR Orthorectified Radar Image (ORI); and, manual review and editing of basin boundaries to improve spatial extent and accuracy. Since each of these approaches required manual intervention and the objective of this research was to develop an automated tool for NHD conflation, none of these basin additions were incorporated in the final tool. In the future, if this automation process was implemented in a production environment, adding basin features using these techniques would provide additional integrity in the final product.

Conflation Tool Execution

Design and development of the conflation tool for 1D and 2D NHD data resulted in several iterations of the workflow processes as approaches were tested, accepted, abandoned and refined. In total, there were three primary iterations that were used to explore both performance of the tool and behavior of the background ArcGIS processes that were accessed for functionality.

For the first iteration it was decided that Python scripting would be the primary development language for creation of the tools. This programming tool was chosen because it expedited sharing of the source code between different individuals and organization for collaboration and was not dependent on a specific version of ESRI ArcGIS software. In addition, because the Python scripts were implemented within and ArcGIS ArcToolbox framework, no separate installation of code or tools was required when the application was moved between users. The following functions were included in the initial iteration of the tool but were modified in subsequent versions:

- A 20 meter search radius was hard coded into the tool for locating matching NHD.
- This search radius was used for both flow lines (streams) and water bodies (lakes/ponds).
- Flow line searches tried to match lines from the derived to lines in the existing NHD.
- Did not flag data in the derived or the original datasets for further investigation.
- Only transferred flow lines and water bodies from the derived to the final datasets that had been matched to an original NHD feature within the search radius.
- Assumed any changes to NHD Areas had been done before the start of the tool.
- Did not process artificial paths separately from the other flow lines.

Testing of the original iteration of the tool resulted in the identification of several processing improvements that were incorporated in the second version. These functional enhancements improved the flexibility of the application for various users, improved the success of the conflation processes and provided greater adaptability to different areas of interest.

To make the scripts more portable and to prevent the need for templates, the first step of the tool was modified so that it copied all the collateral datasets that were required for processing from both the derived and the original datasets to a single file geodatabase. This change permitted the addition of

fields to input datasets which allowed the application to flag any errors and keep track of which features were processed into which final layers.

Functionality was also added to allow the user of the script to set the search radius when looking for matches between the derived features and the original NHD. This provided the application user with the ability to adapt the tool to areas of different hydrographic density and to specify a different search radius for 1D and 2D features. For example, a swampy area with a high density of lakes generally required a smaller search radius (e.g. 20 meters) for successful conflation results. However, because those same areas typically had a lower density of flow lines, a larger search radius (e.g. 40 meters) was required for selection of those features in order to maximize the results if the conflation process.

In order to improve the success of the 1D conflation process, the feature matching logic was also modified in the second version of the tool. Instead of matching the flow lines of the derived data to the original NHD, the application was modified to snap the vertices of the original line to the derived data and then it evaluate the number of vertices on that original line that matched the derived line. This increased the number of successful matches made from the derived data to the original NHD. This modification was implemented as an ArcGIS model builder model as opposed to a Python script due to performance and accuracy limitations encountered with Python.

Instead of transferring all the unmatched NHD original and/or derived features into two output layers, feature-based flags were set on all four layers. Flags were added as attribute fields for each derived and original layer. As the tool processed each feature, it was flagged as being assigned or unassigned. This prevented NHD original attribution from being transferred to more than one feature as, once a feature had been processed and successfully matched, its attribute was no longer available for other features within the same search radius to utilize. If more than one feature was matched to the same original NHD feature all features after the first would be flagged in the derived layer as having matched a feature already processed. Once flagged in this manner, review by an analyst was required in order to override feature matching.

For the final iteration of the tool, several enhancements were added to increase performance. In order to further improve feature matching of NHD flow lines to derived hydrography, intersection junctions were incorporated into the first processing step (vertex snapping). These junctions existed where two features joined in the original NHD and represented an attribution change in the hydrography. To more accurately capture these changes, junctions were snapped to the line and used to split the derived lines so they more appropriately matched the NHD original segmentation values. This increased the number of successful matches and allowed attribute codes from the original NHD to be more accurately assigned to the derived data.

A counter was also added to the evaluation of flow line vertex matches between the original and the derived data. The purpose of the counter was to handle situations where there was more than one set of attributes from the original NHD assigned to the derived data (i.e. more than one original NHD line had vertices snapped to a derived line). Utilizing the counter allowed the application to assign feature attribution based on a poll of the largest number of vertices that intersected a particular derived feature. This added significant confidence to the assignment of attributes being applied to the derived geometry.

Finally, full metadata was developed and added to the tool in order to provide guidance for users related to workflow processes and variables that were required for successful execution of the application. These instructions were incorporated as metadata as opposed to an external user document in order to provide the most utility when running the tool.

The third iteration of the tool represented the final version that was delivered to NPS for testing and evaluation. This version of the application was contained entirely within and ArcGIS Toolbox and was fully documented for user implementation. Execution of the tool required minimal involvement for the user and maximized automation of the conflation process. The tool did require input from the user at various points in the processing in order to set search variables and define modelling parameters. Processing efficiency of the tool for both 1D and 2D conflation was tested using various combinations of ten, twenty, forty and fifty meter search radii and for various geographic locations and landscape types in Alaska.

Results of the tool runs indicated that, when the correct radius was chosen for the density of data being conflated, the accuracy of 2D feature conflation was up to 74%. Accurate conflation of 2D features was further improved by modifying the process used so that larger water bodies were processed and removed from the data set before smaller water bodies were assessed. This process prevented large derived water bodies from being assigned attribution of smaller adjacent features and causing confusion in the tool logic.

The primary limitation of this approach for 2D feature conflation was replicating accurate boundaries of basins when compared to the actual features on remotely sensed imagery. In addition, more complicated 2D hydrographic features such as areas of complex channels and swamp/marsh features required considerable manual intervention to characterize properly. In areas of limited topographic relief, automated generation of basin boundaries became considerably more challenging and the surface modeling software had difficulty distinguishing small topographic depressions from actual surface hydrography that was capable of retaining water. This resulted in basin maps with a large number of spurious features that required manual selection and editing.

Success of the conflation process for 1D hydrography was significantly lower than that achieved for 2D features. In most cases the tools were only able to achieve conflation accuracies of between 40 and 50 percent of the selected set and many features were flagged for analyst review in order to resolve conflicts. This was primarily due to the volume of features requiring conflation, the proximity of features to each other and significant differences between geometric configuration of derived hydrography when compared to the smooth, hand drawn cartographic line work of the original data. Researchers theorized that it was possible to increase this accuracy level through ongoing testing and refinement of the tool, however, insufficient funds were available to continue that work within the current project.

Conclusions

The research conducted for this project task supported the following conclusions:

1. Derived hydrography developed from IfSAR digital elevation models provides a viable starting point for both update and densification of existing NHD.
2. Experimentation is required in each area of interest to establish the flow accumulation value that best represents stream initiation point and this value varies considerably with the terrain characteristics of the AOI.
3. Greater success was achieved in both derived hydrography generation and feature conflation in areas of interest characterized by topographic variations as opposed to flat landscapes. In flat areas the tools used to derive hydrography often had difficulty accurately routing water flow paths.

4. While some success was achieved with accurate feature conflation between derived hydrography and NHD, considerable manual intervention and decision making was required to achieve a level accuracy in the conflation process that was consistent with USGS NHD standards.

5. Validation of derived hydrography using recent aerial or satellite imagery was consistently required in order to ensure locational accuracy and attribution accuracy.

6. Given the amount of manual intervention required to achieve satisfactory results, time and cost savings achieved through automated generation of hydrography were negated by manual editing efforts. A hybrid editing approach incorporating hydrography generation as a starting point and manual editing of the derived features proved to the most economical and practical approach.

Editing Protocols for Updating Interior Hydrography

Background

The acquisition of new IFSAR based elevation data and georeferenced SPOT5 satellite imagery, for several Alaska NPS units and ultimately for the entire state has enabled USGS to advance the production schedule of new US Topo maps for Alaska. Since these maps represent the primary cartographic resource for a variety of park visitors and are the definitive source for base geographic data across the state, it was very important for NPS staff to respond quickly with data updates for these maps. Given that the representation of surface hydrography was a key component of these maps and that the original mapping was conducted from poorly referenced 1950's era aerial imagery, accurate NHD updates were immediately required to satisfy the USGS map production schedule.

Utilizing the protocols, workflow processes and tools developed for earlier parts of this cooperative project, SMUMN and NPS staff were able to quickly develop and apply a protocol for updating interior (non-coastal) hydrography data for various NPS units. Methods used include the automation techniques developed as part of the second task in this project as well as traditional photo interpretation and data editing. Testing of the NHD update protocol and workflow process was focused initially on Denali National Park and Preserve where 70, 1:25,000 scale US Topo quadrangles were part of the priority production list for USGS (Figure 15). Following completion of those updates, editing efforts were shifted to quadrangles within Bering Land Bridge National Preserve and Cape Krusenstern National Monument (Figure 16).
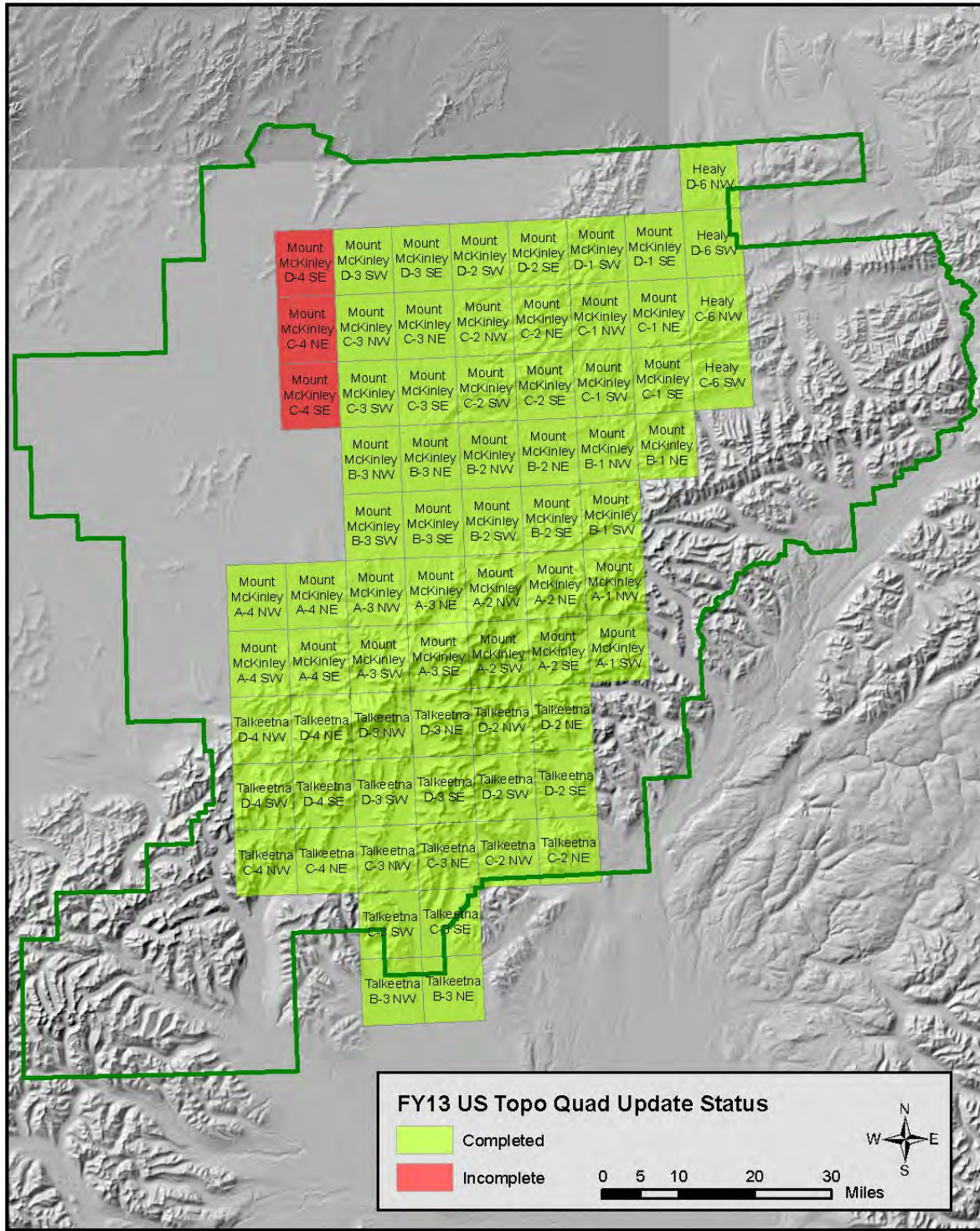
Figure 15: US Topo update priorities with Denali National Park and Preserve. Not all quads were updated for NHD.
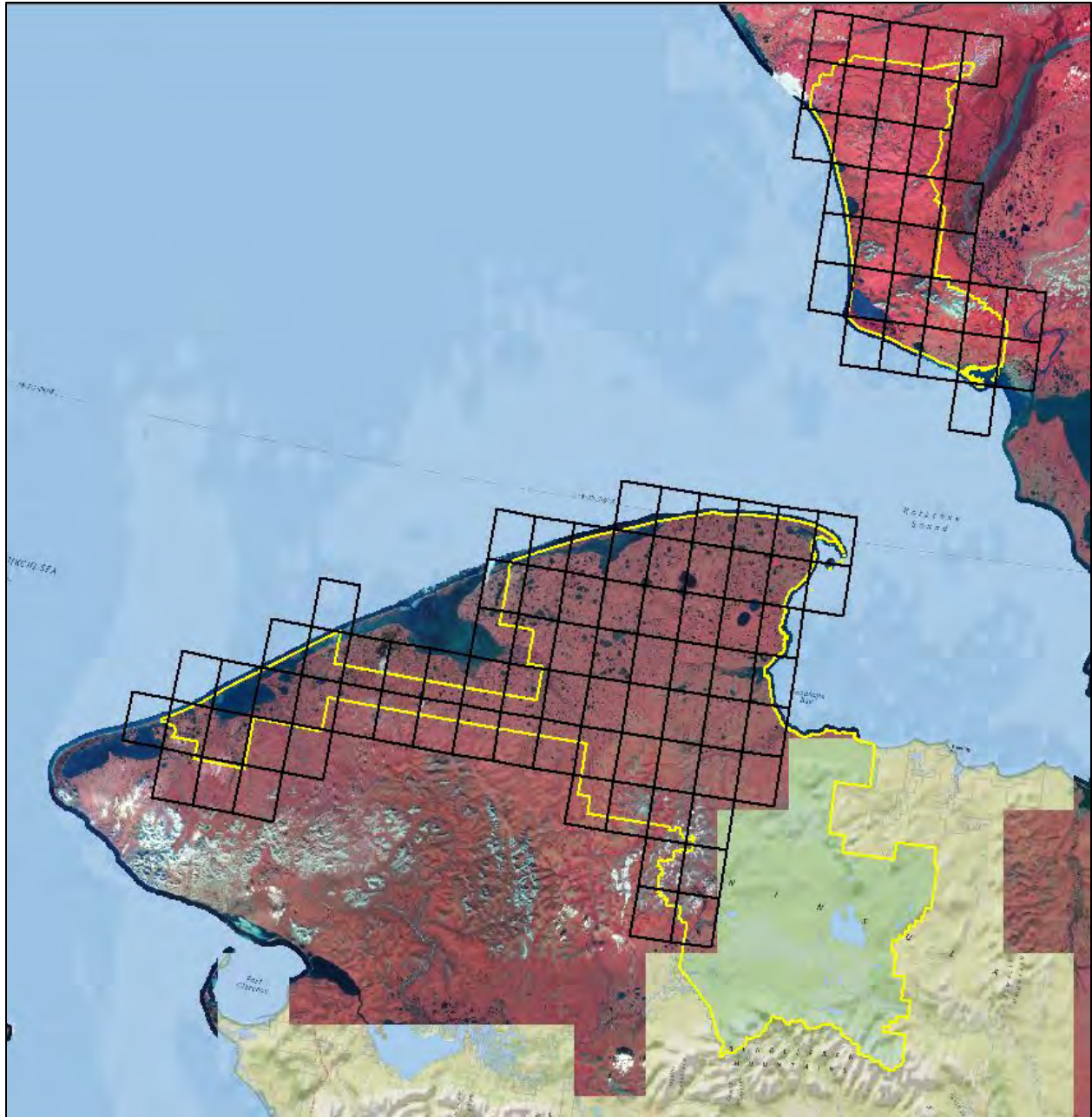
Figure 16: US Topo Quads updated in Bering Land Bridge and Cape Krusenstern

Methods

Discussions between SMUMN GeoSpatial Services and the NPS Alaska Region GIS Team concluded that the most time cost effective approach for conducting NHD updates for the US Topo production schedule was a hybridized editing process. This process was designed to take advantage of manual editing protocols developed for shoreline updates in coastal NPS units and automation techniques that were developed for the NHD conflation process. Input data sets were: original NHD extracted from the USGS stewardship website; SMDI SPOT5 satellite imagery; SDMI IfSAR digital elevation models and orthorectified radar imagery; contour lines derived from IfSAR DEM; and, various collateral data sources such as soils, anadromous waters catalog and NWI wetlands.

The editing protocol for these NHD updates was primarily a traditional image interpretation and manual data editing process. The key layers employed were SDMI SPOT5 imagery for visual validation of hydrography features and the IfSAR elevation data for validating water flow paths across the landscape surface. Derived flow lines and basins from the DEM data were used to guide interpreters to the potential location of both 1D and 2D features on the landscape. Contour lines generated from the IfSAR data were used to guide placement of 1D hydrography so that the feature location correlated to elevation data. In addition, hydrography breaklines from the IfSAR data collection process were used to initially define the boundaries of 2D lakes, ponds and rivers. The satellite imagery and IfSAR orthorectified radar images were used to visually validate and finalize these features.

This SMDI SPOT 5 imagery dataset consisted of three different types of image emulsion; color infrared (CIR), panchromatic (PAN) and true color (RGB). Identification and validation of hydrography was most successfully accomplished from the CIR version of the imagery due to that fact that this sensor filtered blue light from the image and rendered water features in dark grey or black for improved interpretation. The CIR emulsion was also useful for distinguishing live, healthy vegetation from diseased, dying or dead vegetation. The Panchromatic (PAN) image was also useful for decision support while editing, especially in areas where there was excessive shadowing or a majority of dark features. This imagery rendered features in a series of gray tones ranging from black to white and provided the image analyst with the ability to see through highly shadowed areas in order to better interpret landscape features. The true color emulsion was rarely accessed during hydrography interpretation.

The 2.5 meter resolution of the SPOT5 image base and the 5 meter resolution of the IfSAR elevation data contributed to the ability of project analysts to capture NHD updates at on-screen zoom scales of 1:10,000 or larger. In fact, the editing protocol for NHD updates from these sources endorsed three zoom levels: 1:24,000 for reviewing overall network connectivity; 1:10,000 for panning and decision making related to the addition and removal on new features; and, 1:3,000 for actual editing or re-shaping of specific NHD features. The ability to work at these scales contributed to the establishment of a minimum mapping unit of two acres for 2D NHD, twenty meters in width for separating 2D streams and rivers from 1D stream lines and four meters in length for 1D stream lines and artificial paths.

Other datasets that proved beneficial for consultation when making decisions about adding or removing hydrography features included USGS DRG images, SSURGO soils and NWI wetlands. The DRG images proved useful for identifying historic hydrography since those maps were created from 1950's era aerial photography. The soils and wetlands provided the image analyst with information connectivity between hydrographic features with poorly defined channels.

The following items represent some of the key considerations that should be followed when initiating and executing any NHD data update process:

1. When initiating updates, plan to correct polygons first and linears second.

2. Scan the quad area in a grid like pattern starting in the northwest corner and moving west to east and then south.
3. For areas with large or complex polygons, update the largest features first and then do the smaller ones.
4. Utilize SPOT5 imagery as the primary data set for decisions about feature location and consult digital elevation data (hillshade and contours) for feature placement.
5. If a feature has not changed from original configuration in the NHD keep the original.
6. If a feature is present in the original NHD but below the minimum mapping units, retain that feature only if visible on the SPOT5 imagery.
7. For new features, do not add visible hydrography that is below the minimum mapping unit.
8. Delineate new features at an on-screen zoom scale of 1:3,000 in order to ensure accurate feature location and shape.
9. All 2D features in the final NHD updates must not obstruct the hydrographic flow network; that is to say that the network must pass through these features using 1D flow lines, artificial paths or connectors thus position the 2D features within the context of surface flow.
10. Image properties of the SPOT5 imagery for display within ArcGIS should be set consistently throughout the editing process. A default display of histogram with a standard deviation of 2 works well with this imagery. This can be modified for specific editing purpose but should be changed back before proceeding to the next feature.

Additional editing guidelines and observations were submitted in draft form to the NPS Alaska Regional Office (Appendix C).

Results
Development of this NPS protocol for updating interior NHD in Alaska resulted in the revision of approximately 215, 1:25,000 USGS Topo Quadrangles across three NPS units (DENA, BELA and CAKR). In total these revisions result in replacement of more than 20,000 flow lines and 18,000 water bodies in the USGS National Map. In the process of preparing and submitting these revisions, guidelines were established for base map preparation, feature editing and decision support in non-standard situations (Appendix D). Final data editing and NHD data model compliance was ensured by processing the data using the USGS NHD Edit and Conflation Tools prior to submission to the National Map. This was a standard process required by USGS policy for all data intended for submission to the formal NHD database. Access to these tools is granted by the USGS NHD program through the NHD stewardship website.

Conclusions
The research conducted for this project task resulted in the following conclusions:

1. SDMI SPOT5 imagery and IfSAR digital elevation models provided suitable base data for NHD updates in interior NPS units.
2. A hybridized editing approach using traditional remote sensing image interpretation supported by IfSAR derived flow lines and basins plus collateral data in the form of USGS DRG images, SSURGO soils and NWI wetlands proved effective for updating and

densifying the spatial location and configuration of both 1D and 2D NHD features for interior NPS units.

3. The update process should be completed using a combination of editing and topology tools within a typical ArcGIS edit session starting with an NHD checkout from USGS for the project area of interest. Following the completion of feature edits and additions, data must be processed using the USGS NHD Edit or Conflation tools to ensure compliance with national NHD standards.

4. In order to ensure that final data meets the quality standards required, analysts who are performing data edits should be fully conversant with the USGS NHD data model.

5. Quality assurance and quality control of the data should be provided by someone who is familiar with the requirements of the USGS NHD Edit and Conflation tools.

Updating NHD Data for Glacier Bay National Park and Preserve

Background
The final task in this project was to undertake a comprehensive update and densification of interior NHD features for Glacier Bay National Park and Preserve (GLBA). This task built on the editing protocols developed in earlier portions of this project and adopted additional steps for managing data updates within the AK Hydro stewardship framework. Originally this portion of the project identified targeting updates within both GLBA and Kobuk Valley National Park (KOVA). Given the extent of updating required, the level of NHD revisions being conducted by other agencies in the surrounding area and the option of utilizing the AK Hydro data stewardship process for processing and submitting these updates, GLBA was chosen as the area of interest for this task.

Methods
Southeastern Alaska was one of the first regions of the state within which original NHD data had been made available for editing through the AK Hydro NHD stewardship framework. In general terms, the process for conducting NHD edits within that framework involved:

1. Acquiring a database replica of the most recent hydrography data for the area of interest from the AK Hydro data steward;
2. Performing edits within that database replica for the project area of interest;
3. Validating local edits using AK Hydro quality assurance and quality control tools provided by the data steward (ArcGIS Data Reviewer implementation); and,
4. Synchronizing all edits back to the AK Hydro master database using a defined check in procedure.

Conversion of the AK Hydro format data to the NHD schema was handled by conversion scripts developed for the AK Hydro data steward. Finalized data was conflated to the National Map using the USGS conflation tools following conversion. An outline of the basic process steps required for interaction with the AK Hydro regional geodatabase is included in Appendix E.

The editing protocol for GLBA NHD updates was primarily a traditional image interpretation and manual data editing process which followed the guidelines set forth in the AK Hydro Editing Standards version 0.6 (Appendix F). The key layers employed were Pleiades 1A, half meter resolution, color infrared (CIR) satellite imagery for visual validation of hydrography features and SDMI IfSAR elevation data for validating water flow paths across the landscape surface. Derived flow lines and basins from the DEM data were used to guide interpreters to the potential location of both 1D and 2D features on the landscape. Contour lines generated from the IfSAR data were used to guide placement of 1D hydrography so that the feature location correlated to elevation data. Boundaries of permanent ice mass features (glaciers, ice and snow fields) were provided by the NPS in the form of spatial data from the Randolph Glacier Inventory (RGI).

In early discussions with NPS staff, it was determined that NHD edits for GLBA would be focused on interior hydrography and that these features would be matched to shoreline delineations completed by the U.S. Forest Service (USFS) and provided by the AK Hydro data steward. This approach was chosen because, even though the shoreline represented on the Pleiades imagery was more precise and current, there was no way to reference that image data to the tidal stage that was present when the imagery was captured. As a result, editors had no way of knowing whether the shoreline on the imagery represented mean high water, mean lower low water or some value in

between. Since the shoreline updates provided within the AK Hydro database were the best available approximation of mean high water, no edits were performed on these features and interior NHD updates terminated at the existing shoreline..

Results
The area of interest defined for this NHD revision included approximately 140, 1:25,000 scale USGS Topo Quads within and adjacent to Glacier Bay National Park and Preserve. These quads represented portions of five USGS HUC-8 watersheds: Glacier Bay 19010302, Palma Bay 19010406, Alsek River 19010404, Tatshenshini River 19010403, and Icy Strait-Chatham Strait 19010500. Updating was limited to areas covered by available Pleiades 1A satellite imagery and SDMI IfSAR elevation data.   No editing was attempted beyond the areas of available base data although revised NHD was edge matched to features beyond the base data extent.

In total, the NHD updating process for GLBA resulted in the revision of approximately 16000, 1D streams; 2100, 2D lakes and ponds; and, 60 complex area features (e.g. areas of complex channels). In addition, the existing AK Hydro intertidal feature (shoreline) was updated to match the new mean high water shoreline compiled by the U.S. Forest Service and ice mass boundaries from the RGI were modified to match overlapping 2D features such as lakes. These updates were submitted to the AK Hydro data steward via a database replication check in. The AK Hydro data steward was responsible for conversion of the data and conflation to the National Map.

Conclusions
The research conducted for this project task resulted in the following conclusions:

1. Higher resolution imagery (Pleiades) provides more detail; however, analysts must be mindful to stay consistent with editing protocols established for NHD updates in Alaska. As mentioned previously decisions making is made at the 1:10,000 zoom level and features edits at 1:3,000. With the higher resolution imagery there is a tendency to zoom in beyond 1:3,000 due to the clarity of features.
2. Analysts and data editors must take care to ensure that feature delineation is consistent with this scale, even if features appear displaced from the imagery when zoomed in beyond this scale.
3. Since this editing project utilized the database replica process available from AK Hydro, internal subdivisions of the database replica were also utilized to subdivide the project wide dataset into smaller distributed geodatabase for editors to work on. This simplified edge matching and quality control processes when the data was merged back together to form the final product.
4. This was the first NPS NHD project that tested the AK Hydro database schema and it was found to be much more user friendly for editing and quality control. It is recommended that future NPS NHD editing projects be completed using this schema and associated toolsets.
5. When planning new image acquisition projects for NPS Unit coverage, it is important that the requirements of NHD updates be incorporated in the planning process. Given that these features do not correspond to administrative boundaries, it is important to extend image collection to areas beyond the NPS unit in order to accommodate feature connectivity. Planning for data acquisition based on watershed boundaries would mitigate this issue.

Appendix A: Draft NPS NHD Update Protocol

Draft Shoreline Selection Protocol

Compilation of an Accurate and Contemporary Digital Shoreline for Alaska Coastal Parks (PMIS #156638)

The Compilation of an Accurate and Contemporary Digital Shoreline for Alaska Coastal Parks project was initiated with the purpose of creating a high quality defensible digital shoreline dataset for most coastal parks in the National Park Service (NPS) Alaska Region that would replace existing U.S. Geological Survey (USGS) topographic shoreline data represented in the National Hydrographic Dataset (NHD) using the best available National Oceanic and Atmospheric Administration (NOAA) delineations of high water line (HWL) or mean high water (MHW) shorelines. For Alaska, the best available NOAA delineations of MHW shoreline are provided via two data sources, extracted vector shoreline data (EVS) and electronic navigational chart (ENC) shoreline data. This Shoreline Selection Protocol outlines the rationale or decision process to be used for best available shoreline selection and documentation. This protocol is a working document based largely on scenarios encountered during the compilation of a revised digital shoreline for Kenai Fjords National Park (KEFJ). The information provided in this protocol is intended to be used when applicable. However, unique scenarios may exist on a park-by-park basis that warrant deviation from the content of, or revision to this protocol. When such scenarios are encountered NPS Alaska Region and Saint Mary's University of Minnesota Geospatial Services (SMUMN) project staff shall work together in determining and properly documenting the most approach resolution for the issue. This includes modifications or revisions to the protocol as necessary.

SELECTION AND PROCESSING OF NOAA SHORELINE DATA

   I.   DOWNLOADING NOAA SHORELINE DATA

        i.   *Extracted Vector Shoreline (EVS) Data*

NOAA's Extracted Vector Shoreline (EVS) data represents shoreline data extracted from raster nautical charts using a process and software developed by the NOAA Office of Coast Survey (OCS) Cartographic and Geospatial Technology Program (CGTP). Though the EVS data is not currently maintained and may not reflect the shoreline on the latest edition paper marine chart, these data for Alaska coastal parks remain the largest spatially scaled dataset from original NOAA surveys and represent, in many cases, the highest quality tidally-referenced mean high water (MHW) line for this project. EVS data can be downloaded through the National Geodetic Survey (NGS) NOAA Shoreline Data Explorer web viewer at http://www.ngs.noaa.gov/newsys_ims/shoreline/index.cfm. Only high resolution data should be selected since these represent the largest spatial scale data available (Figure 1).

The decision to exclude medium resolution EVS data for the five coastal parks covered in this project was made after high and medium resolution datasets were compared for scale and currency (Figures 1 and 2). NOAA marine charts for Alaska, especially in northwest and southwest Alaska, have extremely small scales (i.e. 1:200,000 or larger) and though linework and navigational aids may be updated on a marine chart from recent surveys, the stated publication scale of the chart will compromise the quality of the shoreline GIS layers due to generalization following extraction methods of binary raster marine chart files used in nautical chart production.   This was found evident in all parks including ANIA, BELA, CAKR, KEFJ and LACL.
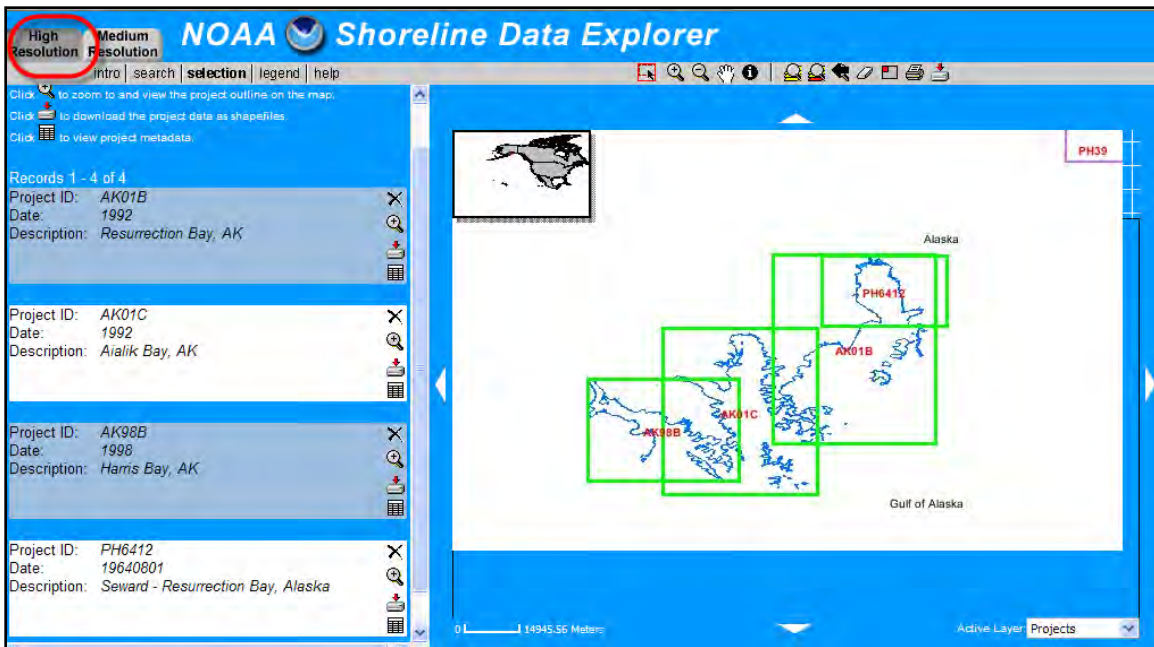
Figure 1. The NOAA Shoreline Data Explorer website and the high resolution EVS project boundary areas of interest for Kenai Fjords National Park (KEFJ).
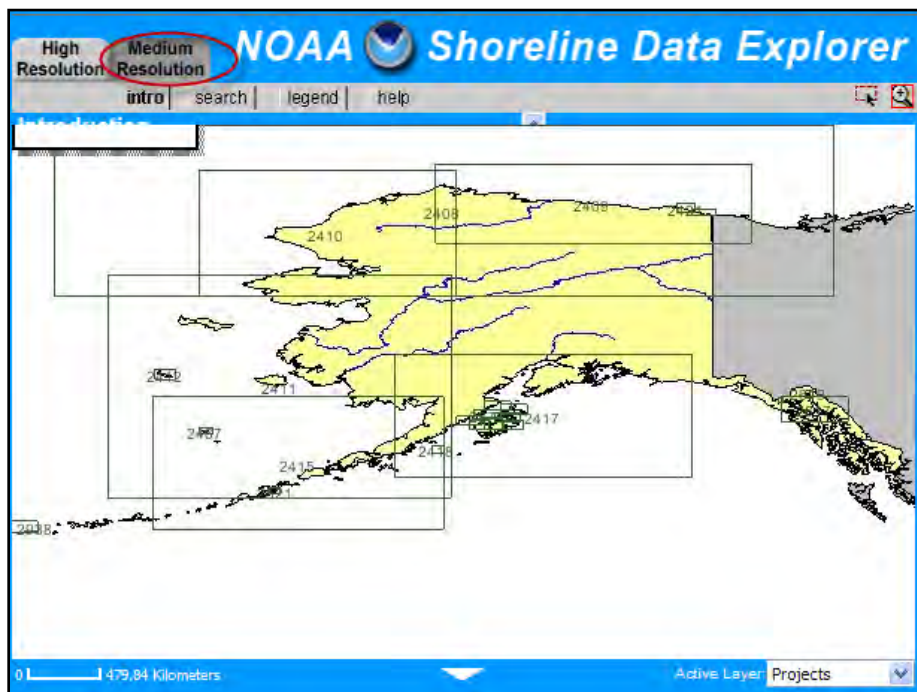
Figure 2. Medium resolution EVS project boundaries for Alaska, the size of which depicts the coarse scale of these products.

High resolution EVS data is extracted on a project boundary basis, which in some cases includes areas outside park boundaries (Figure 1). During the extraction process, no attempt should be made to exclude shoreline data outside of National Park Service (NPS) boundaries. Individual project boundary datasets (identified by Project ID) as well as their associated metadata.html documents should be extracted in compressed file format such as WINZIP and stored in a directory tree structured by the NPS

park code, NOAA data type, and NOAA ProjectID and publication date (e.g. KEFJ\EVS\AK01B_1992) (Figure 3). During the download process, the default download options "Include entire project area" and "Include all project layers" should be selected to ensure the most complete EVS data is captured. In addition to line shapefiles, certain EVS project boundary downloads will include point shapefiles. Point data represents landmarks, obstructions, aids to navigations, and rock features, and were not used in this project for shoreline delineation. The metadata.htm document associated with the EVS project boundary dataset must be downloaded separately. Hyperlinks are embedded in the Source Section of a metadata.html document through which descriptive reports can be accessed. These descriptive reports describe the photogrammetric processes including horizontal control associated with the project, and are internally referenced on the NOAA Index of Descriptive Reports website at http://www.ngs.noaa.gov/desc_reports/. In some cases multiple descriptive reports are available for an EVS project boundary, each representing a different field survey date or geographic cell of coverage. Descriptive reports should be saved into the project directory structure in PDF format alongside the appropriate EVS shapefiles and metadata.htm document.
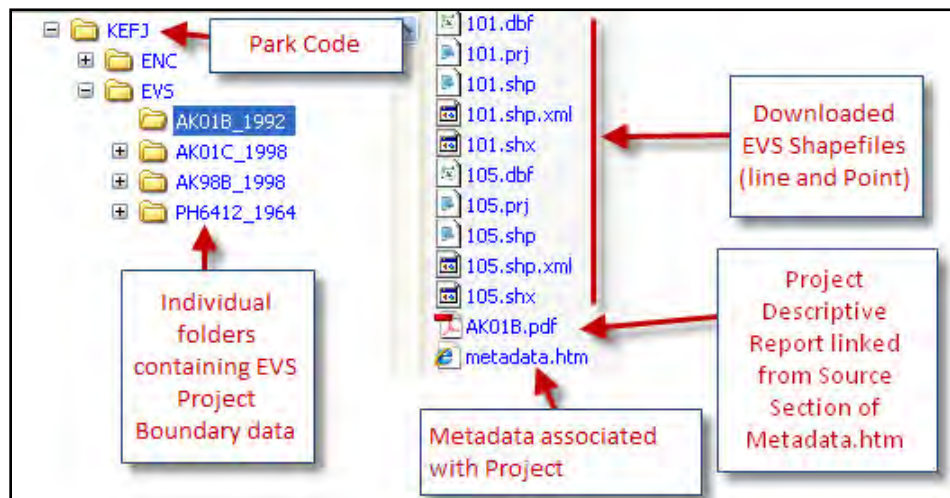
Figure 3. Example of the preferred folder structure and file naming convention for EVS data storage. Typical files within this structure include the EVS project boundary shapfile(s), the metadata associated with the project, and any descriptive report(s) referenced in the metadata.

Table 1 outlines the NOAA high-resolution EVS project boundaries pertinent to the five coastal parks associated with this project.

Table 1. NOAA high resolution EVS project boundaries, survey dates and scales.

Park	EVS Project Boundary	Survey Date of Publication[1] (# Reports)	Scale[2]
Aniakchak National Monument and Preserve (ANIA)	CM-8200	19870701(4)	1:20,000
Bering Land Bridge National Preserve (BELA)	AK301	20030723(1)	1:12,000
Cape Krusenstern National Monument (CAKR)	AK302	20030723(1)	1:12,000
Kenai Fjords National Park (KEFJ)	AK01B	19920101(1)	8m horizontal 95% CI
	AK01C	19980101(1)	24.4m horizontal 95%CI
	AK98B	19980101(1)	7m horizontal 95% CI
Lake Clark National Park and Preserve (LACL)	PH6301B	19700701 (12)	1:20,000

[1] Publication date is the published date of the project obtained from the temporal keyword in the project's metadata.htm document. This may

not reflect the on-water survey date – see the descriptive reports for source date of survey. # of Reports reflect the number the descriptive reports for the project.

[2] Scale is defined per the descriptive report. Nominal scales were used for ANIA, BELA, CAKR and LACL project boundary areas, while horizontal accuracies at 95% CI were used for KEFJ project boundary areas.

ii.   Electronic Navigational Chart (ENC) Shoreline Data

NOAA's Electronic Navigational Chart (ENC) data represent vectorized shoreline data from official NOAA marine charts. ENC data is represented in geodatabase feature classes using ESRI's S-57 protocols and are a combination of charted information as well as original source information from surveys in the area. The ENC shoreline corresponds to the black line (approximate MHW) seen on official NOAA marine charts, which are now downloadable from the web and represent the most current form of officially recognized MHW coastline at charted map scales. ENC datasets should be downloaded using the Graphical Catalog available on the NOAA OCS ENC Chart Downloader website at http://www.charts.noaa.gov/?Disclaimer=noaa%21nos@ocs%23mcd&Submit=Proceed+to+Chart+Downloader. ENC data is extractable through the Graphic Catalog on an ENC cell name basis (Figure 4). Individual ENC datasets are extractable in compressed file format. ENC data is intended to be stored in a directory tree structured by the NPS park code, NOAA data type, and NOAA ENC cell name (e.g. KEFJ\ENC\US4AK2FM) (Figure 5). Within this directory structure, a folder must be established for each ENC dataset downloaded, its title reflecting the assigned ENC cell name. This folder shall serve as a storage location for the ENC data once it is uncompressed. Once downloaded, the ENC dataset shall be uncompressed exposing a folder titled "ENC_ROOT". This ENC_ROOT folder contains the raw ENC data and must be stored within the appropriately titled ENC cell name folder. Further processing of raw ENC data is necessary before the ENC data is compatible within an ESRI environment. These processing steps are outlined in Section III (ii) of this protocol, *ENC Data Processing*.

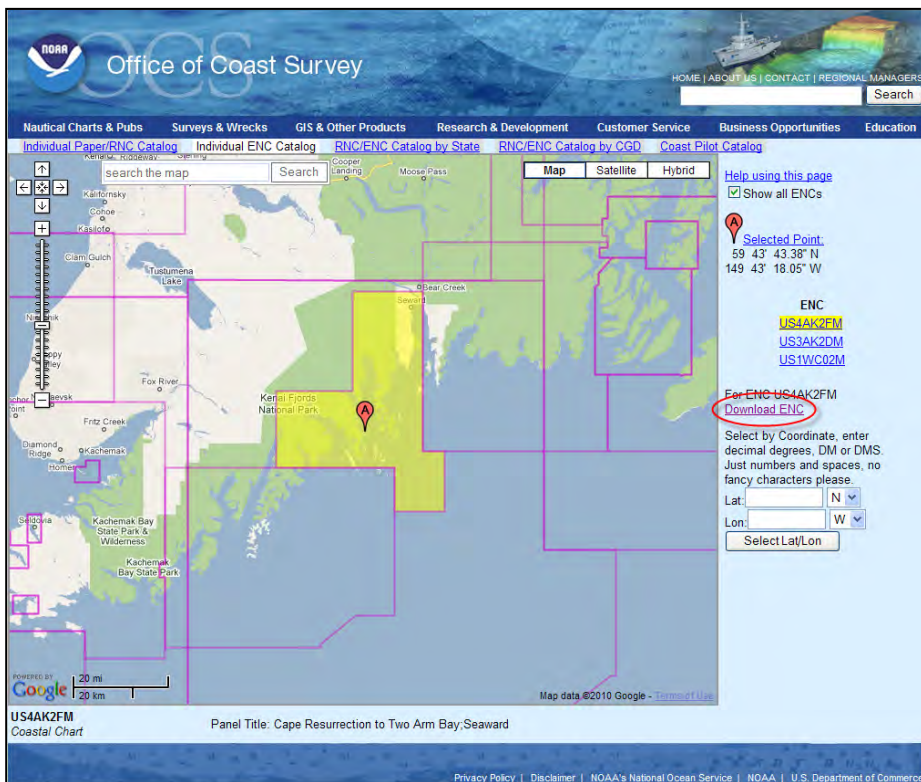**Figure 4. The Graphical Catalog NOAA OCS ENC Chart Downloader website and an ENC dataset of interest for KEFJ identified by ENC cell name.**
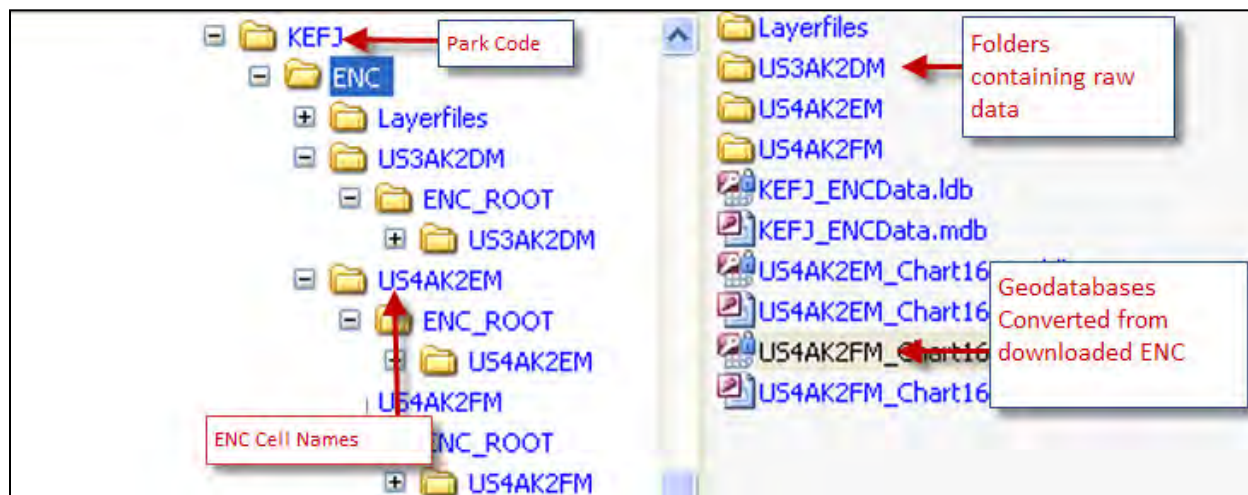
Figure 5. Example of the preferred folder structure and file naming convention for ENC data storage.

Table 2 outlines the NOAA ENC cell name boundaries pertinent to the five coastal parks associated with this project.

Table 2. Largest scale charts available in ENC format from NOAA's Graphic ENC Catalog map server.

Park	ENC Cell Name	Marine Chart Number/Name	Charting Survey Dates[1]	Scale[2]
ANIA	US2AK5FM US4AK5HE[3] US4AK5IE[3]	16011/Alaska Peninsula and Aleutian Islands to Seguam Pass 16566/Chignik and Kujulik Bays, Alaska Pen 16568/Wide Bay to Cape Kumlik, Alaska Pen.	1950 - 1970	1:1,023,188 1:77,477 1:106,600
BELA	US1BS03M US3AK80M	514/Bering Sea Northern Part 16200/Norton Sound; Golovnin Bay	1950 - 2003	1:3,500,000 1:400,000
CAKR	US1BS03M US2AK92M	514/Bering Sea Northern Part 16005/Cape Prince of Wales to Point Barrow	1950 - 2003	1:3,500,000 1:700,000
KEFJ	US4AK2DM US4AK2EM US4AK2FM	16680/Point Elrington to East Chugach Island 16681/Seal rocks to Gore Point 16682/Cape Resurrection to Two Arm Bay; Seward	1927 - 2001	1:200,000 1:83,074 1:81,847
LACL	US4AK13M	16661/Cook Inlet, Anchor Point to Kalgin Island	1935 - 1975	1:100,000

[1]Charting survey dates were determined in part by information provided through the NOAA NOS Hydrographic Survey Data web viewer.

[2]Scale is defined from scale noted on chart.

[3]This data was provided directly to the NPS Alaska Region from James Hawks at NOAA OCS and is not currently available on the NOAA NOS Hydrographic Survey Data web viewer.

II.   PROJECT GEODATABASE DEVELOPMENT

Using ArcCatalog a file geodatabase titled "Shoreline_PMIS_156683" shall be created. This geodatabase shall serve as the project's primary data repository, in which raw and processed data is stored. Within the file geodatabase a feature dataset for each coastal park unit shall be established to accommodate the storage of park-specific spatial data (Figure 6). Each feature dataset shall be named in accordance with the four-digit NPS park code (e.g. KEFJ for Kenai Fjords National Park), and assigned the Alaska Albers Equal Area Conic projected coordinate system using the North American Datum of 1983 (NAD83). The Alaska Albers Equal Area Conic NAD83 projected coordinate system is the preferred projection for

use during interim linework preparation. However, prior to integration into the USGS National Hydrographic Dataset (NHD) finalized data will need to be re-projected to the coordinate system supported by the USGS NHD.

Figure 6. Project geodatabase structure.

III.   PROCESSING NOAA SHORELINE DATA

i.   *EVS Data Processing*

EVS data downloaded from the NGS NOAA Shoreline Data Explorer internet map server is defined in a geographic coordinate system using NAD83. Before this raw data may be incorporated into the project geodatabase it must be re-projected to the Alaska Albers Equal Area Conic projected coordinate system. This can be accomplished using the Project tool available in the Feature toolset of ArcToolbox's Projection and Transformations toolbox. However, no datum transformation is required. The re-projected EVS file should be saved as a feature class in the appropriate feature dataset of the geodatabase. The output name assigned to the feature class shall first reflect the NOAA data type (i.e. EVS) followed by the NOAA project boundary (Figure 7).

Figure 7. Example of the approach for raw EVS data storage in the project geodatabase structure.

Each raw EVS dataset may now be loaded into ArcMap for further processing. Raw EVS datasets likely contain linework extraneous to this project, such as transportation linework depicting inland runways, and/or natural feature linework depicting bluffs or cliffs, etc. For this project, efforts shall focus on evaluating EVS data coded as SHORELINE and ALONGSHORE FEATURE in the attribute field "CLASS". Shoreline and alongshore feature line segments can be extracted from raw EVS data by performing a Select By Attribute query on the data using the definition query: SELECT *FROM [feature class name] WHERE: "CLASS" = "SHORELINE" OR "CLASS" = "ALONGSHORE FEATURE". Once shoreline and/or alongshore features have been extracted, the selected records should be exported as a new feature class representing processed EVS data. The naming convention for the processed dataset shall first reflect the data type followed by the NOAA project boundary followed by the type or types of CLASS feature values now contained in the dataset (Figure 8).

Figure 8. Example of the approach for processed EVS data storage in the project geodatabase structure.

Replicate features have been identified in certain EVS datasets (e.g. the KEFJ dataset EVS_AK98B contains triplicate features). A replicate feature scenario is one in which a single line segment is mistakenly repeated appearing as multiple records that are spatially coincident and identical in the attribute table (i.e. in terms of attribution, excluding unique Object ID values). The existence of replicate features does not diminish the quality of the EVS data provided, it simply adds needlessly to its volume. Therefore, all processed EVS datasets should be examined for the presence of replicate features. Replicate features can be exposed via an ascending sort of the data's Shape_Length attribute field values. The Shape_Length attribute field provides the length of each line segment to six decimal places. Records with repeating Shape_Length values are likely replicate features and should be evaluated. Replicate features can be manually removed from a processed EVS dataset by loading the dataset into ArcMap, entering an edit session, and selecting and deleting the replicate records from the dataset's attribute table. When replicate features exist, the eldest record for each feature as determined by the Object ID value should be the record that is retained in the attribute table.

ii. ENC Data Processing

Raw ENC data downloaded using the Graphical Catalog available on the NOAA OCS ENC Chart Downloader website requires certain processing before it is ESRI-compatible. Each raw ENC is a complex vector database containing approximately 180 possible data layers. Because of this, NOAA OCS developed extensions to simplify the use of ENCs in an ESRI environment. The ENC Data Handler extension for ArcGIS should be downloaded at http://www.csc.noaa.gov/products/enc/arcgis9x.html. This extension imports ENC data into a defined geodatabase structure based on ESRI's S-57 data model, assigns nautical chart symbology to each feature class, and removes extraneous data layers that do not contain data. Once the extension is downloaded, the necessary steps for processing the ENC dataset from its raw format into an ArcGIS geodatabase should be followed. These steps are provided in the tutorial document "Tutorial for Using the ENC Data Handler Extension for ArcGIS 9.0" packaged with the extension. The tutorial document can be found at C:\Program Files\ENC_DATA\ENC_Docs.

Once the raw ENC data is downloaded and processed for ESRI compatibility, it may be reviewed in ArcCatalog. ENC datasets are composed of multiple point, line, and polygon-type feature classes. The line-type feature class "CoastlineFeature" shall be the feature class of interest for the purpose of this project. The ENC CoastlineFeature linework downloaded from NOAA's Graphic Catalog is defined in a geographic coordinate system using the World Geodetic System 1984 (WGS84) datum. Before this

CoastlineFeature data may be incorporated into the project geodatabase it must be re-projected to the Alaska Albers Equal Area Conic NAD83 projected coordinate system. This can be accomplished using the Project tool available in the Feature toolset of ArcToolbox's Projection and Transformations toolbox. During the re-projection process, the geographic datum transformation "NAD_1983_To_WGS_1984_1" should be applied. The "NAD_1983_To_WGS_1984_1" datum transformation "does nothing" to the data since the datum shift parameters for the transformation are 0, 0, and 0. Per communication between NPS project staff and NGS NOAA in July 2010, this particular transformation should be applied to all ENC data tagged or assigned the WGS84 datum as the data is already in the latest realization of NAD83. Therefore, projecting ENC data using the "NAD_1983_To_WGS_1984_5" datum transformation would needlessly transform the data. NOAA expresses all marine chart data in WGS84/NAD83 as these datums are considered the same for navigation at charted scales.

The re-projected ENC CoastlineFeature linework should be saved as a feature class in the appropriate feature dataset of the project geodatabase. The CoastlineFeature feature class shall be renamed so that the output name assigned to the feature class reflects the NOAA data type (i.e. ENC) followed by the NOAA ENC cell name (Figure 9).
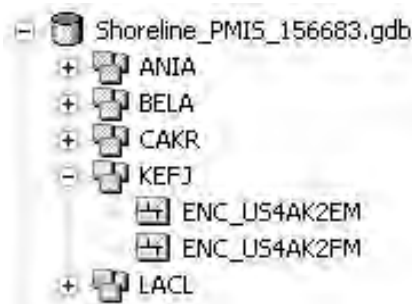
Figure 9. Example of the approach for processed ENC data storage in the project geodatabase structure.

IV.   DATA SOURCE PREFERENCES

When available, EVS linework provided by NGS NOAA shall serve as the primary data source for updates to the National Map NHD digital shoreline. The EVS data pertinent to this project is based on survey-work postdating USGS National Map efforts, is well documented with FGDC-compliant metadata, and offers highly accurate large-scale depictions of mean high water (MHW) resulting from the application of modern survey technologies. EVS linework should be validated against the highest quality verifiable digital orthorectified imagery available (i.e. 1:24,000 or higher) and the most current, large scale NOAA marine chart prior to acceptance. Marine charts may be accessed and downloaded from the NOAA OCS Online Chart Viewer website at http://www.nauticalcharts.noaa.gov/mcd/OnLineViewer.html. In cases where multiple marine charts exist for the same area, the largest scale chart should be selected.

High resolution imagery shall serve as a more current validation dataset to compare EVS linework. The NPS Alaska Region has an excellent compilation of various satellite and aerial imagery. Table 5 outlines the highest quality imagery datasets available for the five coastal parks associated with this project. Unique characteristics of these imagery datasets include:

- orthorectified imagery based on high quality DEM (including LIDAR and SRTM 30 meter);
- tidally-coordinated photography allowing for exposure of the tidal areas below high water;
- acquisition dates that are more current than DLG-based 1950s survey data;
- FGDC compliant metadata; and,

- in some cases, GPS-collected ground control point data for verification.

Since the late 1990s various NPS Alaska Region coastal field crews have used global positioning systems ranging from ± 8 meter precision lightweight GPS (PLGRs) and Trimble mapping grade GPS systems to collect point features on visible identifiable objects (VIO) scattered along coastal ranges. Due to these unique characteristics, especially independent ground control verification with GPS, the NPS Alaska Region is confident in the use of this imagery as a reference for EVS data validation, minor digitizing for the establishment of connecting arcs, and minor digitizing efforts as needed along glacial extents (Digital Shoreline data Assembly and Verification, Sections III and VI, respectively).

Table 3. Select metadata for the high quality imagery dataset available for this project.

Park	Imagery	Acquisition Date(s)	Type(s)	Scale(s)	NMAS[1] Accuracy (m)	GPS Accuracy (m)	GPS Accuracy Source(s)	Pixel Size (m)	Notes
ANIA	Coastal Imagery ANIA	July – August 1994	True Color, Pan	1:24,000	± 12	± 10 – 20 (est.)	1999 PLGR GPS (NPS); 2009 Building Survey	1.0	Tidally coordinated (see index for est. tides). Aerial photos rectified to Govt. Use Only DOQQs; GPS control pts.
	IKONOS OrthoImage Mosaic (NRCS)	2004 - 2005	True Color, Near IR	1:24,000	± 12	± 10 – 20 (est.)	1999 PLGR GPS (NPS); 2009 Building Survey	1.0	GPS control pts. for on-ground verification.
	IKONOS OrthoImage Mosaic	2005, 2007	True Color, Near IR	1:24,000	± 12	± 10 – 20 (est.)	1999 PLGR GPS (NPS); 2009 Building survey	1.0	GPS control pts. for on-ground verification.
BELA	Aircraft GMU and LIDAR Controlled Aerial photography[2]	2002	True Color	1:5,000	± 5	± 5	See Source Project AK0301	0.3	LIDAR controlled. Local tidal datum provides high quality imagery interpretive shoreline.
CAKR	Aircraft GMU and LIDAR Controlled Aerial photography[3]	2002	True Color	1:5,000	± 5	±5	See Source Project AK0302	0.3	LIDAR controlled. Local tidal datum provides high quality imagery interpretive shoreline.
KEFJ	IKONOS OrthoImage	2005	True Color	1:24,000	± 12	± 8	1998 GPS survey (NPS)	1.0	
	Coastal Pan OrthoPhotos	1993 -1994	Pan	1:24,000	± 12	± 8	1998 GPS survey (NPS)	0.3	Tidally coordinated (see index for est. tides). Co-referenced to IKONOS imagery and DEMs.
	CIR Orthophotos	2003 - 2004	Color IR	1:36,000, 1:40,000	± 12	± 8	1998 GPS survey (NPS)	0.5	Co-referenced to IKONOS imagery and DEMS.
	Seward OrthoImage IKONOS	June 2005	True Color	1:24,000	± 12	Unknown		1.0	
LACL	IKONOS OrthoImage	2005	True Color	1:24,000	± 12	Unknown		1.0	
	Coastal Imagery LACL	1992 -1994	Pan	1:24,000	± 40	Unknown		1.0	Low quality rectification. Tidally coordinated. Wait on use until Coastal OrthoPhoto is in place.
	Coastal OrthoPhoto[4]	July 2010	Color IR	1:24,000	NTE 1.5m RMSE	Unknown		0.6	Tidally coordinated. See Index for est. tides.

[1] National Mapping Accuracy Standards – horizontal accuracy. See the website http://rmmcweb.cr.usgs.gov/nmpstds/nmas.html

[2] Detailed metadata, including estimated horizontal accuracies, can be found at http://www.ngs.noaa.gov/desc_reports/AK0301.PDF

[3] Detailed metadata including estimated horizontal accuracies of imagery can be found at http://www.ngs.noaa.gov/desc_reports/AK0302.PDF

[4] Imagery acquired in July 2010. Processing is due Fall 2010 and is expected to be available Winter 2010/2011.

This validation effort shall serve as a means to identify potential errors contained in the linework. For this project, a potential error is defined as a section of linework that significantly deviates from the imagery and/or NOAA marine chart (Figures 10 and 11). When a potential error is identified, other NOAA data may prove more appropriate for shoreline revisions and should be evaluated. Potential errors in EVS linework are not expected to be common and should be brought to the attention of NPS Alaska Region project staff so the approach for shoreline revision in the affected area can be jointly discussed (Conceptual Model 1). In areas where potential EVS errors exist best efforts shall be put forth to determine the most reasonable approach for shoreline revision. This may include, but is not limited to, evaluation of NOAA ENC shoreline data and existing National Map NHD shoreline data, solicitation of shoreline/terrain characteristics from professionals with expert knowledge of the area, and/or the solicitation of supplemental information that could assist project staff in evaluating the reasonableness of the available shoreline linework (e.g. GPS data).
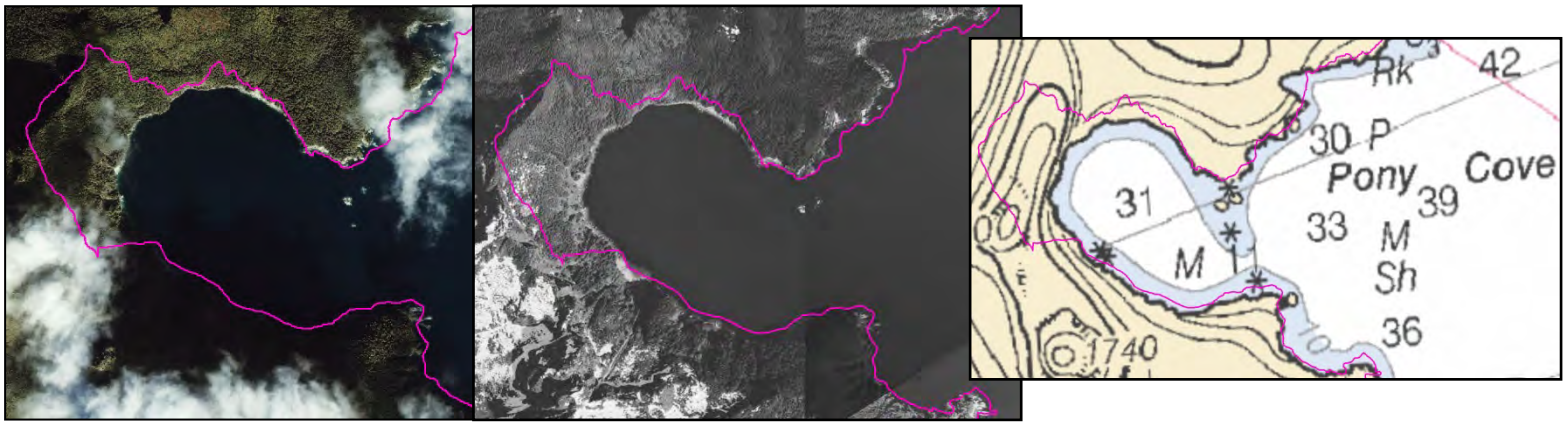
Figure 10. A potential EVS dataset error associated with the Pony Cove area at KEFJ. At this location the EVS MHW linework (pink) deviates from the coastlines depicted in the 2005 IKONOS and the 1993 coastal panchromatic imagery as well as the NOAA marine chart black line by distances greater than 350 meters in areas.

Figure 11. A potential EVS dataset error associated with the Agnes Cove area at KEFJ. At this location the EVS MHW linework deviates from the coastline depicted in the 2005 IKONOS and the 1993 coastal panchromatic imagery by distances greater than 70 meters in areas, but appears to agree with the NOAA marine chart black line.

During the KEFJ shoreline revision process two potential errors in the EVS dataset AK01B were identified along the Aialik Peninsula, one at Pony Cove and one at Agnes Cove. The most significant of these was

exhibited at Pony Cove, where the EVS MHW linework deviated from the coastlines depicted in the available imagery (i.e. 2005 true color IKONOS satellite imagery and the 1993 coastal panchromatic aerial imagery) as well as from the black line MHW notation in the NOAA marine chart #16682 by distances greater than 350 meters in some areas (Figure 10). Per protocol, the NOAA ENC US4AK2FM dataset was then examined.   The latest MHW linework available in the ENC US4AK2FM dataset for the Pony Cove area was derived from hydrographic survey work performed by NOAA in August and September 2001 as described in NOAA's H-Cell descriptive reports H-11074 and H-11075. During these 2001 hydrographic survey efforts NOAA conducted verification on their vector shoreline data from geographic cell 10494 (i.e. the EVS AK01B data from 1992). Shoreline revision recommendations based on this verification were subsequently captured by the ENC US4AK2FM dataset as identified in the descriptive reports. Validation of the ENC US4AK2FM data against the available imagery illustrates a correction in the shoreline for the Pony Cove area (Figure 12). For this reason, the ENC data was incorporated into the shoreline revision for this area of KEFJ[1] .
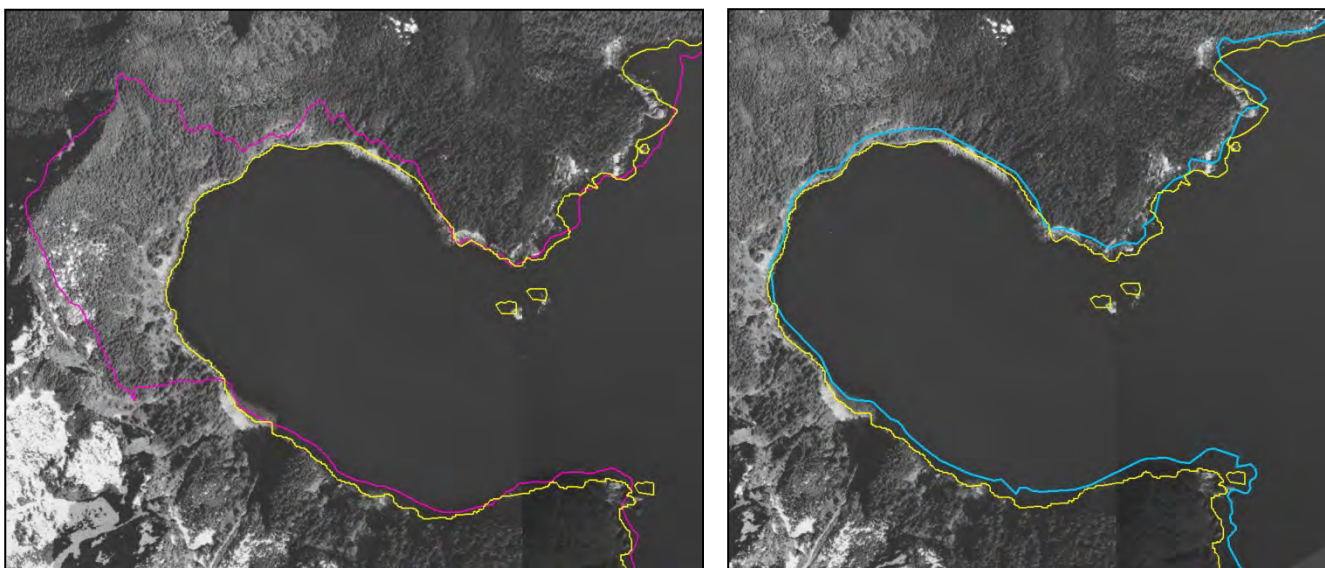
Figure 12. The image series above compares the quality of the ENC data available for the Pony Cove area of KEFJ (yellow) against the available EVS shoreline data (pink) and the existing National Map NHD linework (blue).

In the area of Agnes Cove where the other potential error at KEFJ was identified, EVS MHW linework deviated from the coastline depicted in the 2005 true color IKONOS satellite imagery and the 1993 panchromatic aerial imagery by distances greater than 70 meters in some areas, but appeared consistent with the black line MHW notation as seen in the NOAA marine chart #16682 (Figure 11). The ENC linework for the Agnes Cove area which was based on the same survey efforts as the linework at Pony Cove was evaluated. The ENC linework in the area was generally consistent with the EVS linework, expect for a minor correction to a small southern cove that had been disproved. Based on expert knowledge from the KEFJ Natural Resource Program the Agnes Cove shoreline is a very steep, stable rock shoreline. MHW is in this area is therefore not expected to fluctuate greatly over time nor extend as far landward as depicted by the NOAA data into the interior's spruce, hemlock, and alder vegetation.

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[1] Prior to of NOAA's ENC dataset acceptance US4AK2FM into the shoreline revision for KEFJ, linework derived from the 2001 survey efforts described in NOAA's H-Cell descriptive reports H-11074 and H-11075 required generalization. The reasons for generalization as well as the approach applied are outlined in Section XII, *Generalizing Line Segments*.

For this reason, the existing National Map NHD digital shoreline data was conservatively retained in the southern portion of Agnes Cove where the potential error was seen (Figure 14).
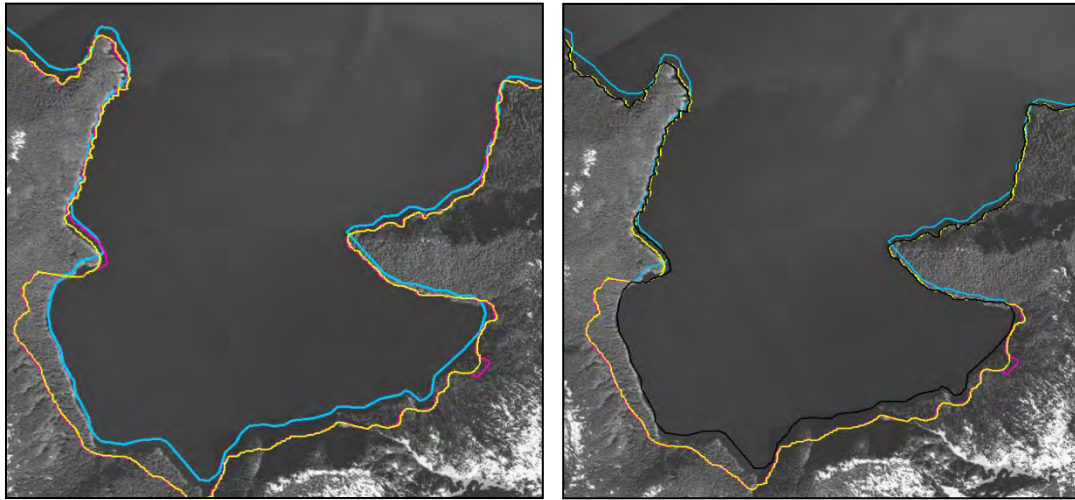

Figure 13. The image series above compares the quality of the ENC data available for the Agnes Cove area of KEFJ (yellow) against the available EVS shoreline data (pink) and the existing National Map NHD linework (blue). The right-hand image depicts the linework selections adopted in the Shoreline_Updates feature class in black for Agnes Cove.

The validation effort shall also serve as a means to identify potentially outdated linework in areas such as harbors where changes in shoreline occur more frequently due to the modification or construction of man-made waterfront structures and alongshore features such as breakwaters, wharfs, etc (Figure 14). In cases where EVS data appears outdated, other NOAA data may prove more appropriate for shoreline revision and should be evaluated. The best available NOAA shoreline data should be accepted, given the data postdates that of the National Map NHD line segment (Conceptual Model 1).

Figure 14. Example of outdated EVS data at the Seward Harbor near KEFJ. The EVS data for this area (red) is derived from survey work conducted in 1992. The linework is consistent with the appearance of the Seward Harbor as seen in the USGS digital orthophoto quadrangle (DOQ) from June 1997 (left), but does not reflect the more recent changes in breakwater or wharf configuration as seen in the 2005 IKONOS satellite imagery (right).

When imagery of sufficient quality is unavailable to validate the available EVS linework National Map NHD digital shoreline data shall be conservatively retained. Table 3 outlines the suitable imagery sources currently available for the five coastal parks associated with this project.   However, over the course of this project additional imagery sources may become available for use in data validation.

When EVS linework is unavailable, ENC shoreline data provided by NOAA OCS shall serve as the secondary source for updates to the National Map NHD digital shoreline. ENC linework should be validated against the highest quality verifiable digital orthorectified imagery available (i.e. 1:24,000 or higher) and the most current, large scale NOAA marine chart prior to acceptance. This validation effort shall serve the same purpose as described for the NOAA EVS data. Conceptual Model 1 outlines the protocols established for the use of ENC data. Certain ENC linework provided by NOAA OCS is derived from survey work predating the USGS National Map NHD digital shoreline efforts of the 1940s and 1950s. Source inset maps available on the NOAA marine charts as well as the information provided by the NOAA NOS Hydrographic Survey Data ArcIMS site available at http://map.ngdc.noaa.gov/website/mgg/nos_hydro/viewer.htm can be of assistance in making these determinations. In such cases, the retention of existing National Map NHD digital shoreline is likely preferred. However, this will need to be determined by NPS and SMUMN project staff on a park by park basis (Conceptual Model 1).   Along the western half of the KEFJ shoreline from Sandy Bay to Nuka Passage, for example, National Map NHD digital shoreline data was retained over the available NOAA ENC data. For the above mentioned stretch of shoreline the ENC dataset US4AK2EM was available. Excluding island linework, the shoreline data in this ENC dataset references the NOAA marine chart 16681 Seal Rocks to Gore Point as its source.   The source inset map for marine chart 16681 indicates that much of ENC data in the area is based on survey work performed between 1900 and 1939 (Figure 15). Information provided through the NOAA NOS Hydrographic Survey Data ArcIMS site confirmed that the majority of the NOAA survey work in the area was conducted between 1927 and 1930 (Figure 16).
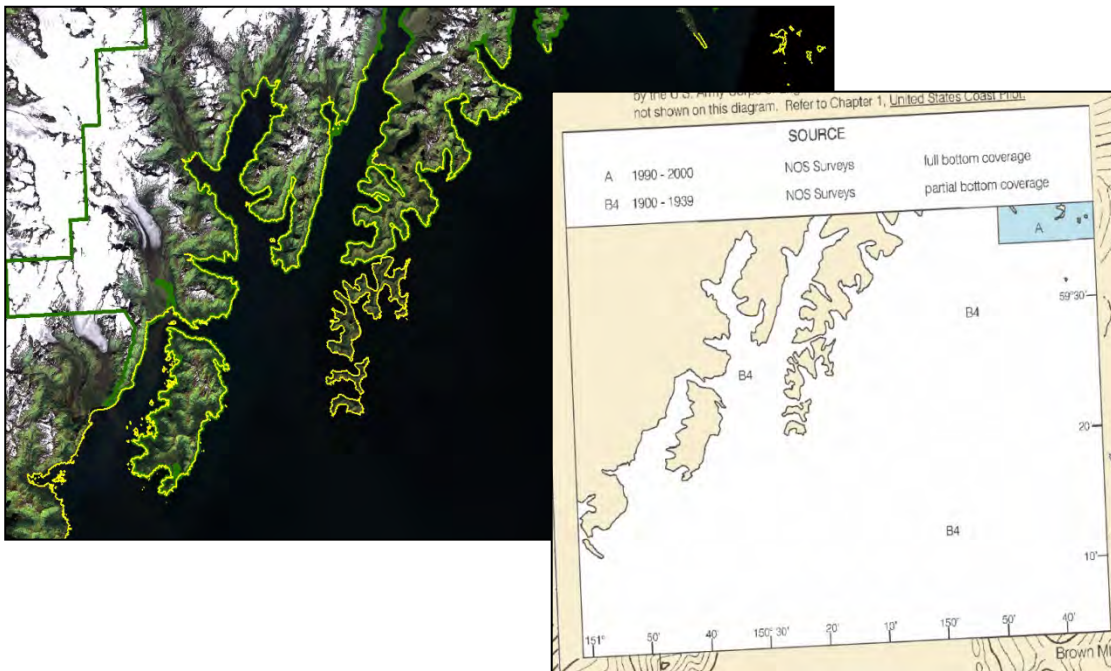
Figure 15. The NOAA ENC dataset US4AK2EM covers the western side of KEFJ as shown by the yellow linework in the left-hand image. The right-hand image depicts the source inset for NOAA marine chart #16681. Within this inset areas depicted in blue pertain to survey work conducted between 1990 and 2000, while areas depicted in white pertain to survey work conducted in 1939 or earlier.
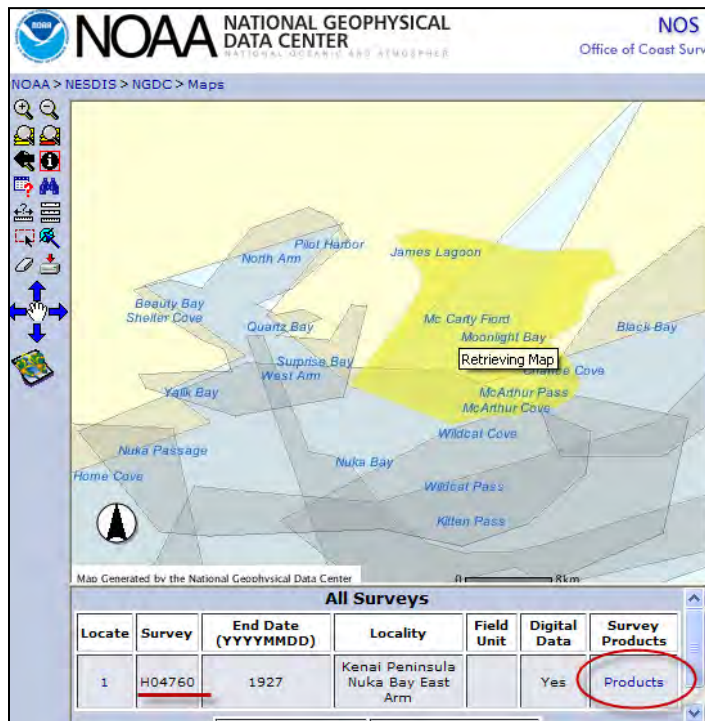
Figure 16. Screenshot from the NOAA NOS Hydrographic Survey Data web viewer showing the selection of a hydrographic survey conducted in McCarty Fjord (KEFJ). The descriptive report for the survey H-04760 can be accessed via the Products link. The end date for this survey is listed as 1927.

In this area of KEFJ a large number of dispersed GPS-collected ground control points were captured in 1998 for the purpose of registering imagery referenced in Table 3 (Figure 17). As a result this imagery has an implied accuracy of ± 8 meters. The NOAA shoreline data in the ENC US4AK2EM dataset does not agree well when compared against the imagery. Discrepancies ranging from approximately 50 meters to over 100 meters between the ENC shoreline linework and the 2005 IKONOS satellite imagery appeared frequently across the ENC dataset (Figure 19). As the available ENC data fails to provide an improved consistent representation of MHW, the decision was made in this instance to retain the existing National Map NHD digital shoreline data for this western stretch of KEFJ shoreline.
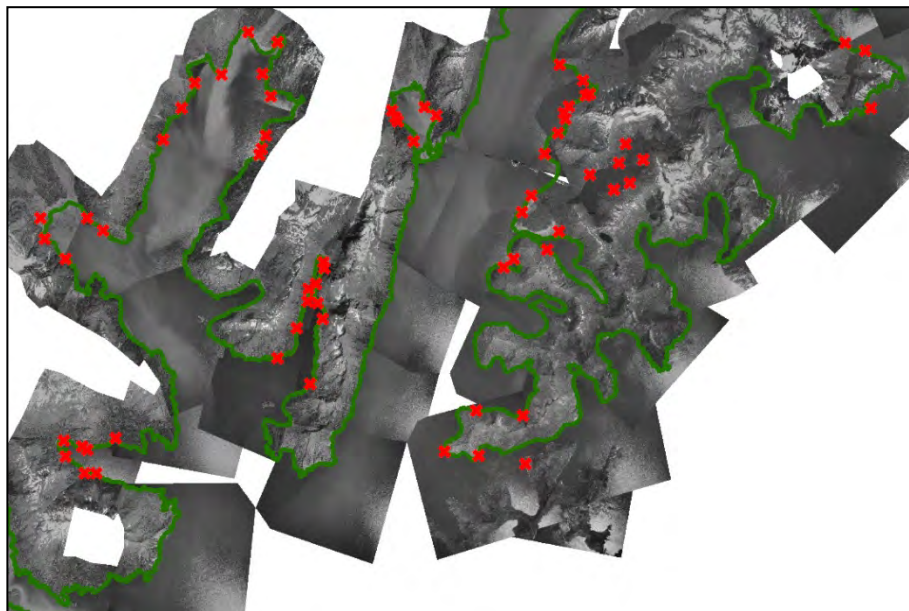
Figure 17. Location of GPS-collected ground control points (red crosses) captured in 1998 in the western half of KEFJ for the purpose of registering the aerial imagery of the Coastal Pan OrthoPhotos dataset. Additional control points were collected for this effort; however, this image focuses on presenting those that are spatially relatable to the NOAA ENC US4AK2EM dataset.

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Figure 18. The image series above compares the quality of the ENC data available along the western half of KEFJ (yellow) against the available the existing National Map NHD linework (blue). Frequent discrepancies ranging from approximately 50 meters to over 100 meters between the ENC shoreline linework and the 2005 IKONOS satellite imagery are exemplified in the above images.

DIGITAL SHORELINE DATA ASSEMBLY AND VERIFICATION

I.   COMPILING THE UPDATED DIGITAL SHORELINE

A new line-type feature class titled "Shoreline_Updates" should be developed in each park feature dataset of the project geodatabase (Figure 19). All line segments involved in the shoreline revision process for a park shall be stored as separate data records in the Shoreline_Updates feature class established for that park. The attribute structure for each Shoreline_Updates feature class should adopt the schema outlined in Table 4. The attribute structure of the Shoreline_Updates feature class was designed to facilitate documenting the linework decisions made for each park's shoreline revisions. The attribute fields "ObjectID", "Shape", and "Shape_Length" are mandatory fields assigned to the feature class by ESRI. Values for these fields will be automatically generated as data records are loaded into the Shoreline_Updates feature class.

Figure 19. Example of the Shoreline_Updates feature class for KEFJ in the project geodatabase structure.

The attribute fields "Source_ID", "Source_Date", "Hor_Acc", "Attribute", and "Class" were included in the schema to capture information pertaining to the source and quality of the NOAA data used in the update process. These attribute fields are taken from the existing EVS data structure, as the extracted vector shoreline data is expected to be the primary source for revisions to the National Map NHD digital shoreline. When loading EVS data into a Shoreline_Updates feature class, values for these fields will be automatically generated given the attribute field mapping defined in Table 4 is followed. When loading ENC data into a Shoreline_Updates feature class, values for the attribute fields "Source_ID" and "Source_Date" will be automatically generated given the attribute field mapping defined in Table 4 is followed. However for ENC datasets, information related to the attribute fields "Hor_Acc", "Attribute", or "Class" is either not available or not attributed as a text field. Therefore, the population of these fields in the Shoreline_Updates feature class is not mandatory to ENC line segments.

The attribute fields "Update_Data_Reference", Update_Agency", and "Update_Method" were added to the schema to capture important reference information. Values for these attribute fields must be manually populated for all data records loaded in the Shoreline_Updates feature class. Largely, the values assigned to these attribute fields serve to assist project staff in tracking 1.) the source dataset from which the line segment originated, 2.) the agency providing the source dataset for the line segment, and 3.) whether the line segment is an existing line segment, was manually created through head-ups digitization, or was developed based on an outlined generalization approach. The information provided in these three attribute fields is expected to facilitate any review process that shall take place prior to linework finalization for NHD incorporation. Table 5 outlines the approach to be taken for entering notations into the "Update_Data_Reference" attribute field.

Table 4. Schema model for the Shoreline_Updates feature class.

Attribute Name	Data Type (Width)	Description	Domain	Mapping EVS	Mapping ENC	Mapping Other Segments
ObjectID	OID	Internal feature number.	-	Automatic	Automatic	Automatic
Shape	Geometry	Specifies the geometry of the record.	-	Automatic	Automatic	Automatic
Source_ID	Text (50)	Raw data source reference[1].	-	SOURCE_ID	SORIND	-
Source_Date	Text (8)	Date assigned to raw data source[2].	-	SRC_DATE	SORDAT	-
Hor_Acc	Text (6)	Specifies the implied horizontal accuracy of the raw EVS data.	-	HOR_ACC	-	-
Attribute	Text (50)	Indicates the feature type of the raw EVS data based on NGS C-Coast definitions[3].	-	ATTRIBUTE	-	-
Class	Text (32)	Specifies the class type of the raw EVS data based on NGS C-Coast definitions[3].	-	CLASS	-	-
Update_Data_Reference	Text (50)	Dataset reference for the record.	-	Manual	Manual	Manual
Update_Agency	Text (10)	Specifies the agency that provided the dataset referenced for the record.	NOAA NPS SMUMN USGS	Manual	Manual	Manual
Update_Method	Text (50)	Specifies whether the record is based on existing linework or digitizing efforts.	Existing Digitized Generalized	Manual	Manual	Manual
Shape_Length	Double	Specifies the length of the record.	-	Automatic	Automatic	Automatic

[1] EVS data source notations reference a survey's geographic cell or the survey's descriptive report code. ENC data source notations do not reference a raw data source. Instead they reference the NOAA-specific code assigned to the raw data source (e.g. the source indication "US,US,graph,BP-1884460" references the NOAA H-Cell Survey #11074. Inquiries regarding the meaning of ENC source values can be fielded by NOAA Office of Coast Survey (OCS). Once the meaning of the source value is obtained, further information on the raw data source may be accessible through the products offered online at the NOAA NOS Hydrographic Survey Data Viewer website (http://map.ngdc.noaa.gov/website/mgg/nos_hydro/viewer.htm).

[2] EVS source date notations reference the source survey date. ENC source date notations either reference the source survey date or the date of paper marine chart publication.

[3] The NGS's Coastal Cartographic Object Attribute Source Table (C-COAST) Index and Glossary is available online at http://www.ngs.noaa.gov/newsys_ims/misc/c_coast_def.htm.

Table 5. Notation protocol for the Update_Data_Reference attribute field in the Shoreline_Updates feature class.

Source Type	Update_Data_Reference Notation	Example(s)
NOAA EVS line segment	Data type followed by the NOAA project boundary.	EVS_AK01B; EVS_AK01C; EVS_AK98B
NOAA ENC line segment	Data type followed by the NOAA ENC cell name.	ENC_US4AK2EM; ENC_US4AK2FM; US4AK2GM
USGS NHD line segment	Source dataset title reference	NHD Flow Network- Region 19 Alaska
Digitized line segment – imagery based	Source dataset title reference	IKONOS OrthoImage True Color- KEFJ; Seward OrthoImage IKONOS 20050603
Digitized line segment – connect arc	Connecting Arc	Connecting Arc
Generalized NOAA line segment	Data type followed by the NOAA project boundary or cell name	EVS_AK01B; ENC_US4AK2EM

II.   CLIPPING

The NOAA coastline data, whether EVS or ENC, covers the entire coast of Alaska irrespective of National Park boundaries. Since the focus of this project is NPS lands, it is necessary to limit the extent of the data to be updated. The park boundary provided in NPS Theme Manager can be used to extract the required data through a clipping operation. However, as is often the case there are inconsistencies between the park boundary and the coastline data which may lead to exclusion of data that should be included. This is normal and typically occurs because of projection, temporal, and scale differences between the data sets involved. These inconsistencies vary from park to park. An example for Cape Krusenstern (CAKR) is shown in Figure 20. The heavy green line is the park boundary, and the red line is the EVS data. An effective strategy for dealing with the inconsistencies between the park boundary and coastline data is to buffer the park boundary.   An appropriate buffer size is determined by measuring the offset between the park boundary provided in NPS Theme Manager and the coastline data. Essentially, take the largest offset measured and double it. In the case of CAKR the buffer was 500 meters based on the largest measured offset of approximately 230 meters. The NPS Theme Manger park boundary is then buffered with the resulting layer used to clip the coastline data. The idea is to include all of the data that should be included while limiting the amount of extraneous data.
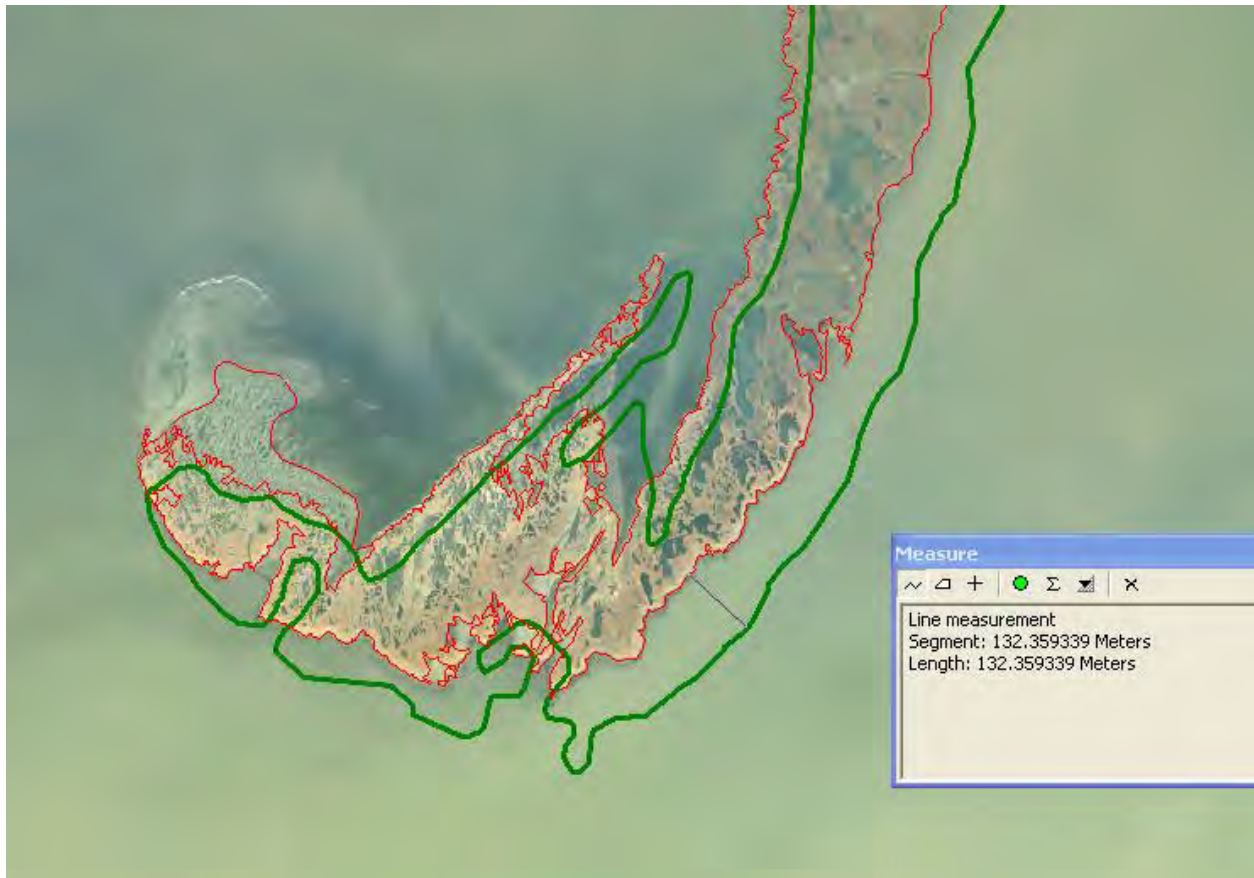
Figure 20. Inconsistency between park boundary and coastline data in eastern Cape Krusenstern National Monument (CAKR). Red is EVS coastline data and green is the CAKR boundary provided in the NPS Theme Manager.

III.   JOINING LINE SEGMENTS

This project aims to replace the 1940-1950s era topographical National Map NHD digital shoreline with the best available NOAA delineations of high water line or MHW for five coastal parks in the Alaska Region NPS. Accomplishing this requires the joining or splicing of line segments together, whether to connect existing National Map NHD data with NOAA shoreline data or to connect various NOAA shoreline data sources together. The following text outlines preferred approaches for line segment joining.

i.   *Joining Dangling Line Segments*

If the linework to be joined dangles and does not intersect at or near the point of the desired join, a connecting arc should be developed. The connecting arc should connect to existing nodes in each dataset when a snapping environment is applied, and promote a short transition between the two line segments, with as much of the original linework as possible preserved. The use of background imagery may be of assistance in determining an appropriate location for the placement of a connecting arc. Before developing a connecting arc the line records to be joined should be examined. The average distance between nodes should be determined for each line record. This can be accomplished generally

through the use of the measurement tool, or more precisely through the application of the Split at Vertices tool available in the Features toolset of ArcToolbox's Data Management Tools toolbox. The distance between nodes in a connecting arc should be comparable to the smaller of the average node distances exhibited in the two original lineworks (Figure 21). For longer connecting arcs, this may require the placement of multiple nodes. Imagery should serve as a reference for the appropriate placement of multiple nodes when required (Figure 22).

In the scenario where two datasets of comparable quality (e.g. two NOAA EVS datasets) overlap in coverage but do not intersect, both datasets should be evaluated to determine a suitable join approach. Attribute values for fields such as "SRC_DATE", "HOR_ACC", and "ATTRIBUTE" should be examined and the linework compared against high quality verifiable digital orthorectified imagery (i.e. 1:24,000 or higher). When no such imagery is available for comparison, the dataset with the highest horizontal accuracy should be followed until an appropriate connecting arc between the two datasets can be established. When the distance between the two datasets (given their stated horizontal accuracies) implies either provides a reasonable representation of MHW and imagery is available for comparison, the linework that best fits the imagery may be followed until an appropriate connecting arc between the two datasets can be established (Figure 22). Additionally, the protocol outlined in the above paragraph shall further govern the development of the connecting arc.
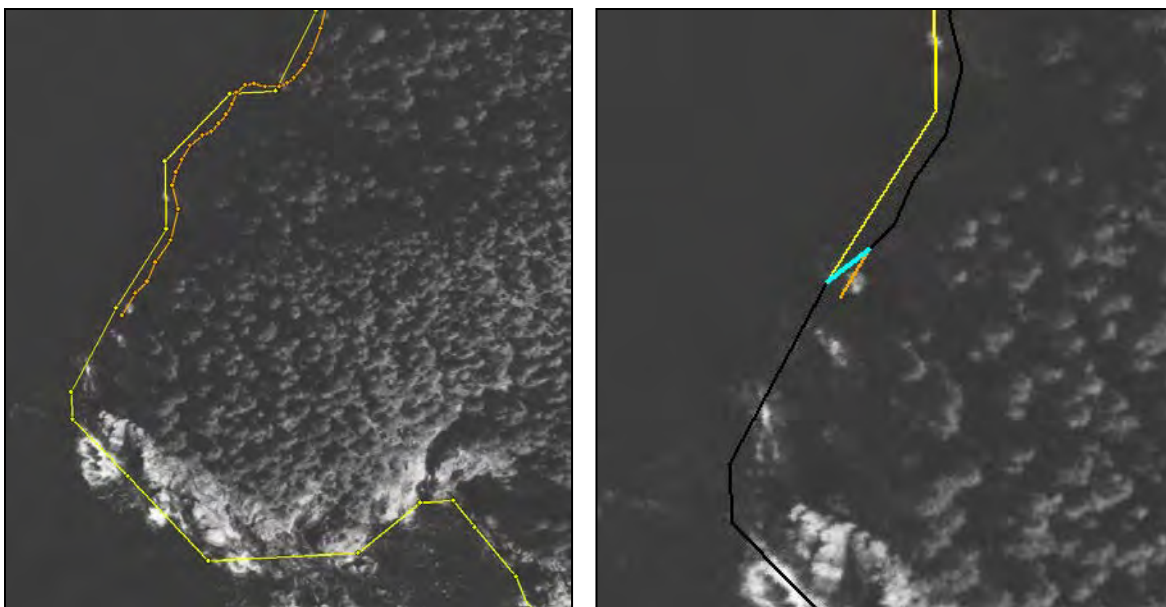
Figure 21. The image series above illustrates the join of an NOAA ENC dataset (yellow) to a NOAA EVS dataset (orange) for the KEFJ shoreline revision through the development of a connecting arc. The datasets to be joined provide an example of a dangle, as they do not intersect at the point of the desired join. The EVS dataset depicted in orange has a listed horizontal accuracy of 24.4 meters. Connecting the datasets at their existing intersection was not preferred as that would account for a loss of over 100 meters of high-quality EVS data. Instead a short connecting arc was established. The left-hand image presents the nodes that occur in each dataset. The average node distance for the ENC linework (yellow) was determined to be approximately 31 meters while the average node distance for the EVS linework (orange) was determined to be approximately 8 meters. Based on this information and the prerequisite that a connecting arc snap to existing nodes within the original data, the connecting arc depicted in blue in the right-hand image was established. The length of the connecting arc established (i.e. approximately 11 meters) is comparable to the average node distance seen in the EVS dataset.
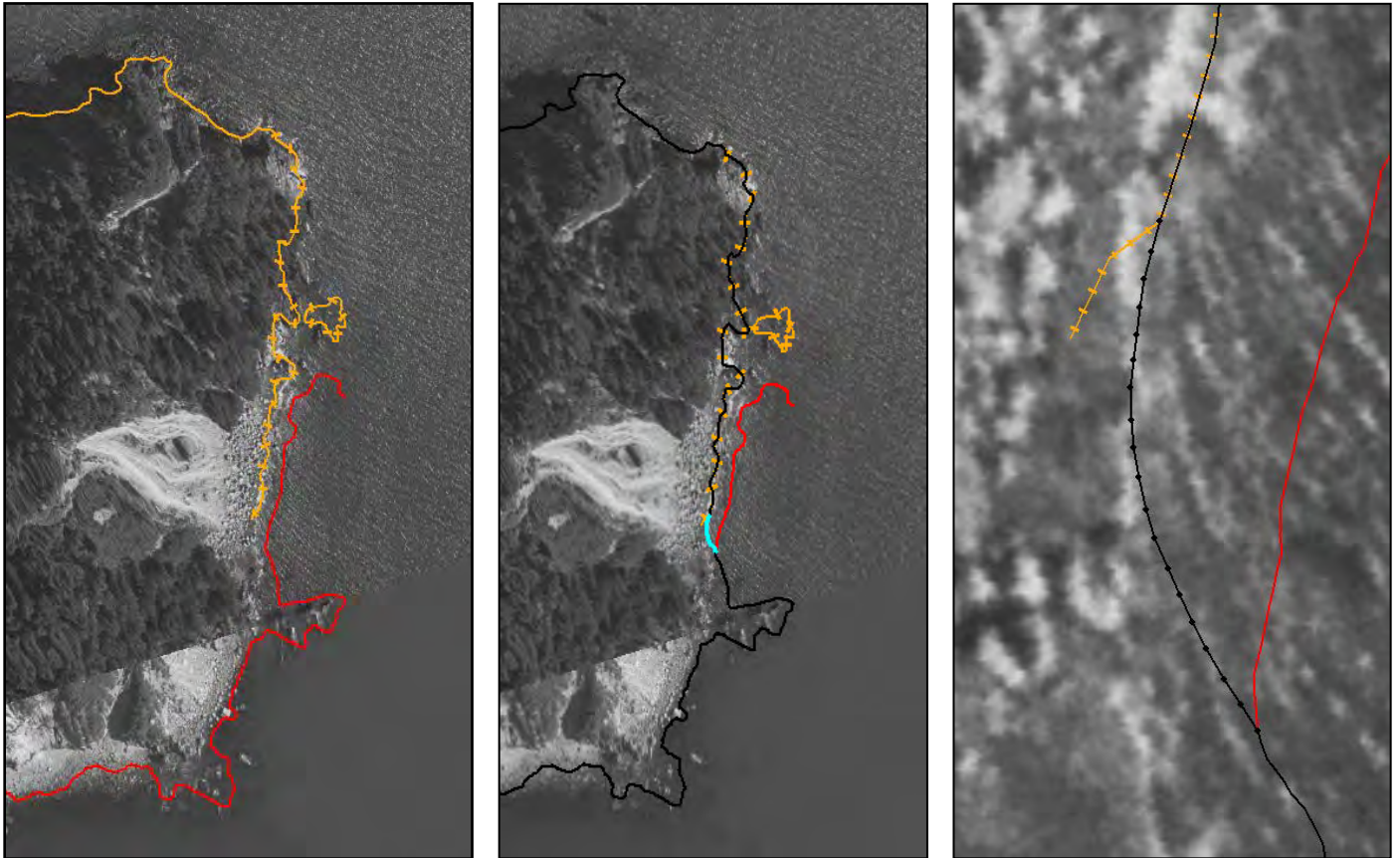
Figure 22. The above image series illustrates the join of two NOAA EVS datasets from 1998 for the KEFJ shoreline revision through the establishment of a connecting arc. The original linework for the two datasets is shown in the left-hand image. The orange hatched linework represents EVS data coded as Natural.Mean High Water.Approximate. Per the NGS C-Coast definition approximate NMHW linework is considered to be within 100 feet (30.5 meters) of its correct geographic location, and is used to denote shoreline obscured by shadows or line-of-sight blockage. The solid red linework represents EVS data coded as Natural.Mean High Water with a horizontal accuracy of 7.0 meters. The distance between the two datasets averages 15 meters or less (implies the actual MHW line could reasonably fall in the middle of the two sets of linework). As shown in the middle image the decision was made to use the orange EVS data over the red EVS data in the area of overlap given the imagery available. The connecting arc established for the join is shown in both the middle and right-hand images.

Once the connecting arc is established in the Shoreline_Updates feature class proper attribution should be assigned to the data record as follows:

- Update_Data_Reference = Connecting Arc
- Update_Agency = NPS, SMUMN, etc.
- Update_Method = Digitized

After the connecting arc is documented, the line segments adjoining the arc should be edited as appropriate to its end nodes.

> ii.   *Joining Line Segments at a Point of Intersection*

If the linework to be joined intersects at or near the point of the desired join, then the linework should be spliced together at the point of intersection (Figures 23). This approach does not necessitate the development of a connecting arc. Instead both participating line segments should be loaded into the Shoreline_Updates feature class and appropriately edited to the point of intersection using editing

properties and/or advanced editing options such as the Trim tool. Changes in shape length imparted to the line segments through editing should be automatically captured by the ESRI ArcGIS software once editing is complete.
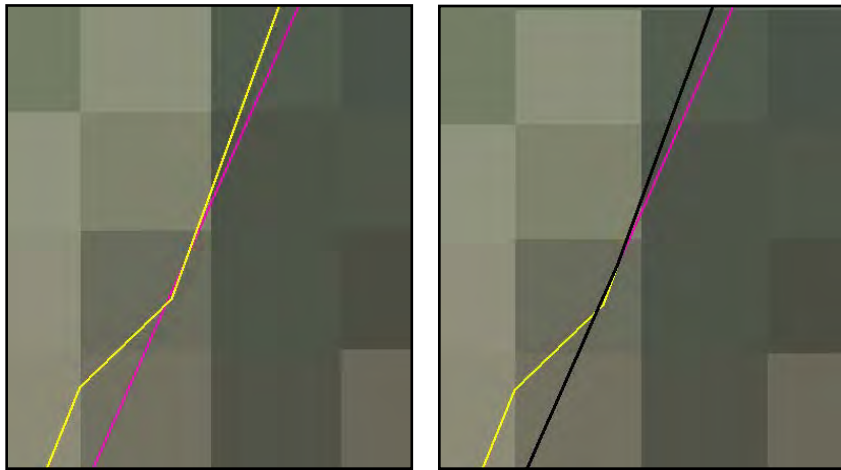
Figure 23. The image series on the left illustrates the join of NOAA EVS data (pink) to NOAA ENC data (yellow) at a point of intersection. The original linework for the two NOAA datasets is shown in the left-hand image. The right-hand image depicts the final Shoreline_Updates linework resulting from the join (black).

IV.   HANDLING UPDATES ACROSS GLACIAL EXTENTS

       i.   EVS Line Segments

Certain EVS datasets will contain shoreline segments attributed as Natural.Glacier. NGS C-COAST defines natural as "composed of naturally occurring materials, or created, or appearing to have been created, by natural processes," and glacier as "a mass of snow and ice continuously moving from higher to lower ground or, if afloat, continuously spreading"[2]. EVS linework coded as Natural.Glacier may not match a glacial edge depicted in the available imagery. Furthermore, EVS linework coded as Natural.Mean High Water may appear to cross sections of glacial ice (Figure 24).
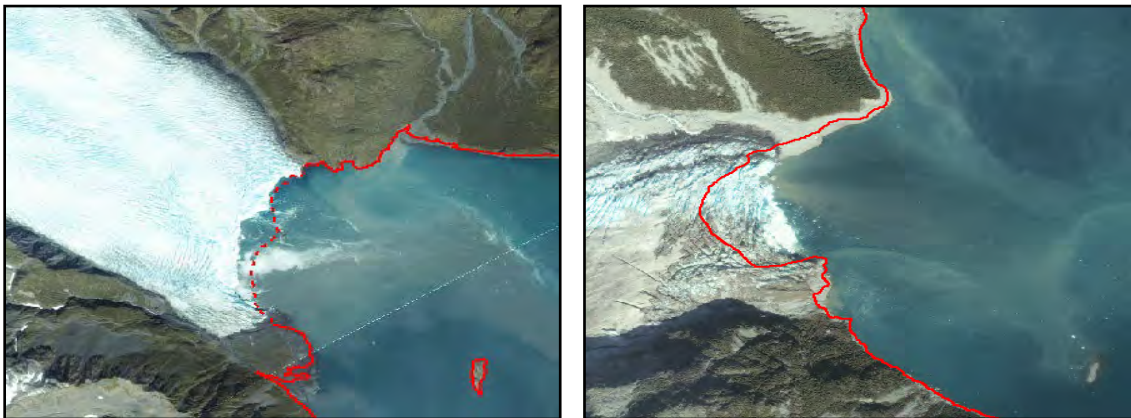
Figure 24. Differences in glacial edge depictions between NOAA EVS linework from 1998 and IKONOS satellite imagery from 2005 for KEFJ. In both images EVS linework is depicted in red, with solid line segments representing MHW and dashed line segments representing natural glacier.

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[2] The NGS C-COAST index/glossary is available at http://www.ngs.noaa.gov/newsys_ims/misc/c_coast_def.htm.

These variations may be explained by the process of glacial retreat or advance, and temporal differences between the date of the NOAA coastal survey and the date of image acquisition. When such scenarios are encountered the protocol outlined in Conceptual Model 2 (Digital Shoreline Data Assembly and Verification, Section XI) should be followed. When the protocol outlined in the conceptual model calls for the heads-up digitization of a line segment, digitizing shall be conducted in a controlled manner. All digitizing shall be conducted in stream mode at a scale of 1:5,000 or larger using the highest quality verifiable orthorectified imagery (i.e. 1:24,000 or higher) available for reference. During stream mode digitizing vertices are recorded automatically at preset intervals of either distance or time as the cursor is moved. The minimum interval between vertices is defined by the streaming tolerance assigned. For this project, a streaming tolerance of 10 meters shall be used. A snapping environment should be applied to ensure the ends of the digitized line segment reconnect to existing nodes in the MHW linework of the EVS data.

Digitizing efforts to update glacial linework are only appropriate if EVS data representing MHW (i.e. Natural.Mean High Water or Natural.Mean High Water. Approximate, etc.) abuts either side of the glacial edge. In this situation, the digitized segment should immediately reconnect to an existing node in the EVS MHW data. It is inappropriate to digitize across a glacial edge if the digitized segment cannot immediately reconnect to EVS MHW data, therefore requiring the extrapolation of MHW (Figure 25). One exception to this rule was made for updates to the KEFJ shoreline in the location of Pederson Glacier (Figure 26). At this location existing linework following a visual approximation of high water line using 2005 IKONOS true-color satellite imagery was available from the NPS Alaska Region Land Resources Program Center. This linework is not tied to a vertical tidal datum, nor is intended to be the definable NOAA MHW line. However extrapolation of MHW between EVS data at this location accounts only for about 1 km of shoreline (excluding the glacial edge), vastly improves upon the existing linework depicted by the National Map NHD, and offers a more current representation of the glacier's edge compared to the EVS from 1998. This linework originated from the most current version of the Alaska National Park Boundaries dataset managed by the NPS Alaska Region (i.e. May 2010), which is intended to provide a statewide summary of all park, preserve, monument, and current wilderness boundaries.
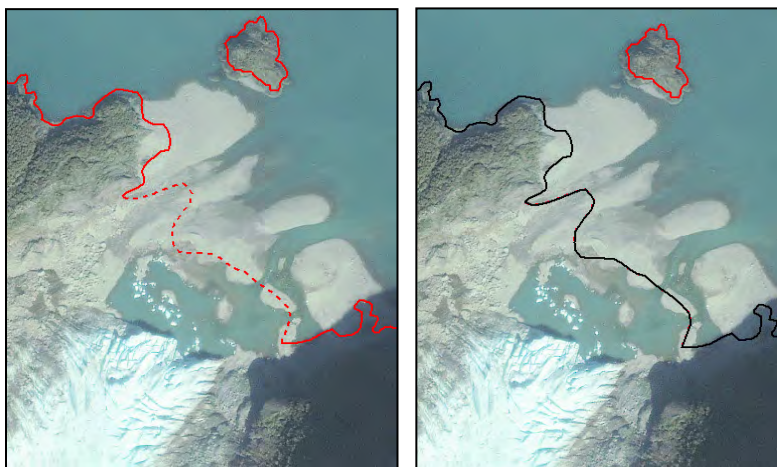
Figure 25. The image series above illustrates a scenario in KEFJ where digitizing a line segment across a glacial edge was inappropriate as the EVS data available did not abut the glacial edge and would therefore require the extrapolation of MHW. The left-hand image depicts the EVS data from 1998 in red, with solid line segments representing MHW and dashed line segments representing natural glacier. Despite disagreement with the 2005 IKONOS satellite imagery, the EVS data was directly accepted per protocol into the Shoreline_Updates feature class linework depicted in black in the right-hand image.
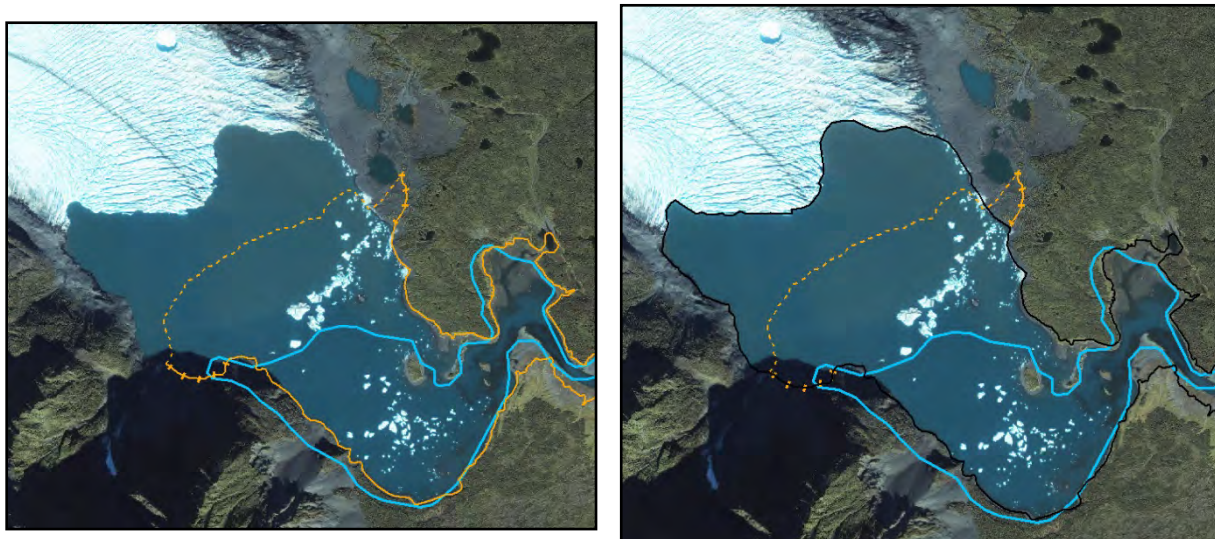
Figure 26. The left-hand image compares the EVS data available in the area of Pederson Glacier (KEFJ) (orange) against the existing National Map NHD digital shoreline data (blue). Solid orange linework represents MHW; hatched orange linework represents approximate MHW; and, dashed orange linework represents segments of natural glacier. The right-hand image depicts in black the shoreline linework that was accepted, as an exception to this protocol, into the Shoreline_Updates feature class for KEFJ.

Once established, digitized line segments should be appropriately attributed in the Shoreline_Updates feature class as follows:

- Update_Data_Reference = Imagery source used for the digitizing process
- Update_Agency = NPS, SMUMN, etc.
- Update_Method = Digitized

Figure 27. The image series above illustrates slight differences in glacial edge representation between the NOAA EVS data from 1998 and IKONOS satellite imagery from 2005 for the eastern portion of Northwestern Glacier in KEFJ. The left-hand image depicts the EVS data from 1998 in red, with solid line segments representing MHW and dashed line segments representing natural glacier. In this instance, EVS line segments deviate less than 20 meters from the glacial edge seen in the IKONOS satellite imagery. Based on the protocol outlined in Conceptual Model 2 these line segments were directly accepted into the Shoreline_Updates feature class linework depicted in black in the right-hand image.

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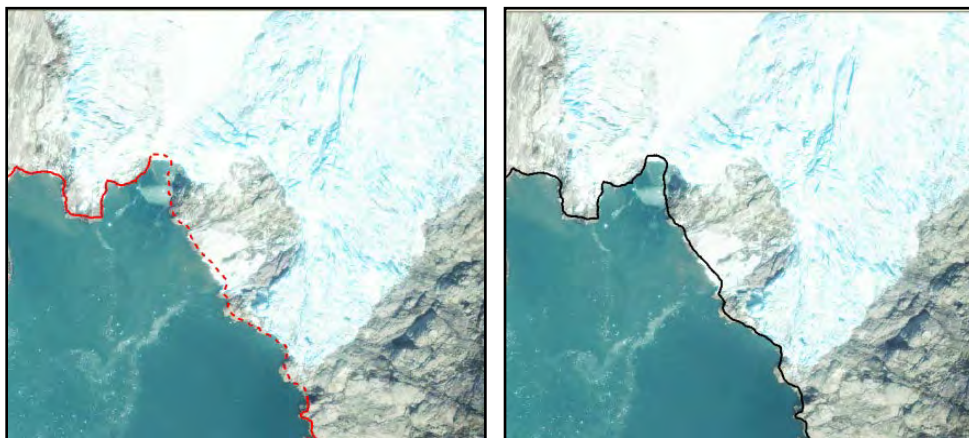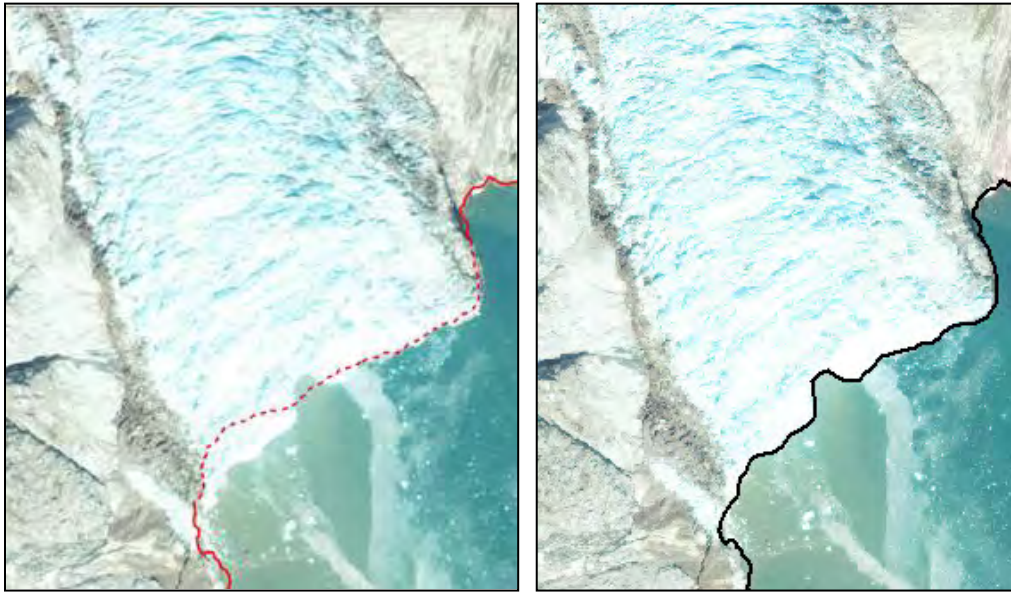**Figure 28. The image series above illustrates varying degrees of differences in glacial edge representation between the NOAA EVS data from 1998 and IKONOS satellite imagery from 2005 for the western portion of Northwestern Glacier in KEFJ. The left-hand image depicts the EVS data from 1998 in red, with solid line segments representing MHW and dashed line segments representing natural glacier. In this instance, the EVS natural glacier line segment deviates in some areas less than 20 meters from the glacial edge seen in the IKONOS satellite imagery and more than 20 meters in others. Based on the protocol outlined in Conceptual Model 2 the natural glacier line segment was replaced with the digitized line segment depicted in back in the right-hand image.**

ii.   ENC Line Segments

Certain ENC datasets will contain coastline segments valued as glacier (seaward end) in the "Category of Coastline" attribute field. ENC linework coded as glacier (seaward end) may not necessarily match a glacial edge depicted in the available imagery. Furthermore, certain ENC line segments not coded as glacier (seaward end) may appear to cross sections of glacial ice. As described in Digital Shoreline Data Assembly and Verification, Section IV, these variations may be explained by the process of glacial retreat or advance, and temporal differences between the date of the ENC data and the date of the image acquisition. When such scenarios are encountered the same general protocol referenced and outlined in Digital Shoreline Data Assembly and Verification, Section IV applies.

iii.   National Map NHD Line Segments

When neither NOAA EVS nor ENC linework is available for use existing National Map NHD digital shoreline data shall be retained. Due to the era of the National Map NHD data, the linework contained is unlikely to match glacial edges depicted in the available imagery. However, digitizing efforts should be avoided in these scenarios to eliminate extrapolations of MHW (Figure 29).
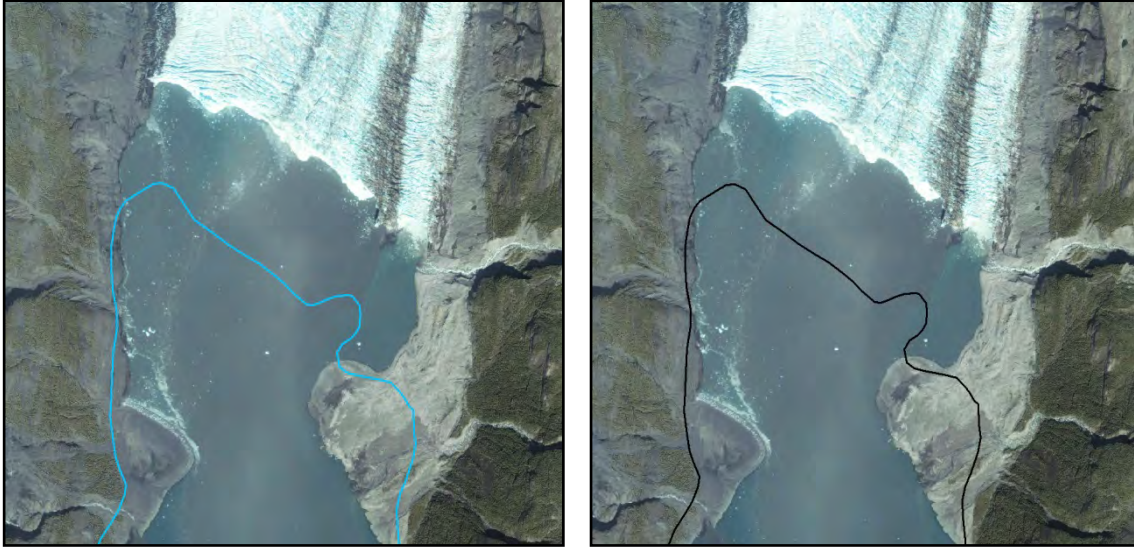
Figure 29. The image series above illustrates the decision to accept National Map NHD digital shoreline depictions of glacial extents in areas where neither NOAA EVS nor ENC data is available. In this scenario digitizing is inappropriate as it would require the extrapolation of MHW for distances between the National Map NHD data and the glacier's edge.

V. HANDLING UPDATES OF MAN-MADE WATERFRONT STRUCTURES & ALONGSHORE FEATURES

i. EVS Line Segments

As described in Selection and Processing of NOAA Data, Section III (i), project efforts shall focus on evaluating EVS line segments valued in the "CLASS" attribute field as SHORELINE and ALONGSHORE FEATURE. NGS C-COAST defines SHORELINE as "the intersection of the land, including man-made waterfront structures, with the water surface," and ALONGSHORE FEATURE as "an object that intersects, abuts, or is adjacent to and seaward of the shoreline." In the EVS data, the "ATTRIBUTE" attribute field provides more descriptive information on the type of SHORELINE or ALONGSHORE FEATURE depicted by a record (e.g. Man-made.Wharf or Quay, Breakwater.Bare, Pier, etc.). Linework related to man-made waterfront structures and alongshore features are currently contained in the National Map NHD digital shoreline. Largely, this includes linework related to breakwaters and wharfs or quays (Figure 30). For this reason, coastal linework in areas where man-made waterfront structures exist should be evaluated and updated if more current, higher-quality NOAA data is available. In such cases where EVS data will be used to update the digital shoreline the protocol outlined in Conceptual Model 3 (Digital Shoreline Data Assembly and Verification, Section XI) should be followed.

Figure 30. National Map NHD digital shoreline linework for the Seward Harbor (KEFJ). The left-hand image depicts the National Map NHD digital shoreline data against a USGS DOQ from June 1997. The right-hand image depicts the National Map NHD digital shoreline data against IKONOS satellite imagery from 2005. The breakwater and wharf/quay linework contained in the National Map NHD dataset generally appears to have been last processed between the 1980s and early 2000s, but is outdated compared to the IKONOS satellite imagery from 2005.

ii. ENC Line Segments

Per Selection and Processing of NOAA shoreline Data, Section III, the line-type feature class "CoastlineFeatures" shall be the ENC feature class of interest for the purpose of this project. Within the "COAST_TYPE" attribute field of this feature class line segments are valued as either Coastline or Shoreline records. Shoreline records relate to man-made waterfront structures and alongshore features. The "Category of shoreline construction" attribute field may provide more descriptive information on the type of ENC Shoreline feature depicted by a record (e.g. breakwater, pier [jetty], wharf [quay], rip rap, sea wall, ramp, etc.), while the "Condition" attribute field may provide more descriptive information regarding the feature's condition. As described in Digital Shoreline Data Assembly and Verification, Section VI (i), the National Map NHD digital shoreline contains linework related to man-made waterfront structures and alongshore features, which are eligible for revision. In such cases where ENC data will be used to update the digital shoreline the protocol outlined in Conceptual Model 4 (Digital Shoreline Data Assembly and Verification, Section XI) should be followed.

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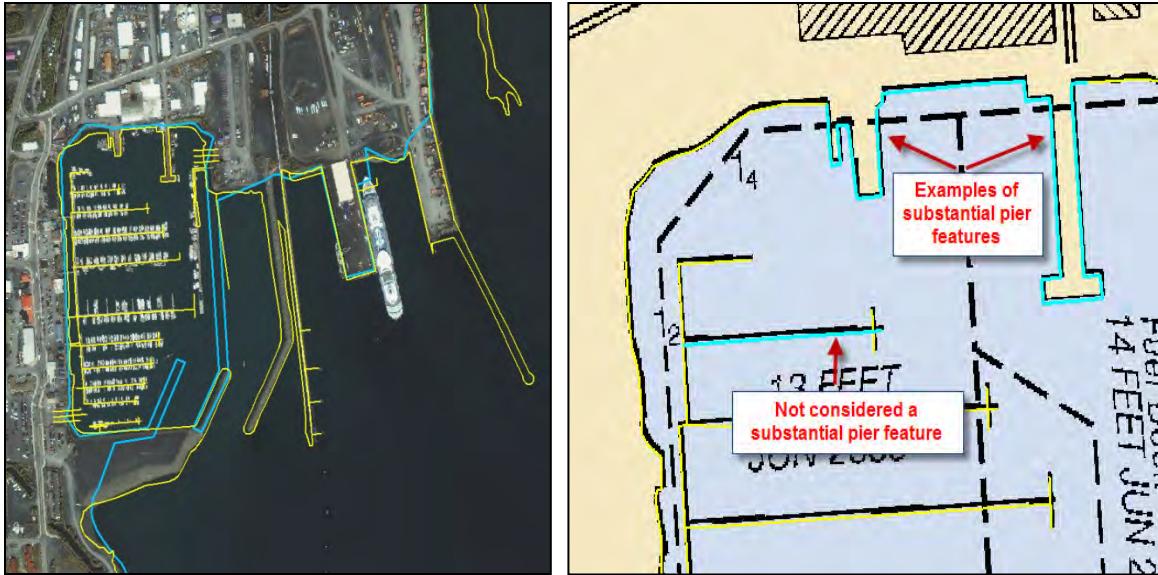
Figure 31. The left-hand image compares NOAA ENC linework for the Seward Harbor near KEFJ (yellow) against National Map NHD data (blue). The ENC linework is derived from August 2006 survey blueprints provided by the US Army Corps of Engineers, Alaska District. The left hand image compares the ENC data against the most current large-scale NOAA marine chart (i.e. 1:10,000), and assists in outlining what is described in Conceptual Model 4 as a substantial pier feature.
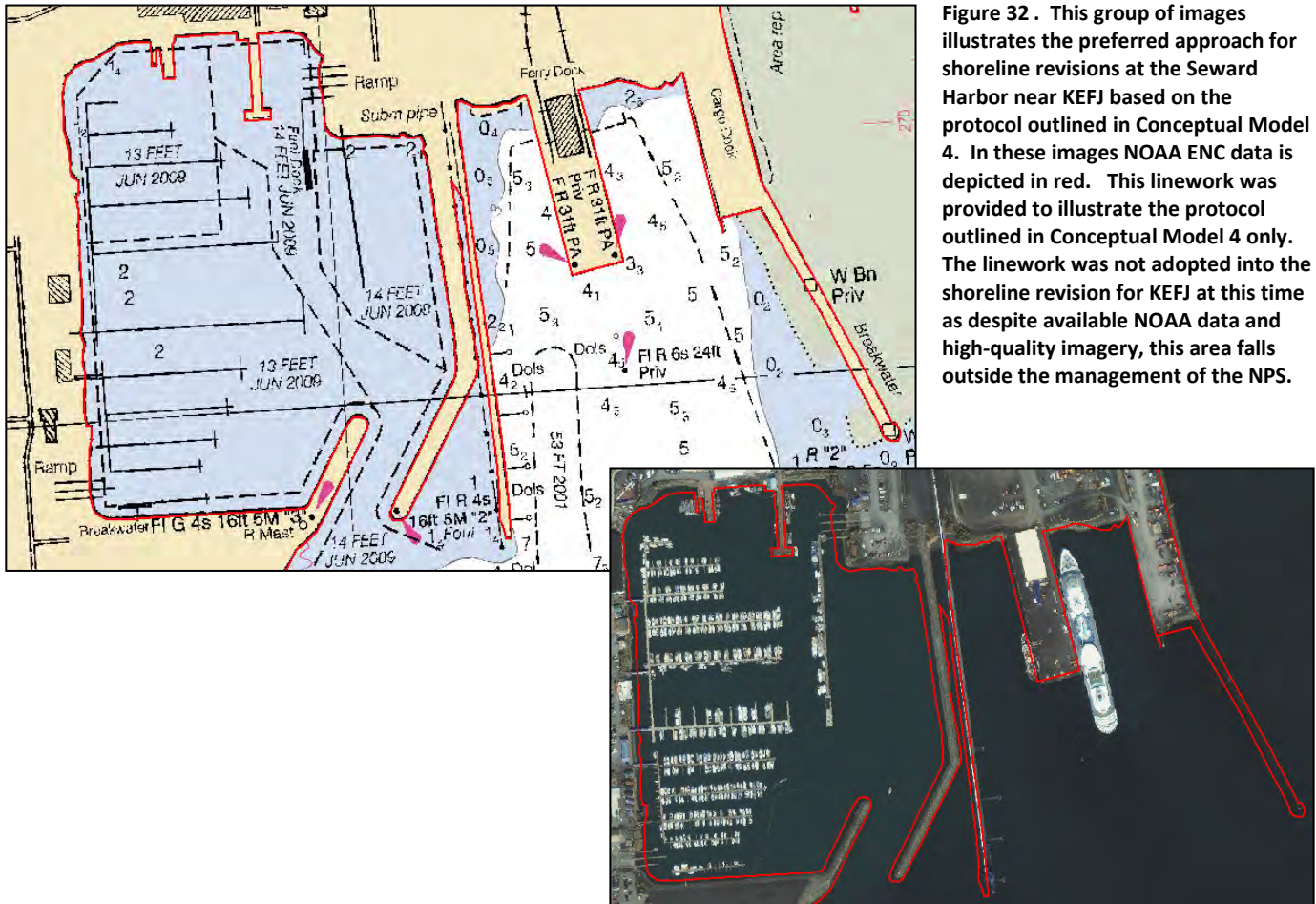
Figure 32 . This group of images illustrates the preferred approach for shoreline revisions at the Seward Harbor near KEFJ based on the protocol outlined in Conceptual Model 4. In these images NOAA ENC data is depicted in red. This linework was provided to illustrate the protocol outlined in Conceptual Model 4 only. The linework was not adopted into the shoreline revision for KEFJ at this time as despite available NOAA data and high-quality imagery, this area falls outside the management of the NPS.

VI. HANDLING INTERIOR DEPICTIONS OF MEAN HIGH WATER PRESENT IN NOAA DATA

Shoreline data provided by NOAA is likely to contain representations of MHW that when compared to the existing National Map NHD shoreline linework extend further landward, covering greater interior reaches (Figure 33). NOAA data may also contain MHW SHORELINE records that represent hydrographic features completely internal to the coast (Figure 34). In such cases, the NOAA data expected to replace the existing National Map NHD data shall be accepted in the interim into the Shoreline_Updates feature class as is, without modification. However, these areas shall subsequently be brought to the attention of the NPS Alaska Region project staff, so further information regarding the tidal influence of these features can be solicited from the suitable subject authorities. MHW linework is expected to be incorporated into the National Map NHD shoreline update where the feature in question is determined to be a tidally influenced saltwater feature. As a result of the determinations made the interim NOAA data accepted into the Shoreline_Updates feature class may require modification prior to finalization and NHD incorporation.
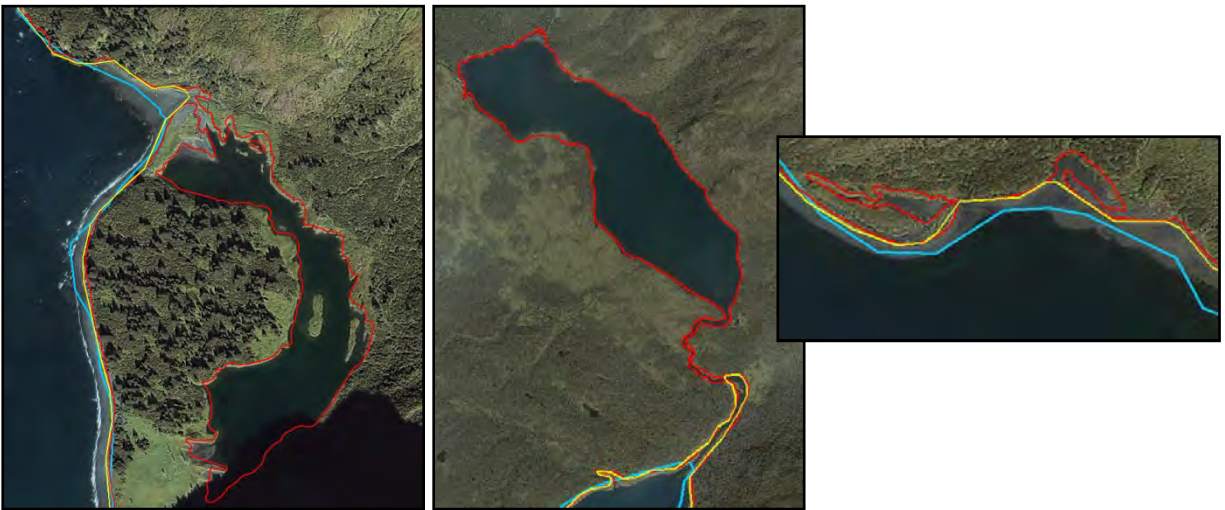
Figure 33. The above image series illustrates how EVS (red) and ENC (yellow) shoreline data provided by NOAA contains representations of MHW that when compared to existing National Map NHD linework (blue) extend further landward, covering greater interior reaches.

Figure 34. The images series to the left illustrates how EVS data provided by NGS NOAA (red) depicts the MHW level of features that are completely internal to the coast.

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VII.   HANDLING UPDATES OF OFFSHORE ISLANDS OR ROCKS (ISLETS)

Shoreline data provided by NOAA in EVS and ENC form depicts offshore islands, rocks (islets), shoals obstructions and other pertinent navigational hazard and features. A complete list of standard chart symbols can be found in the reference publication U.S. Chart 1: Nautical Chart Symbols, Abbreviations and Terms which can be freely downloaded at http://www.nauticalcharts.noaa.gov/mcd/chartno1.htm. In NOAA data offshore islands or islets represent areal extents that are separate and seaward of the mainland coastline and surrounded by a solid back line delineating MHW (Figures 35 and 36). Some nautical charts may also associate a number with an island, which represents the height in meters above the height datum. In the NOAA EVS and ENC datasets, islands and islets are represented by a single or a set or line records.
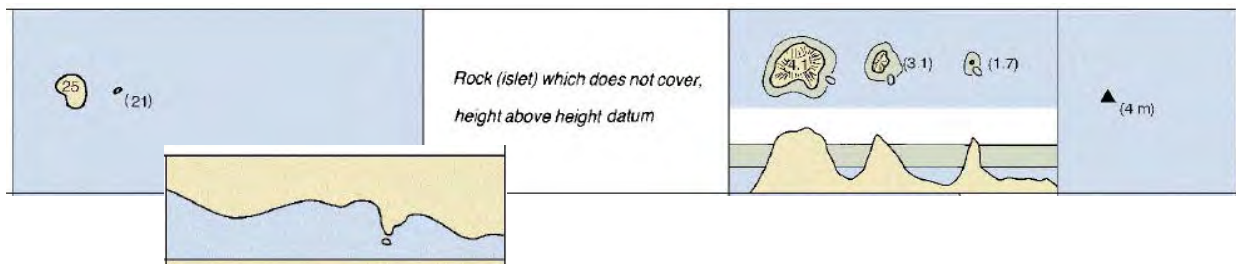
Figure 35. NOAA marine chart depiction of a rock (islet) and an island.
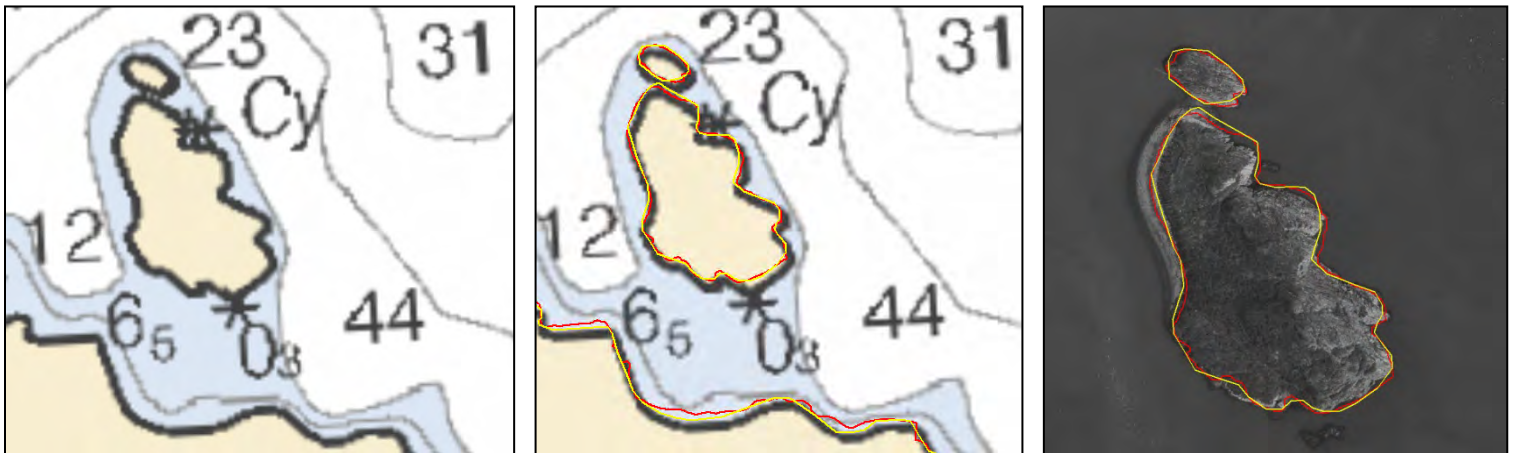
Figure 36. The left-hand illustrates the NOAA depiction of an island and/or islet group in Northwestern Lagoon of KEFJ as seen on a nautical chart. The middle image illustrates the EVS (red) and ENC (yellow) representations of those features against the chart. In the right-hand image the same EVS and ENC linework is compared the available panchromatic coastal imagery for KEFJ.

The National Map NHD also contains data related to islands and islets. However, islands and islets are handled as holes in the NHD Area dataset or as coastline reaches in the NHD Flowline dataset detached or seaward of the mainland coastline (Figure 37). No minimum mapping unit is currently assigned to islands and islets contained in the National Map NHD. Information regarding the minimum mapping unit for NOAA EVS and NOAA ENC datasets is still being solicited from NOAA OCS. Island and islet features are not represented consistently between National Map NHD, NOAA EVS, and NOAA ENC datasets. That is, an island or islet feature appearing in one dataset may be present in a second dataset but shaped differently, or may be absent from that second dataset altogether (Figure 38).

Figure 37. The image series above illustrates how island and islet features are handled in the National Map NHD. Within the NHD Area dataset as seen in the left-hand image island and islet features appear as holes in data classified as SeaOcean. Island or islet features in the NHD Flowline dataset are represented as linear features as seen in the right-hand image.
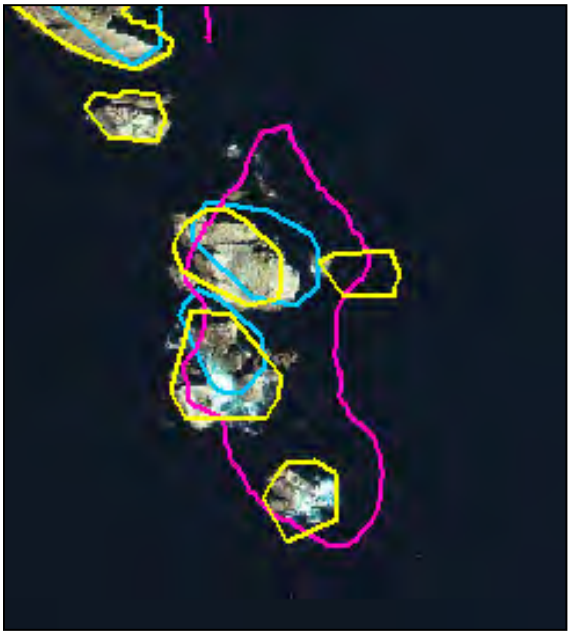
Figure 38. Example of how the representation of island/islet features vary between National Map NHD data (blue), NOAA EVS data (pink), and NOAA ENC data (yellow) for an area off of Aialik Cape at KEFJ.

With the exception of Nuka Island at Kenai Fjords National Park, the legislated park boundaries for the parklands associated with this project do not currently include offshore islands or islets[3]. For this reason, offshore island/islet feature representation as it currently exists in the National Map NHD data shall be maintained. That is, efforts shall not be put forth to replace the existing NHD island/islet data with island/islet data from NOAA EVS or NOAA ENC sources. Even though Nuka Island at KEFJ is a known exception, the choice to retain National Map NHD linework for the island was made as no NOAA EVS

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[3] The jurisdiction of offshore islands/islets is pending legislation for Lake Clark National Park and Preserve (LACL).

data was available, and the NOAA ENC shoreline data that was available failed to provide an improved consistent representation of MHW.

As NOAA EVS and/or ENC linework is adopted into the shoreline revision process situations where NOAA data intersects or encompasses a National Map NHD island/islet feature are likely to occur (Figure 39). In these scenarios, the NOAA data expected to replace the existing National Map NHD data shall be accepted in the interim into the Shoreline_Updates feature class as is, without modification. However, these areas shall subsequently be brought to the attention of the NPS Alaska Region project staff so consultation with land managers at the appropriate agency or agencies can be initiated. The NPS Alaska Region wishes to avoid making changes to the National Map NHD dataset that would affect other agency boundaries without their notice or participation. Through discussions, it is hoped that the preferred approach for shoreline updates using NOAA data will be determined acceptable. In such cases the interim data contained in the Shoreline_Updates feature class can be finalized. This would require the removal of the National Map NHD island or islet feature, as island or islet feature cannot not topologically exist landward of the mainland coastline. If no consensus can be made following consultation, modification of the interim data would be necessary. This may require the retention of a section of existing National Map NHD linework.

Figure 39. The image series above illustrates how the acceptance of NOAA shoreline data may impact National Map NHD island/islet feature data. In the left-hand image, NOAA EVS data (red) intersects a National Map NHD island feature (blue) near Tooth Cove at KEFJ. In the right-hand image NOAA EVS data encompasses a National Map NHD island feature.

If the scope of this project is expanded to include other NPS Alaska Region parklands such as Katmai National Park and Preserve (KATM) or Glacier Bay National Park and Preserve (GLBA), whose legislated boundaries include offshore islands/islets a set distance off the coastline, the protocol for handling updates of offshore islands and islet must be revised. A reasonable minimum mapping unit for island and islet features would need to be determined, as well as a conceptual model developed outlining how the available linework will be evaluated to determine the best and most comprehensive island/islet feature updates.

VIII.   MERGING

There are many instances in the NOAA coastline data of connected features having identical attributes. In Figure 40, the 6 features highlighted in light blue have identical attributes as shown in the table.   In some cases these linear features are extremely small (<50 meters long). Often there are as many as 8-10 or more adjacent features with identical attributes.
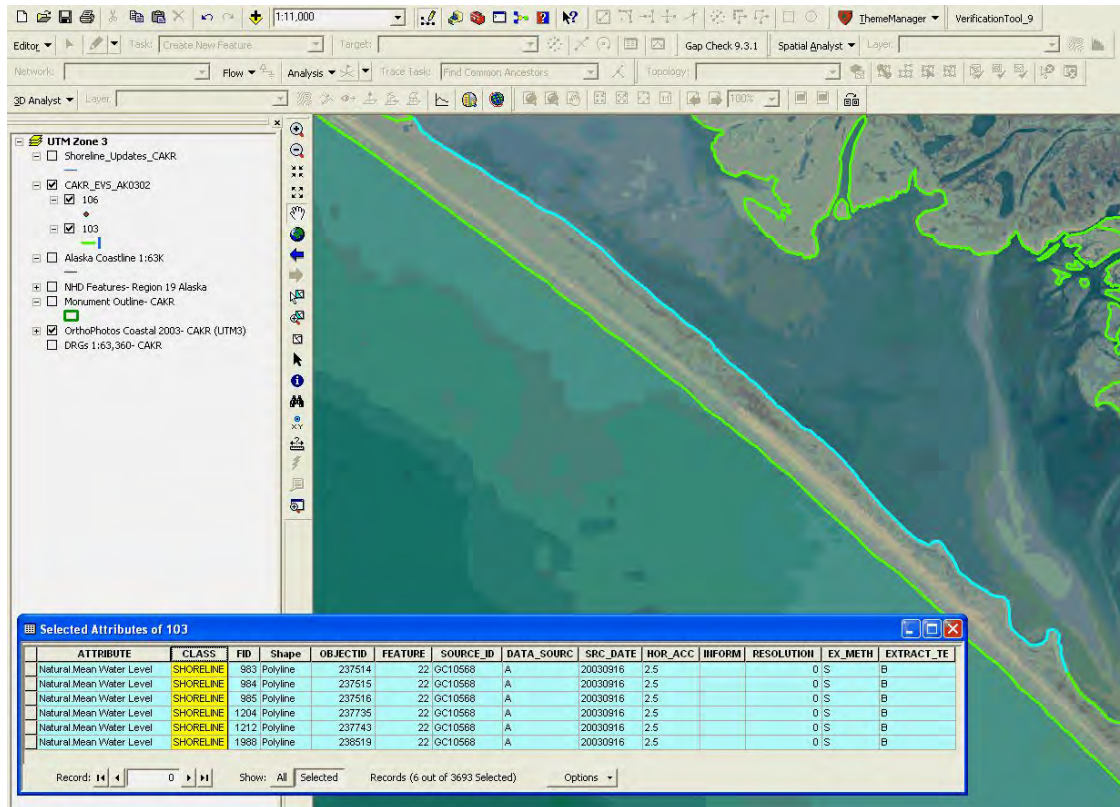
Figure 40. Features that should be merged. The selected (blue) line is actually 6 separate adjoining features with identical atributes.

The purpose of merging at this point is mainly to minimize the size of the database, making it less susceptible to data corruption. If there are any different attributes between adjoining features they are not merged.   The data may be aggregated further before it is loaded into the NHD template, mainly because the ENC and EVS data have many more classes than the NHD for attributing a line. This is explained further below in Migration to the National Hydrograhy Dataset, Section II (iii-A).

IX.   GENERALIZING LINE SEGMENTS

Over the course of the project it may be necessary, under special circumstances, to generalize shoreline data provided by NOAA. One such circumstance warranting data generalization occurred during the KEFJ shoreline revision process for a section of ENC data extending along the eastern side of Aialik Peninsula. The ENC dataset US4AK2FM contained a subset of 48 line records with a rasterized appearance for a stretch of coastline south of Bulldog Cove to the Aialik Cape area (Figure 41). This linework was derived from hydrographic survey work performed by NOAA in August and September

2001. During these 2001 survey efforts shoreline verification was conducted against the existing shoreline vector data from NOAA's project geographic cell 10494 (GC10494) (i.e. the EVS data AK01B from 1992). Shoreline verification was done in part as errors in the EVS dataset AK01B were known to exist at certain areas (Figures 10 and 11). The resulting ENC data are based on shoreline revision recommendations outlined in NOAA's H-Cell descriptive reports H-11074 and H-11075[4]. As a result, the ENC linework was preferred in certain areas over the available EVS data. Generalization of this ENC data subset was necessary as the rasterized nature of the original linework would have inhibited its incorporation into the National Map NHD digital shoreline.
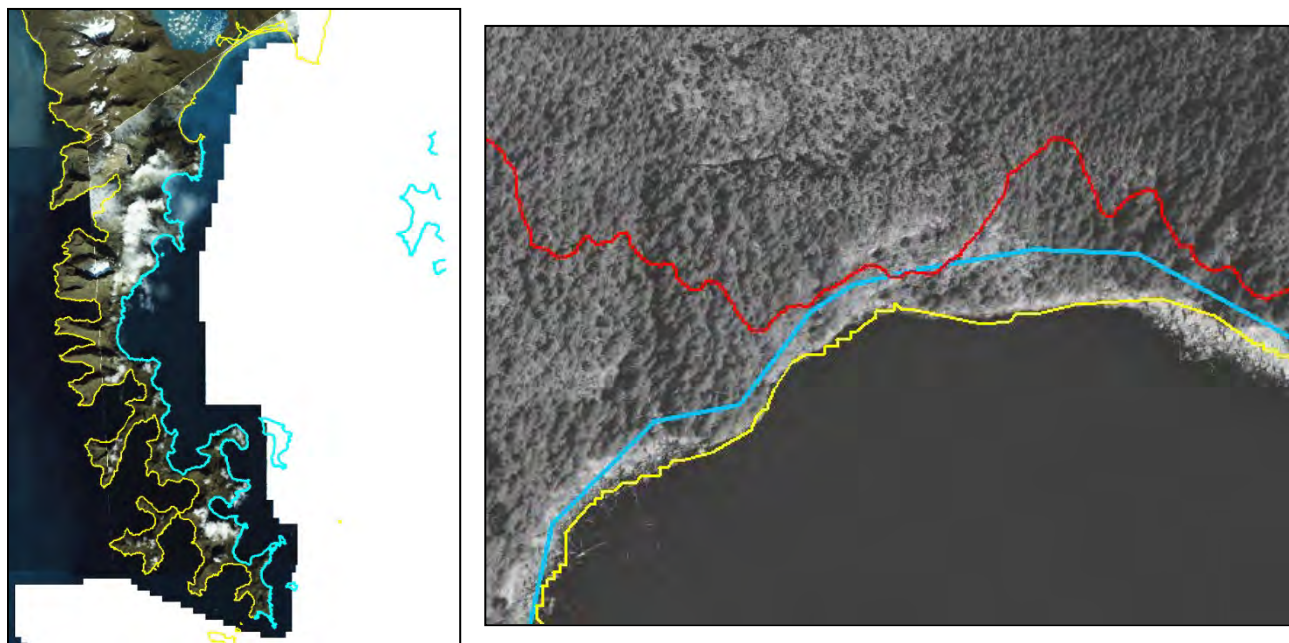
Figure 41. The image series above depicts a subset of shoreline linework within the ENC US4AK2FM dataset provided by NOAA. The extent of the ENC subset (blue) appears in the left-hand image. In the right-hand image a section of the potential EVS error identified at Pony Cove is depicted (red) against the ENC data (yellow) and National Map NHD data (blue). This image provides an example of suitability of this ENC data for areas along the Aialik Peninsula at KEFJ, but also portrays its rasterized character.

For generalization the 48 line record subset of the ENC US4AK2FM dataset was first extracted. The Split Line at Vertices tool available in the Feature toolset of ArcToolbox's Data Management Tools toolbox was then applied to break the line records into their most fundamental arc lengths. This created a dataset consisting of 13,036 records. Next, all records with a Shape_Length value greater than zero were selected (i.e. 12,978 records) using a Select by Attribute Query, and a text file was exported. The text file was opened in Microsoft Excel and the arc length mode, or value that occurs most frequently, was then determined for the dataset. For this subset of ENC data, the arc length mode was calculated

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[4] The 48 line records that required generalization within the ENC dataset US4AK2FM were coded either "US, US, graph, BP-188460" or "US, US, graph, BP-188619" in the Source Indication attribute field. Per NOAA OCS the source code BP-188460 corresponds with the H-Cell survey H-11074 and the source code BP-188619 corresponds with H-Cell survey H-11075. NOAA's H-Cell descriptive reports H-11074 and H-11075 can be accessed through the NOS Hydrographic Survey Data website at http://map.ngdc.noaa.gov/website/mgg/nos_hydro/viewer.htm.

to be 4.1 meters. A new line-type feature class with an assigned XY tolerance of 4 meters (i.e. arc length mode) was then established in an interim file geodatabase titled ENC_US4AK2FM_Generalization[5]. During the development of this feature class the ENC attribute schema was imported from the raw ENC dataset within the project geodatabase. The 48 record subset of ENC data was then loaded into the established feature class and the Smooth Line tool available in the Generalization toolset of ArcToolbox's Data Management Tool toolbox applied. In the Smooth Line tool's dialog box, the Output Feature Class to be saved within the interim file geodatabase was titled ENC_US4AK2FM_Subset_4mPAEK; the PAEK smoothing algorithm was applied; a smoothing tolerance of 4 meters (i.e. arc length mode) was assigned; the option to preserve endpoint for closed lines was selected; and the "No Check" option for handling topological errors was chosen. PAEK, which stands for polynomial approximation with exponential kernel, was the algorithm type selected for the smoothing as it calculates a smoothed line that will not pass through input line vertices. Generalization results are presented in Figure 42. The resulting feature class was then loaded into the KEFJ feature dataset of the project geodatabase[6], loaded into an ArcMap session, and incorporated as needed into the Shoreline_Updates feature class for KEFJ.
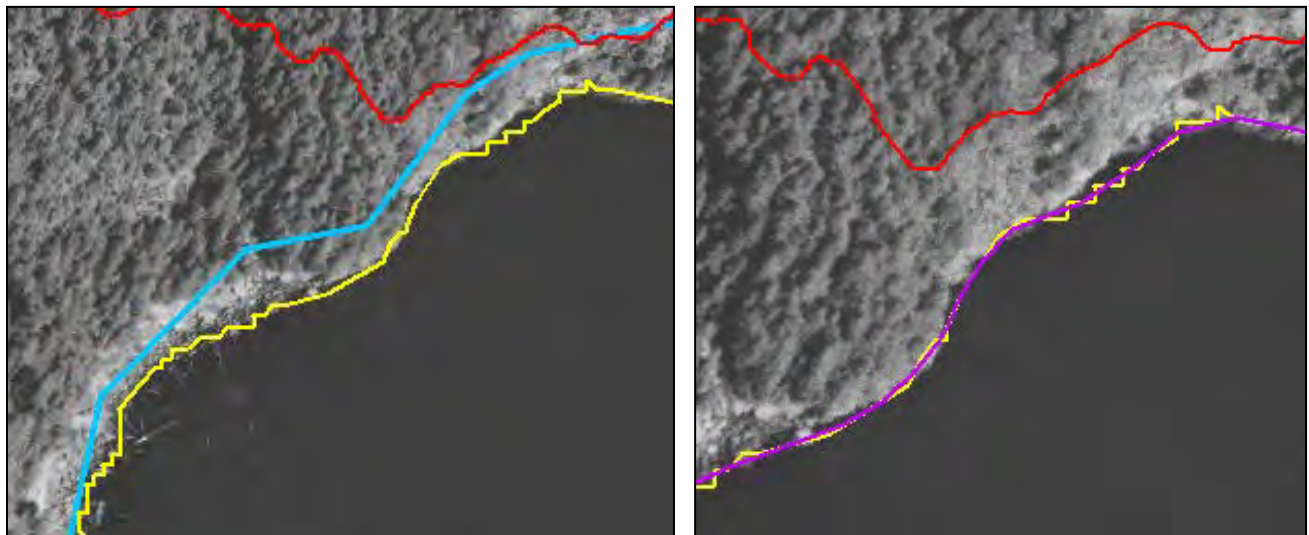
Figure 42. The image series above presents a snapshot of the results from linework generalization on a subset of ENC data from the dataset US4AK2FM for KEFJ. The original ENC data is presented in the left-hand image (yellow) along with EVS data (red) and National Map NHD shoreline data (blue). The right-hand image depicts how the generalized ENC shoreline data (purple) compares with the original linework.

If generalization of NOAA data is necessary, generalization shall follow the procedure outlined above. When submitting data to the NPS Alaska Region for review, all interim file geodatabases created for generalization purposes shall be submitted along with the project geodatabase for examination. Using

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[5] The creation of an interim file geodatabase for data generalization was necessary as the feature class XY tolerance required for generalizing the ENC linework (i.e. 4 meters) differed from the default XY tolerance assigned to the feature classes within the project geodatabase (i.e. 0.001 meters). A feature class for generalization within the KEFJ feature dataset of the project geodatabase would not have permitted this change in XY tolerance.

[6] When loading the feature class into feature dataset the XY tolerance is reassigned from 4 meters to 0.001 meters. This change allows for the feature class to be adopted into the feature dataset, but does not actually adjust the data itself. This can be verified by comparing the ENC_US4AK2FM_Subset_4mPAEK feature class from the interim database to the ENC_US4AK2FM_Subset_4mPAEK feature class from the project geodatabase.

this approach, it is expected that linework generalization should be representative of the original data as well as repeatable.

X.   SHORELINE UPDATES – FINAL VERIFICATION

After the data has been prepared as explained in the previous sections, topology is built and validated to find any errors that might be present. Errors that might be present in the coastline linear data include:

1. Lines that overlap another line
2. Lines that self-overlap by looping back upon themselves.
3. Lines that cross another line.
4. Lines that loop back upon themselves and cross.
5. Lines with multiple vertices at the same location.
6. Lines that have gaps between them, but should be connected.

Topology is used to find these errors and ensure data quality. Topology rules are set to look for specific types of errors. The following rules are set for the coastline data:

1. Must not Overlap
2. Must not Self-Overlap
3. Must not Intersect
4. Must not Self-Intersect
5. Must not have Dangles

Rules 1-4 find instances where lines overlap or cross. Rule 5 finds the ends of lines that do not connect to another line. For example a connecting arc that was not properly snapped to the existing linework. Rule 5 will produce false positives along the edges of the data extent. All of the "must not have dangles" errors are inspected on a case by case basis. The false positives are marked as exceptions to the topology rules and the true errors are fixed.

Compacting the Shoreline_Updates geodatabase is the final step before submitting the data to the NPS for review. This is accomplished through ArcCatalog. For a little background, there is a group of tables in the database called delta tables. The delta tables keep track of every operation performed on the data and can get extremely large. Compacting reduces the size of the database by purging any unneeded records from the delta tables. This also helps promote stability of the database making it less susceptible to data corruption.

XI.   CONCEPTUAL MODELS

The conceptual models outlined in this protocol were developed in Microsoft PowerPoint. The following hyperlinks can be selected to access each individual conceptual model.

- Conceptual Model 1 – Data Source Preferences
- Conceptual Model 2 – Updates Across Glacial Extents
- Conceptual Model 3 – Updates of Man-Made Waterfront Structures and Alongshore Features For EVS Data
- Conceptual Model 4 – Updates of Man-Made Waterfront Structures and Alongshore Features For ENC Data

MIGRATION TO THE NATIONAL HYDROGRPAHY DATASET

    I.   NATIONAL HYDROGRAPHY DATASET OVERVIEW

The National Hydrography Dataset (NHD) is the portion of the National Map that deals with hydrologic features. NHD contains information on both naturally occurring and constructed bodies of water. The information uses a coded classification system to identify features by type. Hydrologic flow networks are also part of the NHD. Information on related entities such as dams, bridges, or any other related features can be included as well. Each feature in the NHD is assigned a unique identifier that can be used to link additional data to the feature.

        i.   *NHD Data Model Overview*
The current NHD data model can be found at:
http://nhd.usgs.gov/NHDv2.0_poster_6_2_2010.pdf
This data model represents the current model for NHD data. It consists of a number of feature classes. There is some overlap between the types of features that can be added to each feature class. The core feature classes for the purposes of migrating the Shoreline Updates to the NHD template are:

- NHDLine – contains linear landmark features. This feature class contains landmark features that typically are not part of the drainage network and are included for cartographic purposes. In some cases, features in NHDLine can overlay features in NHDFlowline.
- NHDFlowline – contains the linear features that make up the hydrologic drainage network. This feature class is the basis for the geometric network that defines the flow relationships between the NHD features. The majority of these features are StreamRivers that are too narrow to be delineated as a polygon. NHDFlowline is probably the most important of all the NHD feature classes.
- NHDArea – contains polygon features. There is some overlap between the features in the NHD Area and NHD Waterbodies feature class. Generally the features in NHD Area are included for cartographic purposes. Areal StreamRivers and SeaOcean polygons fit into this feature class.
- NHDWaterbody – contains hydrographic features that are represented by polygons. Lakes, ponds, and estuaries fall within this category.

All of the feature classes use subtypes to describe each feature type. The subtypes are populated using a variety of coded value domains. The FType and FCode fields contain the coded values. The FType contains a 3 digit code while the FCode contains a 5 digit code that includes the FType + 2 digits which provide more detail about the nature of the feature. Examples of valid FTypes are 460 for StreamRiver, 558 for Artificial Path, and 390 for LakePond. 39004 is an example of an FCode for a LakePond – Perennial.   All of the domains are described in the data model diagram.
There are some unique conventions concerning how features fit into each of the four feature classes. For instance, a river that is delineated as an area is not in the NHDWaterbody feature class but the NHDArea feature class. However, a LakePond areal feature is part of the NHDWaterbody feature class. In order to maintain the integrity of the drainage network the approximate center line of an areal river is represented as an artificial path in the NHDFlowline feature class. Similarly, SeaOcean is a subtype of the NHDArea feature class while Estuary is part of the NHDWaterbody feature class.

        ii.   *Reaches*

For the purposes of the NHD, a reach is a segment of surface water with similar hydrologic characteristics. NHD contains three types of reaches: transport, coastline, and waterbody. Transport reaches represent paths that water takes through a drainage network. Coastline reaches represent a section of coastline along the following bodies of water:

- Atlantic Ocean
- Pacific Ocean
- Arctic Ocean
- Great Lakes
- Gulf of Mexico
- Caribbean Sea

Both transport and coastline reaches are delineated using linear features. It should be noted that coastline reaches end where a transport reach discharges into the sea or a Great Lake.

A waterbody reach is a hydrologic feature delineated using polygons. LakePonds make up the majority of waterbody reaches, although in Alaska ice masses (glaciers), and estuaries are more common than in the lower 48 states.

iii.   Geographic Names

The NHD uses the Federal government's Geographic Names Information System (GNIS) to name features. The GNIS name is stored in the GNIS_Name field. GNIS_ID contains the eight digit identifier for the feature in GNIS. If a feature does not have a GNIS name, the GNIS_ID and GNIS_Name fields are left blank.

iv.   NHD Stewardship

The concept of the NHD program is to have a nationwide database of hydrologic features which are included in the National Map and are continuously revised based on the most current information and local knowledge. The United States Geological Survey (USGS) maintains the database, while updates are performed at the local level by public and private entities. All updates have to be reviewed by a data steward before being submitted to USGS for inclusion on the nationwide database. In most cases the data steward is an employee of a state agency who assumes responsibilities for NHD stewardship in addition to their normal duties. The core of the NHD Stewardship process is the idea that local level updates will lead to a more accurate and comprehensive dataset that can be utilized by end users nationwide.

II.   THE NHD EDIT PROCESS

USGS has created several tools to process data for inclusion in the NHD. The NHD GeoEdit Tools are used for small scale edits of the data while the NHD GeoConflation Tool is used for editing large areas of data. Since the areas of interest are isolated to a relatively narrow band along the coast, USGS has recommended that the GeoEdit Tools be used for this project. USGS is currently in the process of rebuilding and improving the GeoEdit Tools. They are writing the tools to work in ArcGIS 9.3.1. Beta versions are expected to be released in late summer 2011. As an interim step, however, data will be migrated into the NHD data model using a template provided by USGS, thus ensuring that it will be ready for the GeoEdit process when the tools become available. The process described below is not the actual GeoEdit process, but it prepares the data for when the new GeoEdit tools become available.

i.   Data Template Preparation

The data templates are downloaded from the NHD Stewardship page:
http://webhosts.cr.usgs.gov/steward/scripts/st2_software.pl
There are two templates that need to be downloaded:
NHD_AlbersEqArea_L48_93_v2.0_05262010.mdb
NHD_Geo_dd_93_v2.0_05262010.mdb
These are saved to a folder called NHD_Templates. Since there is no Albers template for Alaska, the Albers Equal Area template for the lower 48 is projected to Alaska Albers and named:
NHD_AlaskaAlbers_93_v2.0.mdb
The Alaska Albers template will be used for all of the NHD data in the Alaska parks. The Geographic coordinate system template is only used during the final stages of the NHD edit process. The final NHD_Templates folder should look like this:
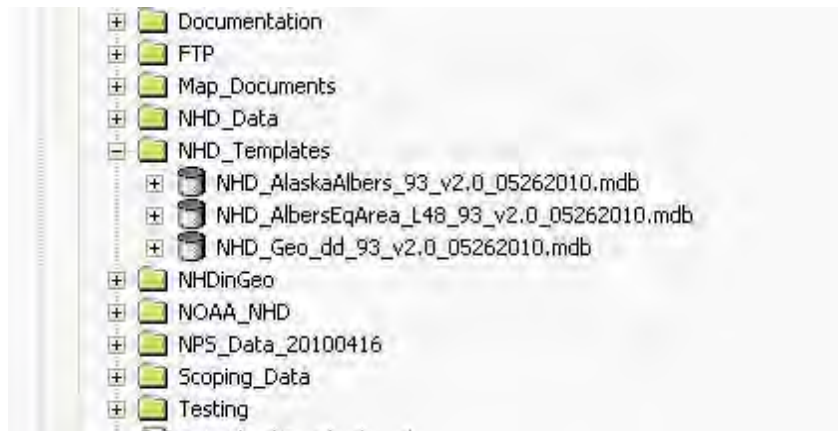
Figure 43. Final NHD_Templates folder showing all four templates required for the complete NHD edit process.

   ii.   Workspace Preparation
Create a folder called NHD Data as shown on the graphic. Under NHD create a folder with the four letter NPS park code for the park to be migrated (CAKR in this example). In this folder create two folders, one named Working and one named Final. As the names imply, Working is the location in which all processing will occur while Final is the location where the completed data will be stored (Figure 44).
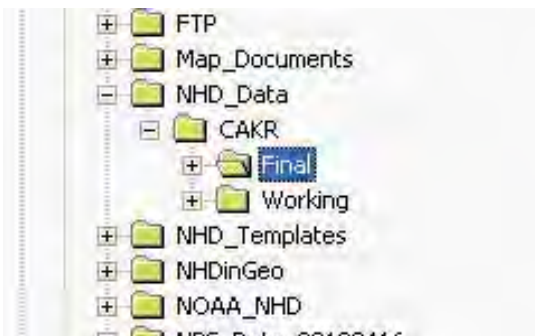
Figure 44. Working schema, showing a subfolder for each park in the NHD_Data folder.

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iii.   Data Preparation for Migration of Shoreline Data to the NHD Template

The starting point for migration is the Shoreline_Updates feature class for the particular park to be updated. Before proceeding with NHD migration, the Shoreline_Updates should have final NPS approval and be free of topology errors.

A.   Linear to Polygon Conversion

Copy the NHD Alaska Albers template into the Working folder associated with the park to be migrated. Rename it with the park code at the beginning. For example, CAKR_NHD_AlaskaAlbers_v2.0.mdb.

1. Create a linear feature class called Lines as shown below (Figure 45).
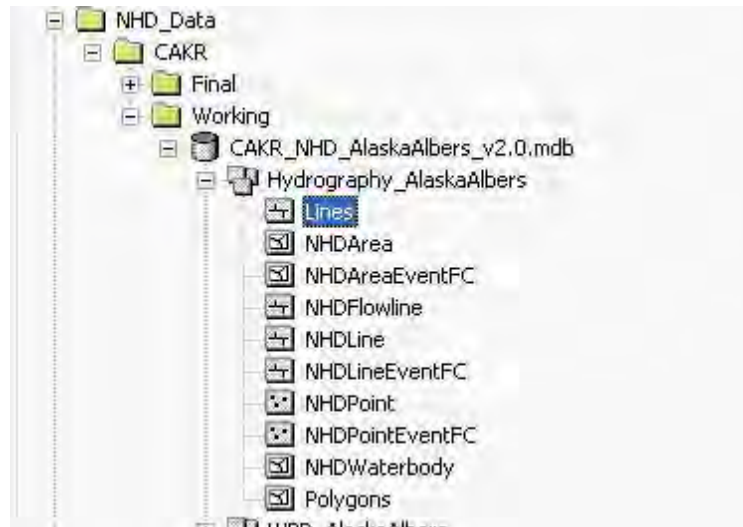
Figure 45. Working folder structure. Note the presence of all of the NHD feature classes. The Lines and Polygons feature classes are interim feature classes created by the editor. The lines are created in step 1, and the Polygons are created during step 4.

2. Import the linear features from the Shoreline_Updates feature class into the Lines feature class created in step 2.
3. Converting the linear feature class into a polygon feature class requires "closing" the lines. Edit the lines to close off any lines that do not form enclosed areas. The polygon conversion process will only convert enclosed areas to polygons. This is also a good time to add any lines that are needed, such as where areal rivers meet a coastline reach as shown in Figure 46 below.

Figure 46. Editing examples. Closing the estuary polygon was necessary because clipping the data to the park boundary, "opened" what would have been a closed polygon. Separation of the StreamRiver from the Estuary is required because once converted to polygon data, the areal StreamRiver will be migrated to the NHDArea feature class while the Estuary will be migrated to the NHDWaterbody feature class. The Artificial Paths are added for inclusion in the NHDFlowline feature class.

These are just a few examples of edits that may need to be performed for the linear to polygon conversion. It may be necessary to merge adjacent sections of coastline as well. For example the Shoreline_Updates data might have a section coast delineated by a series of line attributed some attributed as "Natural Mean High Water", and others as "Apparent Swamp or Marsh." NHD requires these are all attributed as "Coastline." According to the NHD standard, each coastline reach will be assigned a unique identifier. A coastline reach is the section of coast between the points where transport reaches discharge into the SeaOcean or Estuary. In either case, merging should only occur at junctions where only two features meet. When lines are merged in this situation the coincident nodes of each line become a vertex on the merged line. If there are three or more features meeting at a single junction, as is the case where a transport reach discharges, the features will not be merged. Merge coastline sections where there are two coastline sections abutting each other with no transport reach intersecting. NHD requires the entire coastline between transport reaches (StreamRiver or Artificial Path) be one feature for the purposes of assigning reach codes. The coastline feature should begin and end where transport reaches intersect. This means coastline features may need to be cut where they meet transport reaches. This includes any artificial paths that have been added to represent areal rivers. The end result should be one unique coastline reach between the points where any transport reaches meet the coastline. Lines should only be added to close off polygons, create artificial paths or to cut polygons into their proper classification (i.e. StreamRiver from LakePond or Estuary from SeaOcean). **At no time should the geometry of the NOAA data be changed regardless of whether it is based on the EVS or ENC.**

4. The next step is to convert the Lines feature class to a polygon feature class. To do this open ArcCatalog and navigate to the NHD layer containing the Lines feature class as shown in Figure 47. Right-click on the feature dataset containing the Lines feature class, click New (not Import as shown), then Polygon Feature Class from Lines.
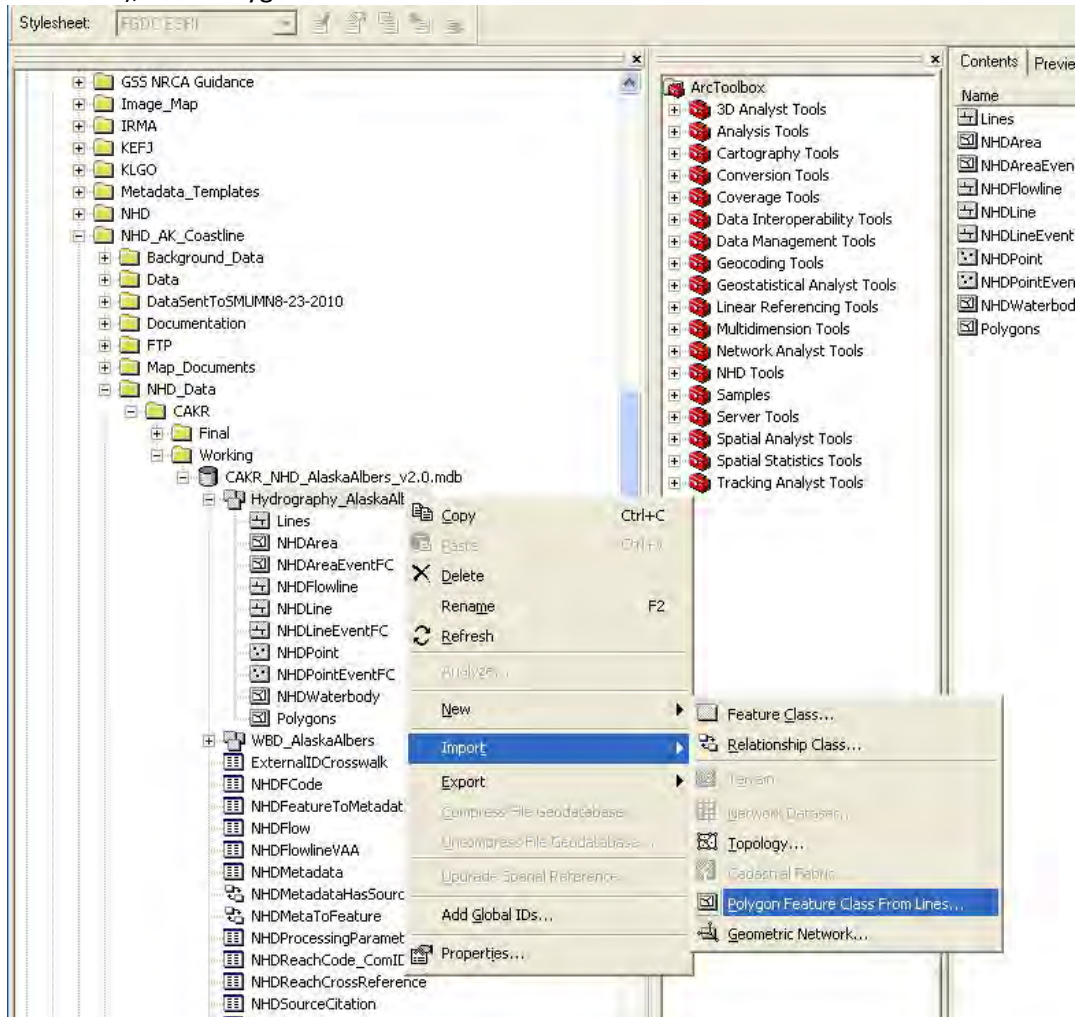
Figure 47. Invoking the Polygon Feature Class form Lines command.

5. Clicking on Polygon Feature Class From Lines brings up the following dialog box. Name the feature class polygons, accept the default Cluster tolerance, check the Lines feature class in the list, and then click OK.
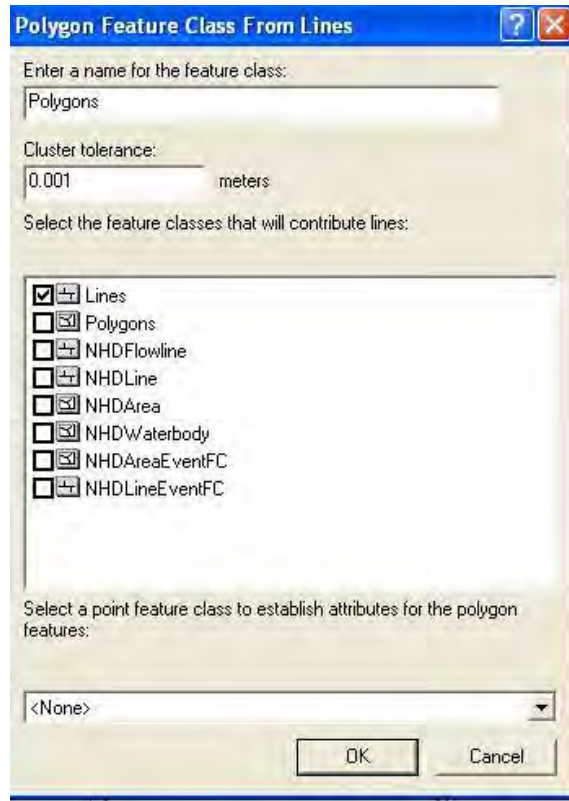
Figure 48. Polygon feature Class from Lines interface.

B. Migration

Migration involves not only moving the features from the Lines and Polygons feature classes to the NHD Data Model, but also populating the NHD feature classes with the appropriate FType, FCode, GNIS_ID and GNIS Name. The best approach is to move the features into the NHD template and then populate it with the correct attributes.

1. Since the features to be migrated reside in two feature classes which will be moved into four feature classes, it is necessary to review the data and specify to which NHD feature class(es) the feature belongs. First, create a coded value domain containing values that will specify to which NHD feature class(es) the feature belongs. Also, create a short integer field called NHD_FC in both the Lines and Polygons feature classes that uses this domain. This field will be populated during the next step to specify the NHD feature class to which the feature will be migrated and then queried during the actual data migration. Include the following values:

A. NHDWaterbody, NHD_FC = 1
B. NHDArea, NHD_FC = 2
C. NHDLine, NHD_FC = 3

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D.   NHDFlowline, NHD_FC = 4

E.   Both NHDLine and NHDFlowline, NHD_FC = 5

F.   Not Included in NHD, NHD_FC = 999

2.   Open ArcMap and add the Polygons feature class with an appropriate imagery layer in the background. Start editing and pan through the data removing any polygons that are land. These will be mainly islands. A Before & After example is shown in Figure 49. Polygons are symbolized in blue with 50% transparency.

Figure 49. Polygon removal example. Left graphic shows data before the island polygons are removed. Right hand side shows the result after the islands polygons are deleted. Polygons are symbolized in blue with 50% transparency.

While looking for islands that need to be deleted, populate the NHD_FC field for all of polygon features. In most cases it will be NHDWaterbody, but in a few instances such as the areal rivers and SeaOcean areas it will be NHDArea. Follow the same procedure to populate the NHD_FC field for the Lines feature class. It is best to not have both the Polygons and Lines feature class in the project at the same time due to the fact it is easy to select a line and unknowingly delete it while editing the polygons.

3.   Use the Simple Data Loader to load data from the Lines and Polygons feature classes into the appropriate NHD feature classes. Start the Simple Data Loader by right clicking on the destination feature class. In the example shown in Figure 50, the destination feature class is NHDArea.
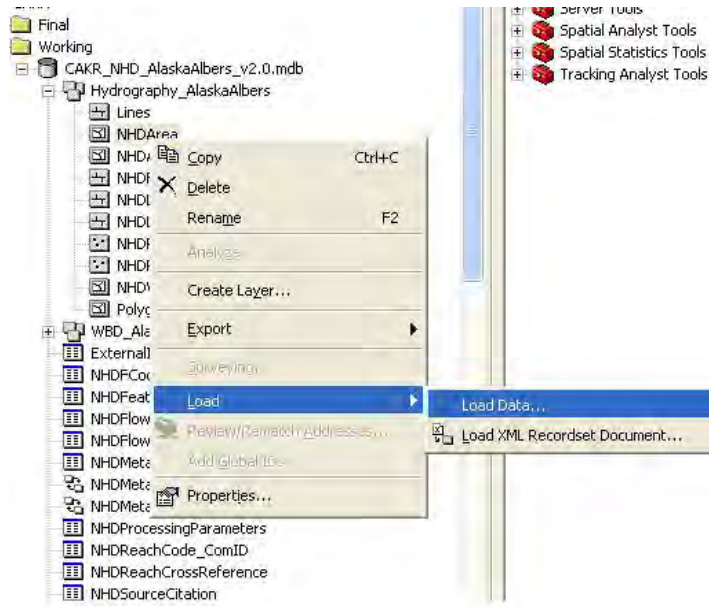
Figure 50. Starting the simple data loader. In this example, data will load into the NHDArea feature class.

Click next, which will bring up the dialog box shown below. Click on the folder button and Navigate to the feature class (Lines or Polygons) containing the data to be loaded. Then click Add and the dialog box will look as shown in Figure 51. Then click Next.
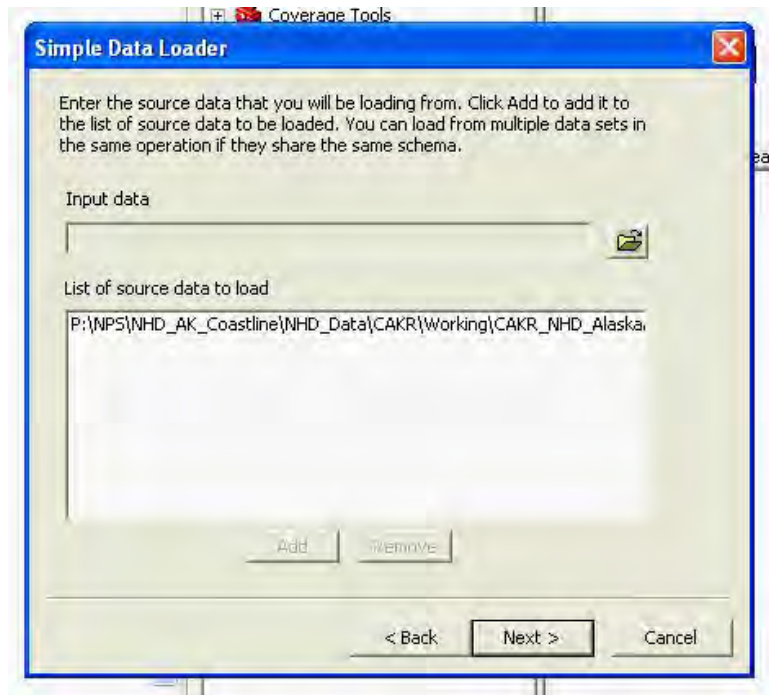
Figure 51. Simple Data Loader Interface.

Click through the next dialog boxes accepting the default values until the dialog box shown below appears. This dialog box allows the use of a query to select the data that will be loaded. Click on the Query Builder button and query the NHD_FC field with the value corresponding to the destination feature class (in this case, NHD_FC =2) as shown in Figure below
.
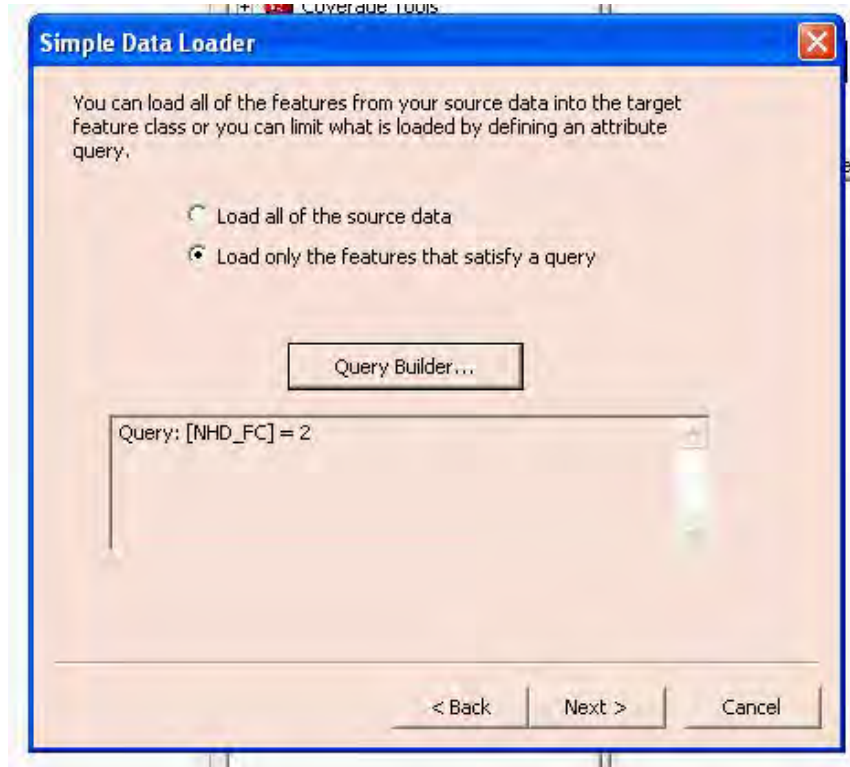
Figure 52. Data Load Selection Query. In this example the data is to be loaded into the NHD Area feature class (NHD_FC=2) therefore those features with an NHD_FC values equal to 2 are queried. See page 44, Section B-1 for further information.

Click OK. Verify the source and target datasets are correct in the next window. If they are correct, click Finish. Repeat the process for all four NHD feature classes.

4. Open ArcMap and add all four NHD feature classes and the appropriate background imagery to the map document. Pan through the data and populate the FType and FCode field of each feature class with the appropriate values as defined by the NHD Data Model. Groups of features with identical attributes can be attributed at the same time using the field calculator. Fix any errors that might still be present in the data.

5. Populate the GNIS_ID and GNIS_Name field of each NHD feature class. To do this, first, add the GNIS Region 19 point shapefile. However, DO NOT populate the GNIS fields of the NHD Line and Flowline feature classes with the adjacent waterbody as specified in the documentation. Per Hank Nelson at USGS, this is no longer valid (7/10/2012) and if these are populated will generate errors when the NHD QC Tools are applied. The GNIS data can be downloaded from the following location:

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6. Spatially join the GNIS shapefile to the NHD feature classes. This creates an output table that is added to the map.

7. Table join the output table to the NHD feature class on OBJECTID. Calculate the GNIS_ID = FEATURE_ID and GNIS_Name=FEATURE_NA. After calculating, both the table join and spatial join can be removed and the output feature class can be removed from the project. If there are only a few features with GNIS Names, this step can be performed manually without doing the join.

8. Review the data again to make sure the GNIS_ID and GNIS_Name fields are correct. There may be a significant amount of manual editing that will need to be done to insure these are correct. Use the DRG and GNIS shapefiles as background information. Not every feature will have a GNIS name associated with it. Those that do not have a GNIS Name will be left blank.

9. Create a topology for the linear feature classes using the following rules:

   a. Must not Overlap
   b. Must not Self-Overlap
   c. Must not Intersect
   d. Must not Self-Intersect.

10. Verify and topology and fix errors, repeat until clean.

11. Similarly, create a topology for the polygon feature classes using the following rules:

   a. NHDArea – Must not overlap
   b. NHDWaterbody – Must not overlap

12. Verify and topology and fix errors, repeat until clean.

13. Copy the data to the Final folder. Delete the Lines and Polygons feature classes. Compact the database one last time and it is considered complete and ready to be used as a Target dataset for the NHD editing process.

USING THE NHD GeoEdit TOOLS

The ultimate goal is to submit the updated coastline to the NHD master geodataset. This requires the data passing the NHD quality assurance and verification process. The NHD GeoEdit tools are the main tools used in the process. The latest GeoEdit tools were released in March of 2012. The GeoEdit Tools documentation explains the USGS process in detail. The following sections will give a summary of the USGS process as it relates to the NPS coastal parks.

   I.   Requesting a Check Out From the Master Geodatabase

To obtain data from the master geodatabase, a user must have a username and password for the stewardship website. The username and password is obtained from the NHD regional point of contact. The stewardship website is the vehicle for requesting the data. Data is checked out by Subbasin (8-digit HUC). In cases where the coastline forms the boundary between two subbasins both subbasins need to be checked out in one piece. This is accomplished by selecting one of the subbasins for checkout and then checking the box for the appropriate subbasin in the window. It is critical that both subbabsins are obtained in one check out. This does not mean the entire subbasin needs to be edited. Edits are documented through the use of metadata sessions as explained in the next section. The subbasins are requested from the master NHD dataset and an email notification is sent to the requester when the data is ready. The checkout is referenced with a unique Job ID. The Job is then opened through the NHD Update toolbar in an ArcMap session.

> II.   Metadata in the GeoEdit Process

The GeoEdit tools track edits to the NHD through metadata sessions. Before any changes to geometry or attribution can be made metadata must be created. Metadata in the NHD is to the feature level, therefore each type of edit or source data must have its own metadata session. For example, if an updated section of coastline is made up of source data from multiple sources such as NOAA EVS data as well as ENC data, two metadata sessions would be required. Connecting arc additions also require their own metadata. If existing NHD is being retained it is not required that a separate metadata session be created, because these features will not be changed. In this case, the only edits that might possibly be required would be splitting an existing NHD feature and deleting the portion that overlaps the updated NOAA data. The connecting arc metadata can be used for this situation provided it is clearly explained in the metadata. Similarly, datasets of the same type, but with different dates of acquisition require separate metadata sessions. When performing the NHD edits, it is critical that the correct metadata session is selected in the NHD Editor window.

> III.   Performing Edits Using the NHD GeoEdit Tools

The NHD GeoEdit Tools User Guide provides documentation in both text and video form. These provide the starting point for using the GeoEdit tools. They provide a basic understanding of the NHD edit process, and reviewing the process in detail here would be redundant. However there are some concepts of the process that are not obvious from the USGS documentation:

The target edit layer can be changed within the tool without applying rules and saving edits. This is valuable knowledge for performing edits, especially since the NHD GeoEdit Tools documentation makes no mention of this fact. It allows one to work around the "chicken or the egg" type of scenario when fixing errors requires edits to multiple layers. For example, a coastline feature that does not exactly match the boundary of its adjacent SeaOcean polygon will generate an error. This error likely occurred because the coastline was updated prior to the SeaOcean polygon or vice versa. In either case, it is impossible to apply rules and save either layer individually. The target edit layer must be switched before trying to apply rule in order to make edits to both layers which allows one to apply rules without generating errors and therefore save the changes.

Whenever possible use the replace geometry tool, rather than deleting the old data and importing the new data. Deleting a feature retires its reach code from use. Replacing the geometry preserves the current reach code and therefore maintains the relationships with any HEM events that might be tied to the flow network. As a best practice, replace geometry should be used wherever possible in order to maintain HEM event relationships, and help limit the number of reach codes that are removed from

service. The HEM event issue is probably not as critical for Alaska as it is for the lower 48 states, but with the sheer density of features in Alaska, limiting the number of reach codes that are retired is a good idea.

In cases where there are BayInlet features that are also part of the SeaOcean it is permissible to "stack" a BayInlet feature on top of the SeaOcean feature, in the NHD Area feature class. The caveat is that their boundaries must exactly match. This prevents the tools from flagging coastline on ocean bays and inlets as errors, because the coastline does not fall on the SeaOcean.

The NHD tools limit the options available to an editor. Plus, there is no real clear direction as to which tools or processes must be invoked from within the NHD tools. It appears tools such as the select tool can be safely selected from outside of the NHD tools. Any operation that involves a change to the NHD feature classes that will be saved requires use of the NHD tools. Trying to make edits in a regular ArcGIS edit session will generate an error. Also, when editing outside of the NHD editor, which is required to import features into the Import_Lines or Import_Polygons feature classes, be aware that the NHD tools will change the selectable layers settings. In these cases it will most likely be necessary to set/reset the selectable layers settings. When switching between editing within the NHD and Import feature classes be very careful to save edits and close one edit session before attempting to open the other.

In discussions with the USGS point of contact, Henry Nelson, concerning the sheer number of errors associated with existing transport reaches not properly connecting to the updated coastline reaches, he recommended removing some of the rules from consideration as an interim step. This is accomplished by commenting out lines of code in the .xml file that contains the rules. These rules will be applied by the QA tools during the final QA checks. The graphics below show the location of the GeoEdit rules .xml, and a portion of the text of the file. Obsolete with GeoEdit Tools Version 4.0.3
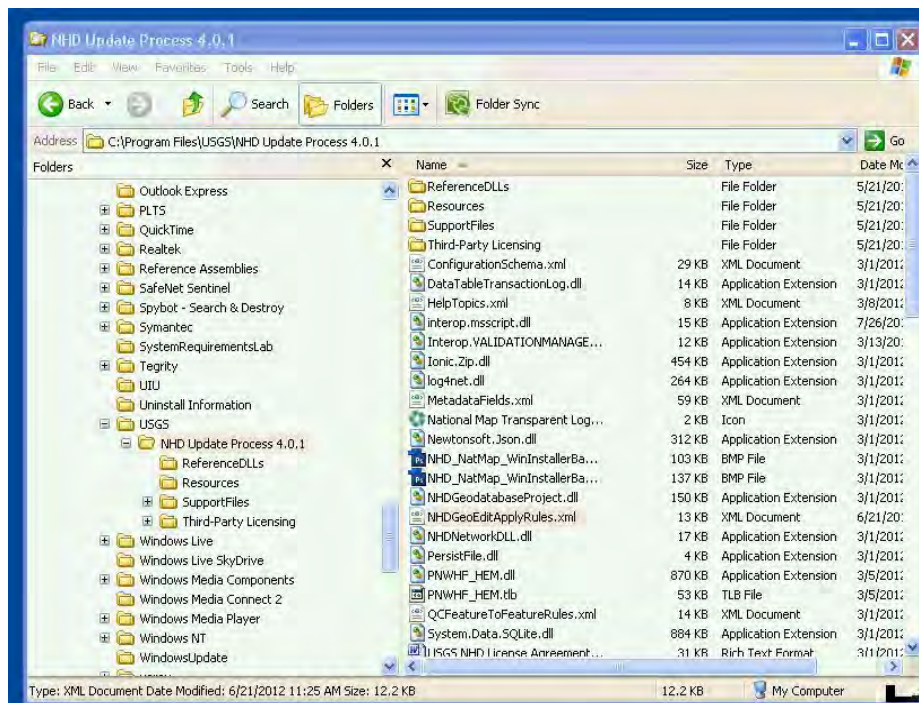
```
<?xml version="1.0" ?>
<!-- XML for storing the configuration for NHD Geoedit Apply Rules version="2.0" -->
- <Layers>
  - <ApLayer Tag="NHDFLOWLINE" Name="NHDFlowline">
    <Topology SubType="CanalDitch" Relation="CanNotCross" With="NHDFLOWLINE:Coastline" />
    <Topology SubType="CanalDitch" Relation="WhenWithinMustWithin" Within="NHDWATERBODY:Ice Mass,LakePond,Reservoir,Estuary"
      With="NHDLINE:Bridge,Tunnel,Flume;NHDAREA:Bridge,Tunnel,Flume" />
    <Topology SubType="CanalDitch" Relation="WhenWithinMustWithin" Within="NHDAREA:StreamRiver,CanalDitch,Spillway,Rapids,SeaOcean,Submerged
      Stream,Area of Complex Channels" With="NHDLINE:Bridge,Tunnel,Flume;NHDAREA:Bridge,Tunnel,Flume" />
    <Topology SubType="CanalDitch" Relation="WhenCrossMustWithin" Cross="NHDWATERBODY:Ice Mass,LakePond,Reservoir,Estuary"
      With="NHDLINE:Bridge,Tunnel,Flume;NHDAREA:Bridge,Tunnel,Flume" />
    <Topology SubType="CanalDitch" Relation="WhenCrossMustWithin" Cross="NHDAREA:StreamRiver,CanalDitch,Spillway,Rapids,SeaOcean,Submerged
      Stream,Area of Complex Channels" With="NHDLINE:Bridge,Tunnel,Flume;NHDAREA:Bridge,Tunnel,Flume" />
    <!-- <Topology SubType="Coastline" Relation="MustIntersect" With="NHDAREA:SeaOcean;NHDWATERBODY:Estuary" /> -->
    <Topology SubType="StreamRiver" Relation="WhenCrossMustWithin" Cross="NHDAREA:CanalDitch"
      With="NHDLINE:Bridge,Tunnel,Flume;NHDAREA:Bridge,Tunnel,Flume" />
    <Topology SubType="StreamRiver" Relation="CanNotCross" With="NHDFLOWLINE:Coastline" />
    <Topology SubType="Pipeline" Relation="CanNotCross" With="NHDFLOWLINE:Coastline" />
    <Topology SubType="Pipeline" Relation="CanNotOverlap" With="NHDFLOWLINE:AnySubTypes" />
    <Topology SubType="Underground Conduit" Relation="MustIntersect" With="NHDPOINT:SinkRise,SpringSeep;NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="StreamRiver" Relation="FLWithFLSplit" With="NHDFLOWLINE:Connector,StreamRiver,Coastline" />
    <Geometry SubType="StreamRiver" Relation="FLWithFLSplitTouches" With="NHDFLOWLINE:StreamRiver,Coastline,CanalDitch" />
    <Geometry SubType="StreamRiver" Relation="FLWithFLSplitBase" With="NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="StreamRiver" Relation="FLWithWBSplit" With="NHDWATERBODY:LakePond,Estuary,Ice Mass,Playa,Reservoir,SwampMarsh" />
    <Geometry SubType="StreamRiver" Relation="FLWithAreaSplit" With="NHDAREA:StreamRiver,CanalDitch,Area of Complex Channels" />
    <Geometry SubType="ArtificialPath" Relation="FLWithFLSplit" With="NHDFLOWLINE:ArtificialPath,Connector,StreamRiver,Coastline" />
    <Geometry SubType="ArtificialPath" Relation="FLWithFLSplitBase" With="NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="ArtificialPath" Relation="FLWithWBSplit" With="NHDWATERBODY:AnySubTypes" />
    <Geometry SubType="ArtificialPath" Relation="FLWithAreaSplit" With="NHDAREA:StreamRiver,CanalDitch,Area of Complex Channels" />
    <Geometry SubType="Connector" Relation="FLWithFLSplit" With="NHDFLOWLINE:ArtificialPath,Connector,StreamRiver,Coastline" />
    <Geometry SubType="Connector" Relation="FLWithFLSplitBase" With="NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="Connector" Relation="FLWithWBSplit" With="NHDWATERBODY:LakePond,Estuary,Ice Mass,Playa,Reservoir" />
    <Geometry SubType="Connector" Relation="FLWithAreaSplit" With="NHDAREA:AnySubTypes" />
    <Geometry SubType="CanalDitch" Relation="FLWithFLSplitTouches" With="NHDFLOWLINE:StreamRiver,Coastline,CanalDitch" />
    <Geometry SubType="CanalDitch" Relation="FLWithFLSplitBase" With="NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="Pipeline" Relation="FLWithFLSplitBase" With="NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="Underground Conduit" Relation="FLWithFLSplitBase" With="NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="Coastline" Relation="FLWithFLSplitBase" With="NHDFLOWLINE:AnySubTypes" />
    <Geometry SubType="Coastline" Relation="FLWithFLSplitTouches" With="NHDFLOWLINE:AnySubTypes" />
  </ApLayer>
```

The lines beginning with "<! - - ", and ending with " - - > " are the commented out lines. By removing these rules from consideration one is able to save in interim steps. If these rules are applied all of the errors generated must be addressed before the changes can be saved. In which case there may be days of work required to fix all the errors required in order to save. After edits connecting the transport reaches to the updated coastline are complete these rules can again be used during the QA checks.

NHD QC Checks

GNIS Names

NHD Flowlines with an FTYPE of coastline should not have any

Draft Shoreline Selection Protocol

Compilation of an Accurate and Contemporary Digital Shoreline for Alaska Coastal Parks (PMIS #156638)

Appendix A: Notes Specific to Each Park

Cape Krusenstern National Monument (CAKR)

Source Data (data highlighted as **BOLD** was selected for inclusion):
EVS – AK0302, 2003
ENC – US1BS03M, 1991; US3AK92M, 1992

Boundary:
CAKR Preserve Boundary, NPS Theme Manager, March 2010, buffered to 500 meters

Background Imagery:
IKONOS Orthoimage True Color – BELA, NPS Theme Manager, 2005

Summary:
There are approximately 70 miles of coastline in CAKR. EVS data covers 100% of the coastline. Per the protocol EVS was chosen because it was not only the most current data, but it more closely matched the imagery. There are no connecting arcs in the data. The boundary was buffered to 500 meters in order to insure all of the islands in the southeastern portion of the preserve were captured. There were a surprising number of very short adjacent line segment with identical attributes. These were merged as appropriate in order to reduce the size of the dataset. There were also a large number of line features with the "apparent marsh" attribute versus the "mean high water" attribute. Features attributed as "apparent marsh" were treated in the same manner as "mean high water" in order to have a continuous coastline. There are also a number of man-made features in the northern portion of the park. These features are permanent piers associated with a mining operation and are therefore included as coastline.

Bering Land Bridge National Preserve (BELA)

Source Data (data highlighted as **BOLD** was selected for inclusion):
EVS – AK0301, 2003
ENC – US1BS03M, 1991; US3AK80M, 1995
NHD – 1905 Subregion, 2005, 2010
Photointerpreteted Coastline, SMU, 2011 based on 2003 Orthophoto

Boundary:
BELA Preserve Boundary, NPS Theme Manager, March 2010, buffered to 175 meters

Background Imagery:
IKONOS Orthoimage True Color – BELA, NPS Theme Manager, 2005
Aerial Orthophoto Mosaic – 2003, 0.6 meter resolution

Summary:

There are approximately 340 miles of coastline in BELA. EVS data covers approximately 70% of the coastline. The eastern 30% of the park coastline is covered by NHD data. Per the protocol EVS was chosen if available, because overall it more closely matched the imagery. Originally, NHD was chosen over the ENC for the remainder of the park because it more closely matched the imagery. After consultation with NPS and internal discussions within NPS, it was decided that SMU would use photo interpretation methods to delineate the coastline for the eastern portion of BELA based on a 2003 aerial orthophoto mosaic, created specifically for studying coastline issues in BELA. The photo-mosaic has a relatively high resolution of 0.6 meters with a horizontal accuracy of +/-1.1 m RMS. The boundary was buffered to 175 meters. To summarize there are 766 features in the data, approximately 2/3 from the EVS data. 1/3 delineated by SMU, and just a handful of connecting arcs generated by SMU.

Anaikchak National Monument and Preserve

Source Data (data listed in **BOLD** selected for inclusion):
EVS – CM-8200, July 1982
ENC – US4AK5HE, February 2006
NHD – 1902 Subregion, January 2007 to July 2008

Boundary:
ANIA Preserve Boundary, NPS Theme Manager, March 2010, buffered to 150 meters

Background Imagery:
IKONOS Orthoimage True Color – ANIA, NPS Theme Manager, 2005

Summary:
There are approximately 60 miles of coastline in ANIA. EVS data covers approximately 80% of the coastline. The western 20% of the park coastline has coverage by both ENC and NHD data. Per the protocol EVS was chosen if available, because overall it more closely matched the imagery. The NHD was chosen over the ENC for the remainder of the park because it more closely matched the imagery, and post dated the ENC data. One connecting arc of approximately 40 meters long was generated to connect the NHD portion of the data to the EVS data. The connecting arc was generated preserving as much of the EVS as possible. Topology found 26 dangles within the data. Most of these were errors in the NHD data where end points of lines that should have been coincident were not. In all cases the points were less than 5 meters apart, in some cases much less, and fixed by snapping together. In one case a gap was present in the NHD data. It appears the line segment was misclassified as "CARTOGRAPHIC LIMIT" rather than "SHORELINE", and therefore was not extracted.   The missing segment was added back into the data and classified as shoreline. There are 115 features in the data, 21 from the NHD, 1 connecting arc generated by SMU and the balance from the EVS.

Lake Clark National Park and Preserve

Lake Clark National Park and Preserve (LACL)
Source Data (data listed in **BOLD** selected for inclusion in Shoreline_Updates):
EVS – PH6301B, July 1970
ENC – US4AK13M, February 2001

NHD – 1902 Subregion, 2006-2010 within park

Boundary:
LACL Park Boundary, NPS Theme Manager, March 2010, buffered to 1250 meters

Background Imagery:
IKONOS Orthoimage True Color – LACL, NPS Theme Manager, 2005-2008

Summary:
There are approximately 85 miles of coastline in LACL. EVS data covers 100% of the coastline. Approximately 40% of the coastline falls within ANSCA holdings inside of the park boundary. Per the protocol EVS was chosen because it was available. It should be noted that the EVS data was the oldest of the data sets. It actually appears that much of the NHD for this park has been up dated within the last year or two. If the decision is made to abandon the EVS in favor of the NHD, it will require a minimum of rework to load the NHD into the feature class. Overall, both the EVS and NHD correlated with the imagery. River mouths were the main areas where the imagery and the data were not in agreement. This was true of both the EVS and the NHD. The boundary was buffered to 1250 meters. Buffering to this distance included a small piece of a USFWS offshore island which can be deleted at the request of NPS. Any smaller buffer created data holes in the Tuxedni River estuary. It was not necessary to generate any connecting arcs for this park since the data came from a single source. There were 16 locations where it appears line segments were misclassified as "CARTOGRAPHIC LIMIT" rather than "SHORELINE", and therefore not extracted.   The missing segments were added back into the data and reclassified as "SHORELINE". Identical adjacent line segments did not appear to be an issue with this data set. There was one replicate feature. To summarize there are 456 features in the data, all of which came from the EVS.

Appendix B: NHD Conflation Tool Python Scripts

```
# ----------------------------------------------------------------------------
# 1st_Prep_Conflate.py
# Created on: 12-10-2012
# Date of Last Update: 02-06-2014
# Created by: Saint Mary's University of Minnesota
# Usage: 1st_Prep_Conflate <NHDWaterbody> <NHDArea> <NHDFlowline> <HYDRO_NET_Junctions> <study_area> <FLowNet> <RawBasins>
<conflag_results_gdb>
# Description:
# 1) Copies the study FlowNet and RawBasins (selects those in or crossing the boundary of the study area).
# 2) Selects NHDFlowline, HYDRO_NET_Junctions, NHDWaterbody, and NHDArea features that intersect or are within the study area.
# 3) Creates conflate containers - (one for waterbodies and one for flowlines)
# 4) Adds needed fields to all the things to be processed.
# 5) Flags those nhdwaterbodies and nhdflowlines that cross the study area boundary
#
# USER WARNINGS
# 1) All FeatureClass must be in the same coordinate system.
# 2) Recomend RawBasins have large (non-basin) polygon(s) removed.
# 3) Only tested processing with a study area with a single simple feature.
# 4) If you clip NHD information do not clip to the study area - without at
#    least a little extra data the tool will be unable to identify features
#    that crosses the study area boundary, something the tool uses to adjust searches.
# ----------------------------------------------------------------------------

# Import arcpy module
import arcpy

#Location of the original Waterbody (suggest cutting data buffered around the study area; don't cut to study area)
NHDWaterbody = arcpy.GetParameterAsText(0)
if NHDWaterbody == '#' or not NHDWaterbody:
    NHDWaterbody = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\NHDH1904_original.gdb\\Hydrography\\NHDWaterbody" # provide a default value if
unspecified

#Location of the original NHDAreas (suggest cutting data buffered around the study area; don't cut to study area)
NHDArea = arcpy.GetParameterAsText(1)
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```python
if NHDArea == '#' or not NHDArea:
    NHDArea = "P:\\NPS\Conflate_Tool_Working\\Working\\Barb\\NHDH1904_original.gdb\\Hydrography\NHDArea" # provide a default value if unspecified

#Location of the original NHDFlowline (suggest cutting data buffered around the study area; don't cut to study area)
NHDFlowline = arcpy.GetParameterAsText(2)
if NHDFlowline == '#' or not NHDFlowline:
    NHDFlowline = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\NHDH1904_original.gdb\\Hydrography\\NHDFlowline" # provide a default value if unspecified

    #Location of the original NHD (suggest cutting data buffered around the study area; don't cut to study area)
HYDRO_NET_Junctions = arcpy.GetParameterAsText(3)
if HYDRO_NET_Junctions == '#' or not HYDRO_NET_Junctions:
    HYDRO_NET_Junctions = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\NHDH1904_original.gdb\\Hydrography\\HYDRO_NET_Junctions" # provide a default value if unspecified

# Location of the study area
study_area = arcpy.GetParameterAsText(4)
if study_area == '#' or not study_area:
    study_area = "P:\\NPS\Conflate_Tool_Working\\Working\\Barb\\Raw_Data.gdb\\Raw_Data\\Study_Area" # provide a default value if unspecified

#Location of the FlowNet IFSAR layer - Raw Flowlines
RawFlowlines = arcpy.GetParameterAsText(5)
if RawFlowlines == '#' or not RawFlowlines:
    RawFlowlines = "P:\\NPS\Conflate_Tool_Working\\Working\\Barb\\Raw_Data.gdb\\Raw_Data\\raw_flowlines" # provide a default value if unspecified

#Location of the RawBasins IFSAR layer
RawBasins = arcpy.GetParameterAsText(6)
if RawBasins == '#' or not RawBasins:
    RawBasins = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\Raw_Data.gdb\\Raw_Data\\Raw_Basins" # provide a default value if unspecified

#Location of the file geodatabase that will hold the results
conflag_results_gdb = arcpy.GetParameterAsText(7)
if conflag_results_gdb == '#' or not conflag_results_gdb:
    conflag_results_gdb = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\Final_Changes\\results.gdb" # provide a default value if unspecified

# Local variables:
RawFlowlines_conflag = conflag_results_gdb + '\\RawFlowlines'
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RawFlowlines_layer = conflag_results_gdb + '\\RawFlowlines_layer'
RawBasins_conflag = conflag_results_gdb + '\\RawBasins'
RawBasins_layer = conflag_results_gdb + '\\RawBasins_layer'
HYDRO_NET_Junctions_conflag = conflag_results_gdb + '\\HYDRO_NET_Junctions_Select'
HYDRO_NET_Junctions_layer = conflag_results_gdb + '\\HYDRO_NET_Junctions_layer'
Conflate_WaterBody = conflag_results_gdb + '\\Conflate_WaterBody'
Conflate_WaterBody_layer = Conflate_WaterBody + '_layer'
Conflate_Flowline = conflag_results_gdb + '\\Conflate_Flowline'
Conflate_Flowline_layer = Conflate_Flowline + '_layer'
NHDArea_Layer = NHDArea + '_layer'
NHDArea_Select = conflag_results_gdb + '\\NHDArea_Select'
NHDFlowline_Layer = NHDFlowline + '_layer'
NHDFlowline_Select = conflag_results_gdb + '\\NHDFlowline_Select'
NHDFlowline_Select_Layer = NHDFlowline_Select + '_layer'
NHDWaterbody_Layer = NHDWaterbody + '_layer'
NHDWaterBody_select = conflag_results_gdb + '\\NHDWaterBody_Select'
NHDWaterBody_select_Layer = NHDWaterBody_select + '_layer'
study_area_PolygonToLine = conflag_results_gdb + '\\polygonToLine'
conflate_study_area = conflag_results_gdb + '\\study_area'

# Process: Copy Features ---- copies study area features to the conflag file geodatabase
arcpy.CopyFeatures_management(study_area, conflate_study_area, "", "0", "0", "0")


#-----------Start NHD Area Processing
# Process: Make Feature Layer --- NHDArea layer needed for select layer by location
arcpy.MakeFeatureLayer_management(NHDArea, NHDArea_Layer, "", "", "")

# Process: Select Layer By Location --- selects the features in the layer that intersect the study area (includes those that cross border)
arcpy.SelectLayerByLocation_management(NHDArea_Layer, "INTERSECT", study_area, "", "NEW_SELECTION")

# Process: Copy Features --- copies the selection and saves in in the conflag file geodatabase
arcpy.CopyFeatures_management(NHDArea_Layer, NHDArea_Select, "", "0", "0", "0")


#-----------Start Rawflowlines Processing
# Process: Make Feature Layer --- Layer needed to select needed features from the waterbodies layer
```

```
arcpy.MakeFeatureLayer_management(RawFlowlines, RawFlowlines_layer, "", "", "")

# Process: Select Layer By Location --- Selects Waterbody features that are in the study area (includes those that
# cross border)
arcpy.SelectLayerByLocation_management(RawFlowlines_layer, "INTERSECT", study_area, "", "NEW_SELECTION")

# Process: Copy Features --- copies FlowNet features to the conflag file geodatabase
arcpy.CopyFeatures_management(RawFlowlines_layer, RawFlowlines_conflag, "", "0", "0", "0")

# Process: Add Field --- Add processing field to the copied Flownet featureclass
arcpy.AddField_management(RawFlowlines_conflag, "IS_ASSIGNED", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")




#-----------Start Rawbasins Processing
# Process: Make Feature Layer --- Layer needed to select needed features from the waterbodies layer
arcpy.MakeFeatureLayer_management(RawBasins, RawBasins_layer, "", "", "")

# Process: Select Layer By Location --- Selects Waterbody features that are in the study area (includes those that
# cross border)
arcpy.SelectLayerByLocation_management(RawBasins_layer, "INTERSECT", study_area, "", "NEW_SELECTION")

# Process: Copy Features --- copies FlowNet features to the conflag file geodatabase
arcpy.CopyFeatures_management(RawBasins_layer, RawBasins_conflag, "", "0", "0", "0")

# Process: Add Field ---- Add processing field to the copied RawBasins featureclass
arcpy.AddField_management(RawBasins_conflag, "IS_ASSIGNED", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")




#-----------Start Network Junctions Processing
# Process: Make Feature Layer --- Layer needed to select needed features from the waterbodies layer
arcpy.MakeFeatureLayer_management(HYDRO_NET_Junctions, HYDRO_NET_Junctions_layer, "", "", "")

# Process: Select Layer By Location --- Selects Waterbody features that are in the study area (includes those that
# cross border)
arcpy.SelectLayerByLocation_management(HYDRO_NET_Junctions_layer, "INTERSECT", study_area, "", "NEW_SELECTION")
```

```
# Process: Copy Features --- copies FlowNet features to the conflag file geodatabase
arcpy.CopyFeatures_management(HYDRO_NET_Junctions_layer, HYDRO_NET_Junctions_conflag, "", "0", "0", "0")

# Process: Add Field ---- Add processing field to the copied RawBasins featureclass
arcpy.AddField_management(HYDRO_NET_Junctions_conflag, "IS_ASSIGNED", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")


#-----------Start waterbody processing (create results layer)

# Process: Make Feature Layer --- Layer needed to select needed features from the waterbodies layer
arcpy.MakeFeatureLayer_management(NHDWaterbody, NHDWaterbody_Layer, "", "", "")

# Process: Select Layer By Location --- Selects Waterbody features that are in the study area (includes those that
# cross border)
arcpy.SelectLayerByLocation_management(NHDWaterbody_Layer, "INTERSECT", study_area, "", "NEW_SELECTION")

# Process: Copy Features --- copies the selected features in the layer and saves them to the conflag file geodatabase
arcpy.CopyFeatures_management(NHDWaterbody_Layer, NHDWaterBody_select, "", "0", "0", "0")

# Process: Add Field ---- add processing field (flaged if polygon intersects the study area boundary)
arcpy.AddField_management(NHDWaterBody_select, "Is_boundary", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field ---- add processing field (flaged once the polygon has been conflated)
arcpy.AddField_management(NHDWaterBody_select, "IS_Processed", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Create Feature Class ---- creates empty copy of NHDWaterbody_select to create the conflate_waterbodies layer
arcpy.CreateFeatureclass_management(conflag_results_gdb, "Conflate_WaterBody", "POLYGON",
NHDWaterBody_select,"DISABLED","DISABLED",NHDWaterBody_select)

# Process: Add Field ---- every row with this attribute set ot "Y" means there was no feature that matched
# the testing criteria.
arcpy.AddField_management(Conflate_WaterBody, "NO_MATCH", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field ---- every row with this attribute set to "Y" needs to be evaluated by analyst
arcpy.AddField_management(Conflate_WaterBody, "NEEDS_Review", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field ---- explanation field filled out when NEEDS_Review is set to "Y", explains when it was flagged
```

```python
arcpy.AddField_management(Conflate_WaterBody, "NEEDS_Review_Details", "TEXT", "", "", "400", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field --- field holds the object feature ID of the NHD FLowline whose attributes are copied into the geometry
arcpy.AddField_management(Conflate_WaterBody, "ORIG_FID", "LONG", "", "", "", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Make Feature Layer ---- create layer from the select layer in the conflate geodatabase
arcpy.MakeFeatureLayer_management(NHDWaterBody_select, NHDWaterBody_select_Layer, "", "", "")

# Process: Polygon To Line ---- make the polygon a line so line intersect rules used during select by location
arcpy.PolygonToLine_management(study_area, study_area_PolygonToLine, "IDENTIFY_NEIGHBORS")

# Process: Select Layer By Location ---- Select the polygons that cross the study area boundary
arcpy.SelectLayerByLocation_management(NHDWaterBody_select_Layer, "INTERSECT", study_area_PolygonToLine, "", "NEW_SELECTION")

# Process: Calculate Field ---- record a Y in all the Is boundary field for the selected features
arcpy.CalculateField_management(NHDWaterBody_select_Layer, "Is_boundary", "'Y'", "PYTHON", "")


#-----------Start NHD flowline processing (creates results layer)
# Process: Make Feature Layer ---- create layer of the NHDFlowline to allow for selection
arcpy.MakeFeatureLayer_management(NHDFlowline, NHDFlowline_Layer, "", "", "")

# Process: Select Layer By Location ---- Selects Flowline features that are in the study area (includes those that
#       cross border)
arcpy.SelectLayerByLocation_management(NHDFlowline_Layer, "INTERSECT", study_area, "", "NEW_SELECTION")

# Process: Copy Features ---- copies selected features to the conflate file geodatabase
arcpy.CopyFeatures_management(NHDFlowline_Layer, NHDFlowline_Select, "", "0", "0", "0")

# Process: Add Field ---- add processing field(flaged if line intersects the study area boundary)
arcpy.AddField_management(NHDFlowline_Select, "Is_boundary", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field ---- add processing field (flaged once the line has been conflated)
arcpy.AddField_management(NHDFlowline_Select, "IS_Processed", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Create Feature Class ---- creates empty copy of NHDFlowlines_select to create the conflate_flowline layer
```

```python
arcpy.CreateFeatureclass_management(conflag_results_gdb, "Conflate_Flowline", "POLYLINE", NHDFlowline_Select, "DISABLED", "DISABLED", NHDFlowline_Select)

# Process: Add Field ---- every row with this attribute set ot "Y" means there was no feature that matched
#the testing criteria.
arcpy.AddField_management(Conflate_Flowline, "NO_MATCH", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field ---- every row with this attribute set to "Y" needs to be evaluated by analyst
arcpy.AddField_management(Conflate_Flowline, "NEEDS_Review", "TEXT", "", "", "1", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field ---- explanation field filled out when NEEDS_Review is set to "Y", explains when it was flagged
arcpy.AddField_management(Conflate_Flowline, "NEEDS_Review_Details", "TEXT", "", "", "400", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Add Field --- field holds the object feature ID of the NHD FLowline whose attributes are copied into the geometry
arcpy.AddField_management(Conflate_Flowline, "ORIG_FID", "LONG", "", "", "", "", "NULLABLE", "NON_REQUIRED", "")

# Process: Make Feature Layer ---_ creates layer so the tool can search for border lines
arcpy.MakeFeatureLayer_management(NHDFlowline_Select, NHDFlowline_Select_Layer, "", "", "")

# Process: Select Layer By Location ---- using the lines created during the waterbodies analysis select rows that intersect
#       the boundary of the study area.
arcpy.SelectLayerByLocation_management(NHDFlowline_Select_Layer, "INTERSECT", study_area_PolygonToLine, "", "NEW_SELECTION")

# Process: Calculate Field ---- record a Y in all the Is boundary field for the selected features
arcpy.CalculateField_management(NHDFlowline_Select_Layer, "Is_boundary", "'Y'", "PYTHON", "")

# Cleanup layers
del RawFlowlines_layer
del RawBasins_layer
del HYDRO_NET_Junctions_layer
del NHDWaterbody_Layer
del NHDWaterBody_select_Layer
del NHDArea_Layer
del NHDFlowline_Layer
del NHDFlowline_Select_Layer

# Show results in the running module
```

```python
print('Data Processing Complete - Proceed to Polygon Conflation')
arcpy.AddMessage("-------------------")
arcpy.AddMessage("Data Processing Complete - Proceed to Step2 - Conflate Waterbody Polygons")
arcpy.AddMessage("-------------------")


# -------------------------------------------------------------------------
# 2nd_Conflate_Poly.py
# Created on: 12-13-2012
# Last Updated 01-07-2014
# Created by Saint Mary's University of Minnnesota
# Usage: 2nd_Conflate_Poly <conflag_results_gdb> <SearchRadius>
# Description: Conflates NHD Water Bodies using IFSAR results - flags problem features for Analyst review.
# All flags should be evaluated and fixed prior to running the NHDFlowline Conflate Script
# Requires all layers in the file geodatabase have the same projection
# Suggest Updating polygons in NHDArea before going to the next step (assuming use in a heads up digization process)
# -------------------------------------------------------------------------

# Import arcpy module
import arcpy

#Location of the file geodatabase that will hold the results and already holds the conflate dependencies
conflag_results_gdb = arcpy.GetParameterAsText(0)
if conflag_results_gdb == '#' or not conflag_results_gdb:
    conflag_results_gdb = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\tool_results.gdb" # provide a default value if unspecified
#Radius that the tool will search by if there are no results returned in a regular intersection search.
Search_Radius = arcpy.GetParameterAsText(1)
if Search_Radius == '#' or not Search_Radius:
    Search_Radius = "25" # provide a default value if unspecified

# Local variables:
IS_Border_Poly = 'N'
NHDWaterBody_select = conflag_results_gdb + '\\NHDWaterBody_Select'
NHDWaterbody_Layer = NHDWaterBody_select + '_layer'
RawBasins = conflag_results_gdb + '\\RawBasins'
RawBasins_Layer = RawBasins + '_layer'
WATERODY_Name = "Conflate_WaterBody"
Conflate_WaterBody = conflag_results_gdb + '\\' + WATERODY_Name
```

```
error_statment = "none"
study_area = conflag_results_gdb + '\\' + "study_area"
NHD_Polys_Assign = 0
NHD_Polys_No_Match = 0
NHD_Analyst_Flag = 0
count_row = 0
lowest_Diff = 10000000000000
index_lw = 0
count_index = 0
has_two_same_diff = 'N'
outPut = conflag_results_gdb + '\\' + "tempOutput"


#Process: Loop though each polygon in the NHDWaterBody_Select
#Search cursor for all the waterbodies
rows = arcpy.SearchCursor(NHDWaterBody_select)
try:
    for row in rows:
        try:
            count_row += 1
            error_statment = "none"
            feat = row
            nhdSearch = '"' + "OBJECTID" + '"' + ' =' + str(feat.OBJECTID)#'"' + str(feat.OBJECTID) + '"'
            # Create layer that contains all the raw basins
            arcpy.MakeFeatureLayer_management(RawBasins, RawBasins_Layer)
            # Create layer that contains the current feature
            arcpy.MakeFeatureLayer_management(NHDWaterBody_select, NHDWaterbody_Layer)
            # Select the current feature from the waterbody layer
            first_qry = "\"IS_ASSIGNED\"='Y'"
            search_query = nhdSearch + " AND NOT " + first_qry
            arcpy.MakeFeatureLayer_management(NHDWaterbody_Layer,"SelectionWaterBodies", nhdSearch) # + "' AND NOT IS_Processed='Y'")
            result = int(arcpy.GetCount_management(RawBasins_Layer).getOutput(0))
            # Select the RawBasins that intersect the current NHD WaterBody
            arcpy.SelectLayerByLocation_management(RawBasins_Layer,"INTERSECT","SelectionWaterBodies")
            # remove any basins from selection that have already been assigned to another result feature
            #print(first_qry)
            arcpy.SelectLayerByAttribute_management(RawBasins_Layer, "REMOVE_FROM_SELECTION", first_qry)
            # Get Record count
```

```
result = int(arcpy.GetCount_management(RawBasins_Layer).getOutput(0))
# Make sure atleast one polygon found - if not search for one within radius
if result == 0:
    #print(str(count_row) + ": " + "No basins intersect - redo selection this time use search radius!")
    # Select features within given search radius
    # Process: Select Layer By Location
    search_distance = str(Search_Radius) + " Meters"
    arcpy.SelectLayerByLocation_management(RawBasins_Layer, "WITHIN_A_DISTANCE", "SelectionWaterBodies", search_distance, "NEW_SELECTION")
    # remove any basins from selection that have already been assigned to another result feature
    first_qry = "\"IS_ASSIGNED\"='Y'"
    arcpy.SelectLayerByAttribute_management(RawBasins_Layer, "REMOVE_FROM_SELECTION", "\"IS_ASSIGNED\"='Y'")
    # Reset the value of the result variable
    result = int(arcpy.GetCount_management(RawBasins_Layer).getOutput(0))

if result == 0:
    # Copy current feature into the results featureclass - flag as finding no matching records
    #print(str(count_row) + ": " + "No basins found using search radius!")
    # Record Statistics
    NHD_Polys_No_Match += 1
    NHD_Analyst_Flag += 1

    # ---- Add a new in results and set flags in results layer -----
    # Create the insert cursor and a new empty row
    rowInserter = arcpy.InsertCursor(Conflate_WaterBody)
    newIncident = rowInserter.newRow()
    # Populate attributes of new row
    newIncident.Shape = feat.Shape
    newIncident.Permanent_Identifier = feat.Permanent_Identifier
    newIncident.FDate = feat.FDate
    newIncident.Resolution = feat.Resolution#don't include in successful
    newIncident.GNIS_ID = feat.GNIS_ID
    newIncident.GNIS_Name = feat.GNIS_Name
    newIncident.AreaSqKm = feat.AreaSqKm#don't include in successful
    newIncident.Elevation = feat.Elevation#don't include in successful
    newIncident.ReachCode = feat.ReachCode
    newIncident.FType = feat.FType
    newIncident.FCode = feat.FCode
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            newIncident.Is_boundary = feat.Is_boundary
            newIncident.ORIG_FID = feat.OBJECTID
            newIncident.setValue("IS_Processed", 'Y')
            newIncident.setValue("NO_MATCH", 'Y')
            newIncident.setValue("NEEDS_Review", 'Y')
            newIncident.setValue("NEEDS_Review_Details", "No Basins intersects or is within search radius of WaterBody.")
            # Insert the new row into the shapefile
            rowInserter.insertRow(newIncident)
            # Clean up the cursor
            del rowInserter

            # ---- Upadate current row so analyst knows that this polygon processed -----
            # Calculate Field ---- record a Y in the Is process field for this feature
            arcpy.CalculateField_management("SelectionWaterBodies", "IS_Processed", "'Y'", "PYTHON", "")

    else:
        if result > 1:
            #print("new result = " + str(result))
            # Test if feature is a border feature
            if feat.Is_boundary == 'Y':
                #set feat to a new feature that has
                #print("Is boundary feature")
                inFeatures = [study_area,"SelectionWaterBodies"]
                #make sure to cleanup just in case
                if arcpy.Exists(outPut):
                    arcpy.Delete_management(outPut)
                #only use the intersected portion of the basin to do calculations
                arcpy.Intersect_analysis(inFeatures, outPut)
                outPut_rows = arcpy.SearchCursor(outPut)
                outPut_row = outPut_rows.next()
                feat = outPut_row
            # Get area of the current feature
            shape_area = feat.Shape_Area
            # Get all the area valus for the basins
            basins = arcpy.SearchCursor(RawBasins_Layer)
            areas = list()#empty list
            ids = list()#empty list
```

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```python
        for basin in basins:
            areas.append(basin.getValue("Shape_Area"))
            ids.append(basin.getValue("OBJECTID"))
        #Find the basin with the closests matching area
        #print(count_index)
        lowest_Diff = 10000000000000
        index_lw = 0
        count_index = 0
        #has_two_same_diff = 'N'
        for area in areas:
            #get the area differences between each of the basins against the waterbody
            new_diff = -1
            if area > shape_area:
                new_diff = area - shape_area
            else:
                new_diff = shape_area - area
            #test if this is the lowest
            if new_diff < lowest_Diff:
                #make sure there isn't matching areas - if there are flag!
                #if new_diff == lowest_Diff:
                #   has_two_same_diff = 'Y'
                    #print(has_two_same_diff)
                #save the lowest index and valu
                lowest_Diff = new_diff
                index_lw = count_index
            #advance the index counter
            count_index += 1
    else: #process the results
        if index_lw >= 0:
            #select the closest basin using the object id List
            qry_str = "\"OBJECTID\"=" + str(ids[index_lw])#'[OBJECTID] = ' + ids[index_lw]
            #print(qry_str)
            arcpy.SelectLayerByAttribute_management(RawBasins_Layer, "NEW_SELECTION", qry_str)
            # Reset the value of the result variable
            result = int(arcpy.GetCount_management(RawBasins_Layer).getOutput(0))
            #print("lowest query result = " + str(result))
if result == 1:
```

```
# Record success for Statistics
NHD_Polys_Assign += 1
# Create new row in results using select basin for the geometry
#print(str(count_row) + ": " + "One feature selected proceed to copy nhd water body feature to results using basin geometry.")
# ---- Add a new row in results and set flags other layers -----
# --- Process the basin feature (Get the selected feature, flag as being assigned)
selected_features = arcpy.UpdateCursor(RawBasins_Layer)
sel_feat = selected_features.next()
sel_feat.setValue("IS_ASSIGNED",'Y')
selected_features.updateRow(sel_feat)

# ---- Add a new in results and set flags in results layer -----
# Create the insert cursor and a new empty row
rowInserter = arcpy.InsertCursor(Conflate_WaterBody)
newIncident = rowInserter.newRow()
# Populate attributes of new rownewIncident.ORIG_FID = feat.OBJECTID
newIncident.Shape = sel_feat.Shape
newIncident.Permanent_Identifier = feat.Permanent_Identifier
newIncident.FDate = feat.FDate
newIncident.GNIS_ID = feat.GNIS_ID
newIncident.GNIS_Name = feat.GNIS_Name
newIncident.ReachCode = feat.ReachCode
newIncident.FType = feat.FType
newIncident.FCode = feat.FCode
newIncident.Is_boundary = feat.Is_boundary
newIncident.setValue("IS_Processed", 'Y')
newIncident.ORIG_FID = feat.OBJECTID
newIncident.setValue("NO_MATCH", 'N')
newIncident.setValue("NEEDS_Review", 'N')

# Insert the new row into the shapefile
rowInserter.insertRow(newIncident)

# Clean up cursors created
del rowInserter
del selected_features
```

```python
        # ---- Upadate current row so analyst knows that this polygon processed -----
        # Calculate Field ---- record a Y in the Is process field for this feature
        arcpy.CalculateField_management("SelectionWaterBodies", "IS_Processed", "'Y'", "PYTHON", "")


    else:
        # Copy current feature and flag saying couldn't isolate enough features
        #print(str(count_row) + ": " + "Could not isolate one feature.")
        #Record Statistics
        NHD_Analyst_Flag += 1

        if error_statment == "none":
            error_statment = "Unable to isolate possilbe basins to a single polygon."
        # ---- Add a new in results and set flags in results layer -----
        # Create the insert cursor and a new empty row
        rowInserter = arcpy.InsertCursor(Conflate_WaterBody)
        newIncident = rowInserter.newRow()
        # Populate attributes of new row
        newIncident.Shape = feat.Shape
        newIncident.Permanent_Identifier = feat.Permanent_Identifier
        newIncident.FDate = feat.FDate
        newIncident.Resolution = feat.Resolution
        newIncident.GNIS_ID = feat.GNIS_ID
        newIncident.GNIS_Name = feat.GNIS_Name
        newIncident.AreaSqKm = feat.AreaSqKm
        newIncident.Elevation = feat.Elevation
        newIncident.ReachCode = feat.ReachCode
        newIncident.FType = feat.FType
        newIncident.FCode = feat.FCode
        newIncident.Is_boundary = feat.Is_boundary
        newIncident.setValue("IS_Processed", 'Y')
        newIncident.ORIG_FID = feat.OBJECTID
        newIncident.setValue("NO_MATCH", 'N')
        newIncident.setValue("NEEDS_Review", 'Y')
        newIncident.setValue("NEEDS_Review_Details", error_statment)
        # Insert the new row into the shapefile
        rowInserter.insertRow(newIncident)
        # Clean up cursors created
```

```
        del rowInserter

        # ---- Upadate current row so analyst knows that this polygon processed -----
        # Calculate Field ---- record a Y in the Is process field for this feature
        if error_statment != "Unable to choose between polygons, because more than one basin with the same area choosen with an unprocessed NHD
WaterBod within search radius.":
            #leave as unprocessed if flagged as having near NHDs so both return same error
            if arcpy.Exists("SelectionWaterBodies"):
                arcpy.CalculateField_management("SelectionWaterBodies", "IS_Processed", "'Y'", "PYTHON", "")
    finally:
        # Clean up feature layers
        if arcpy.Exists(RawBasins_Layer):
            arcpy.Delete_management(RawBasins_Layer)
        if arcpy.Exists("SelectionWaterBodies"):
            arcpy.Delete_management("SelectionWaterBodies")
        if arcpy.Exists(NHDWaterbody_Layer):
            arcpy.Delete_management(NHDWaterbody_Layer)
  #No matter what happens this code runs - allows for multiple code runs
  else:
    # Report Statistics
    #print("--------------------")
    #print("Polygon Conflation Processing Completed!")
    #print("--------------------")
    #print("")
    #print("WaterBodies Processed: " + str(count_row))
    #print("Polygons Conflated: " + str(NHD_Polys_Assign))
    #print("Polygons with No Matching Basins: " + str(NHD_Polys_No_Match))
    #print("Polygons Flaged for Analyst: " + str(NHD_Analyst_Flag))
    #Show the messages if script run from a toolbox
    arcpy.AddMessage("--------------------")
    arcpy.AddMessage("Polygon Conflation Processing Completed.")
    arcpy.AddMessage("To get accurate results evaluate all features flaged before starting the next step.")
    arcpy.AddMessage("--------------------")
    arcpy.AddMessage("")
    arcpy.AddMessage("WaterBodies Processed: " + str(count_row))
    arcpy.AddMessage("Polygons Conflated: " + str(NHD_Polys_Assign))
    arcpy.AddMessage("Polygons with No Matching Waterbodies: " + str(NHD_Polys_No_Match))
```

```
        arcpy.AddMessage("Polygons Flaged for Analyst: " + str(NHD_Analyst_Flag))
finally:
    # Clean up the search cursor
    del rows
    # Clean up temporaries if needed
    if arcpy.Exists(outPut):
        arcpy.Delete_management(outPut)
# --------------------------------------------------------------------------
# 3A_Conflate_Poly.py
# Created on: 11-07-2013
# Last Updated on: 11-09-2013
# Created by Saint Mary's University of Minnnesota
# Usage: 3rd_Conflate_Line_Artificial_Paths <conflag_results_gdb> <SearchRadius>
# Description: Creates artificial paths from Raw Flowlines - flags problem features for Analyst review.
# Requires all layers in the file geodatabase to have the same projection
# --------------------------------------------------------------------------


# Import arcpy module
import arcpy

#Location of the file geodatabase that will hold the results and already holds the conflate dependencies
conflag_results_gdb = arcpy.GetParameterAsText(0)
if conflag_results_gdb == '#' or not conflag_results_gdb:
    conflag_results_gdb = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\tool_results.gdb" # provide a default value if unspecified
#Assumes entry in meters
Search_Radius = arcpy.GetParameterAsText(1)
if Search_Radius == '#' or not Search_Radius:
    Search_Radius = "25" # provide a default value if unspecified

# Local Variables
# Flowline layers and features
NHDFlowline_select = conflag_results_gdb + '\\NHDFlowline_Select'
RawFlowline = conflag_results_gdb + '\\RawFlowlines'
RawFlowline_Layer = RawFlowline + '_layer'
Conflate_Flowline = conflag_results_gdb + '\\' "Conflate_Flowline"
study_area = conflag_results_gdb + '\\' + "study_area"
Conflate_Flowline_layer = Conflate_Flowline + '_layer'
```

```python
NHDFlowline_select_layer = NHDFlowline_select + '_layer'
# Waterbodies and NHD Area layers and features - used for artificial line creation
Conflate_WaterBody = conflag_results_gdb + '\\' + "Conflate_WaterBody"
Conflate_WaterBody_layer = Conflate_WaterBody + '_layer'
Area_select = conflag_results_gdb + '\\NHDArea_Select'
Area_layer = Area_select + "_layer"
RawFlowline_wb_artificial = RawFlowline + "_wb_artificial"
if arcpy.Exists(RawFlowline_wb_artificial):
    arcpy.Delete_management(RawFlowline_wb_artificial)
RawFlowline_area_artificial = RawFlowline + "_area_artificial"
if arcpy.Exists(RawFlowline_area_artificial):
    arcpy.Delete_management(RawFlowline_area_artificial)
Raw_artificial = RawFlowline + "_merged_artificial"
if arcpy.Exists(Raw_artificial):
    arcpy.Delete_management(Raw_artificial)
No_Artificial = RawFlowline + "_NoArtificial"
if arcpy.Exists(No_Artificial):
    arcpy.Delete_management(No_Artificial)
No_Artificial_layer = RawFlowline + "_NoArtificial_layer"
if arcpy.Exists(No_Artificial_layer):
    arcpy.Delete_management(No_Artificial_layer)

# Statistic Variables
NHD_Lines_No_Match = 0
NHD_Lines_Flag = 0
count_row = 0

# Processing variables
#Layer Used to access NHD features
NHDFlowline_Layer = conflag_results_gdb + '\\NHDFlowline_Layer'
if arcpy.Exists(NHDFlowline_Layer):
    arcpy.Delete_management(NHDFlowline_Layer)
#Used to hold current processing feature/row
Line_layer = conflag_results_gdb + '\\Line_Layer'
if arcpy.Exists(Line_layer):
    arcpy.Delete_management(Line_layer)
#Translates the given search radius to something the tools can understand
```

```
distance_text = Search_Radius + " Meters"
#Holds lines that have NHD vertices
RawLines_matched = conflag_results_gdb + '\\RawLines_matched'
if arcpy.Exists(RawLines_matched):
   arcpy.Delete_management(RawLines_matched)
#Holds the split version of the Flownet Lines
RawLines_split = conflag_results_gdb + '\\RawLines_split'
if arcpy.Exists(RawLines_split):
   arcpy.Delete_management(RawLines_split)
RawLines_split_Layer = conflag_results_gdb + '\\RawLines_split_layer'
if arcpy.Exists(RawLines_split_Layer):
   arcpy.Delete_management(RawLines_split_Layer)
#Artificial Path Processing variables
current_raw = conflag_results_gdb + '\\current_raw_layer'
NHD_search = conflag_results_gdb + '\\NHD_search_layer' #holds results of spatial search

#Remove artificial lines from RawFlowlines using Conflated Water Basins
arcpy.Clip_analysis(RawFlowline, Conflate_WaterBody, RawFlowline_wb_artificial)
#Remove artificial lines from RawFlowines using NHD Area
arcpy.Clip_analysis(RawFlowline, Area_select, RawFlowline_area_artificial)
#Merge to single artificial layer
arcpy.Merge_management([RawFlowline_wb_artificial, RawFlowline_area_artificial], Raw_artificial)

#process each artificial line - try to find NHD attributes for each otherwise use default
rows = arcpy.UpdateCursor(Raw_artificial)
for row in rows:
   #count the rows
   count_row += 1
   #create needed variables and objects
   feat = row
   #get current feature in layer for spatial search
   ID_query =   '"' + "OBJECTID" + '"' = ' + str(feat.OBJECTID)
   arcpy.MakeFeatureLayer_management(Conflate_Flowline, current_raw, ID_query)
   #create searchable layer for NHD flowlines
   artificial_query = '"' + "FType" + '"' = 558' #limits layer to artificial paths
   arcpy.MakeFeatureLayer_management(NHDFlowline_select, NHD_search, artificial_query)
   #find artificial paths near the
```

```python
arcpy.SelectLayerByLocation_management(NHD_search,"INTERSECT",current_raw,distance_text,"NEW_SELECTION")
#check to see if anything was found by getting the record count
result = int(arcpy.GetCount_management(NHD_search).getOutput(0))
if result == 0: #add default codes and flag stating no attributes found
    #Advance Flag Counter
    NHD_Lines_Flag += 1
    #print(ID_query + ": result = 0")
    #---- Add a new in results and set flags in results layer -----
    #Create the insert cursor and a new embpty row
    rowInserter = arcpy.InsertCursor(Conflate_Flowline)
    newIncident = rowInserter.newRow()
    #Populate attributes of new row
    newIncident.Shape = feat.Shape
    newIncident.ReachCode = "999"
    newIncident.WBArea_Permanent_Identifier = "999"
    newIncident.FType = 558
    newIncident.FCode = 558
    newIncident.Is_boundary = 'N'
    newIncident.IS_Processed = 'Y'
    newIncident.setValue("NO_MATCH", 'Y')
    newIncident.setValue("NEEDS_Review", 'Y')
    newIncident.setValue("NEEDS_Review_Details", "No Artificial Paths near Raw Flowline Artificial Path.")
    # Insert the new row into the layer
    rowInserter.insertRow(newIncident)
    # Clean up cursors created
    del rowInserter
else:
    #print(ID_query + ": result > 0")
    if result > 0:
        #---- Add a new in results and set flags in results layer -----
        #get feature from the selection in the layer
        NHD_feats = arcpy.SearchCursor(NHD_search)
        NHD_feat = NHD_feats.next()
        #Create the insert cursor and a new empty row
        rowInserter = arcpy.InsertCursor(Conflate_Flowline)
        newIncident = rowInserter.newRow()
        #Populate attributes of new row
```

```
            newIncident.Shape = feat.Shape
            newIncident.Permanent_Identifier = NHD_feat.Permanent_Identifier
            newIncident.FDate = NHD_feat.FDate
            newIncident.GNIS_ID = NHD_feat.GNIS_ID
            newIncident.GNIS_Name = NHD_feat.GNIS_Name
            newIncident.ReachCode = NHD_feat.ReachCode
            newIncident.FlowDir = NHD_feat.FlowDir
            newIncident.WBArea_Permanent_Identifier = NHD_feat.WBArea_Permanent_Identifier
            newIncident.FType = NHD_feat.FType
            newIncident.FCode = NHD_feat.FCode
            newIncident.Enabled = NHD_feat.Enabled
            newIncident.Is_boundary = NHD_feat.Is_boundary
            newIncident.IS_Processed = 'Y'
            newIncident.setValue("NO_MATCH", 'N')
            newIncident.setValue("NEEDS_Review", 'N')
            # Insert the new row into the layer
            rowInserter.insertRow(newIncident)
            # Clean up cursors created
            del rowInserter, NHD_feat, NHD_feats
        #Clean up layers in order to allow for processing of next feature.
        if arcpy.Exists(current_raw):
            arcpy.Delete_management(current_raw)
        if arcpy.Exists(NHD_search):
            arcpy.Delete_management(NHD_search)
del rows

## -------------- Clean up Layers and temporary processing layers.....

### Report Statistics
##print("--------------------")
##print("Line Conflation Processing Completed.")
##print("--------------------")
##print("")
##print("Lines Processed: " + str(count_row))
##print("Flowlines Flaged for Analyst: " + str(NHD_Lines_Flag))
##print("")
##print("********************")
```

```python
###Show the messages if script run from a toolbox
arcpy.AddMessage("--------------------")
arcpy.AddMessage("NHD Flowline Artificial Lines Processing Completeted.")
arcpy.AddMessage("--------------------")
arcpy.AddMessage("")
arcpy.AddMessage("Polylines Processed: " + str(count_row))
arcpy.AddMessage("Polylines Flaged for Analyst: " + str(NHD_Lines_Flag))


# --------------------------------------------------------------------------
# 3C_Conflate_Poly.py
# Created on: 11-05-2013
# Last Updated on: 02-06-2013
# Created by Saint Mary's University of Minnnesota
# Usage: 3rd_Conflate_Poly <conflag_results_gdb> <SearchRadius> <RawFlowlines_no_attributes> <NHD_orginial_line_vectors>
# Description: Conflates NHD Flowlines using IFSAR results - flags problem features for Analyst review.
# Requires all layers in the file geodatabase have the same projection
# --------------------------------------------------------------------------


# Import arcpy module
import arcpy

#Location of the file geodatabase that will hold the results and already holds the conflate dependencies
conflag_results_gdb = arcpy.GetParameterAsText(0)
if conflag_results_gdb == '#' or not conflag_results_gdb:
    conflag_results_gdb = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\Final_Changes\\results.gdb" # provide a default value if unspecified
#Assumes entry in meters
Search_Radius = arcpy.GetParameterAsText(1)
if Search_Radius == '#' or not Search_Radius:
    Search_Radius = "35" # provide a default value if unspecified
#Erase Layer from step 3B
RawFlowlines = arcpy.GetParameterAsText(2)
if RawFlowlines == '#' or not RawFlowlines:
    RawFlowlines = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\Final_Changes\\results.gdb\\RawFlowlines_No_Artificial" # provide a default value if
unspecified

#NHDFlowline_points = conflag_results_gdb + '\\NHDFlowline_Select_points'
#Points Creation from step 3B
```

```python
NHDFlowline_points = arcpy.GetParameterAsText(3)
if NHDFlowline_points == '#' or not NHDFlowline_points:
    NHDFlowline_points = "P:\\NPS\\Conflate_Tool_Working\\Working\\Barb\\Final_Changes\\results.gdb\\NHDFlowline_Select_points" # provide a default
value if unspecified

# Local Variables
NHDFlowline_select = conflag_results_gdb + '\\NHDFlowline_Select'
RawFlowlines_Layer = RawFlowlines + '_layer'
Conflate_Flowline = conflag_results_gdb + '\\Conflate_Flowline'
study_area = conflag_results_gdb + '\\' + "study_area"

# Statistic Variables
NHD_Lines_No_Match = 0
NHD_Lines_Flag = 0
count_row = 0

# Processing variables
#Layer Used to access NHD features
NHDFlowline_Layer = conflag_results_gdb + '\\NHDFlowline_Layer'
if arcpy.Exists(NHDFlowline_Layer):
    arcpy.Delete_management(NHDFlowline_Layer)
#Used to hold current processing feature/row
Line_layer = conflag_results_gdb + '\\Line_Layer'
if arcpy.Exists(Line_layer):
    arcpy.Delete_management(Line_layer)
#Select Layer for NHD Line Vertices that were snapped to RawFlowlines all NHD Line vertices
NHDFlowline_points_Layer = NHDFlowline_points + '_layer'
if arcpy.Exists(NHDFlowline_points_Layer):
    arcpy.Delete_management(NHDFlowline_points_Layer)
#Holds points that were snapped to the RawFlowlines
points_snapped = conflag_results_gdb + '\\NHD_points_snapped'
if arcpy.Exists(points_snapped):
    arcpy.Delete_management(points_snapped)
#Layer points that were snapped to the RawFlowlines
points_snapped_layer = conflag_results_gdb + '\\NHD_points_snapped_layer'
if arcpy.Exists(points_snapped_layer):
    arcpy.Delete_management(points_snapped_layer)
```

```python
#Holds point that are snapped to the NHD lines
points_not_snapped = conflag_results_gdb + '\\NHD_points_not_snapped'
if arcpy.Exists(points_not_snapped):
    arcpy.Delete_management(points_not_snapped)
points_not_snapped_layer = conflag_results_gdb + '\\NHD_points_not_snapped_layer'
if arcpy.Exists(points_not_snapped_layer):
    arcpy.Delete_management(points_not_snapped_layer)
#Translates the given search radius to something the tools can understand
distance_text = Search_Radius + " Meters"
#Holds lines that have NHD vertices
RawFlowlines_matched = conflag_results_gdb + '\\RawFlowlines_matched'
if arcpy.Exists(RawFlowlines_matched):
    arcpy.Delete_management(RawFlowlines_matched)
#Holds the split version of the RawFlowlines Lines
RawFlowlines_split = conflag_results_gdb + '\\RawFlowlines_split'
if arcpy.Exists(RawFlowlines_split):
    arcpy.Delete_management(RawFlowlines_split)
RawFlowlines_split_Layer = conflag_results_gdb + '\\RawFlowlines_split_layer'
if arcpy.Exists(RawFlowlines_split_Layer):
    arcpy.Delete_management(RawFlowlines_split_Layer)
Conflate_Flowline_layer = Conflate_Flowline + '_layer'
if arcpy.Exists(Conflate_Flowline_layer):
    arcpy.Delete_management(Conflate_Flowline_layer)
#NHD Junctions Processing Variables
NHD_Junctions = conflag_results_gdb + '\\HYDRO_NET_Junctions_Select'
NHD_Junctions_layer = conflag_results_gdb + '\\HYDRO_NET_Junctions_Select_layer'
NHD_Junctions_snapped = conflag_results_gdb + '\\HYDRO_NET_Junctions_snapped'
if arcpy.Exists(NHD_Junctions_snapped):
    arcpy.Delete_management(NHD_Junctions_snapped)
RawFlowlines_Junctions_split = conflag_results_gdb + '\\RawFlowlines_junction_split'
if arcpy.Exists(RawFlowlines_Junctions_split):
    arcpy.Delete_management(RawFlowlines_Junctions_split)

# Snap points in NHD that are within the search radius to the Raw Flowline data
#print ("flowlines location:" + str(RawFlowlines))
arcpy.Snap_edit(NHDFlowline_points, [[RawFlowlines, "EDGE", distance_text], [RawFlowlines, "Vertex", distance_text],[RawFlowlines, "END", distance_text]])
#print("Snapped points")
```

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```
# Create Search layer to seperate points that match search radius and those that do not
arcpy.MakeFeatureLayer_management(NHDFlowline_points, NHDFlowline_points_Layer)
# Select points that were snapped and save as NHD_points_snapped
arcpy.SelectLayerByLocation_management(NHDFlowline_points_Layer,"INTERSECT", RawFlowlines)
arcpy.CopyFeatures_management(NHDFlowline_points_Layer, points_snapped)
#print("Got Snapped points layer")
# Reverse selection and save the results as NHD_points_not_snapped
arcpy.SelectLayerByLocation_management(NHDFlowline_points_Layer,"INTERSECT", RawFlowlines,0,"SWITCH_SELECTION")
arcpy.CopyFeatures_management(NHDFlowline_points_Layer, points_not_snapped)
#print("Got Not Snapped Layer")

# Get RawFlowlines with atleast one snapped NHD point
arcpy.MakeFeatureLayer_management(RawFlowlines,RawFlowlines_Layer)
arcpy.SelectLayerByLocation_management(RawFlowlines_Layer,"INTERSECT", points_snapped)
arcpy.CopyFeatures_management(RawFlowlines_Layer, RawFlowlines_matched)
#print("Get RawFlowlines with snapped points")

#Snap juntion points to the raw flowline
arcpy.Snap_edit(NHD_Junctions, [[RawFlowlines_matched, "EDGE", distance_text], [RawFlowlines_matched, "Vertex", distance_text],[RawFlowlines_matched, "END", distance_text]])
#Save points that snapped to line in seperate layer
arcpy.MakeFeatureLayer_management(NHD_Junctions, NHD_Junctions_layer)
arcpy.SelectLayerByLocation_management(NHD_Junctions_layer,"INTERSECT", RawFlowlines_matched)
arcpy.CopyFeatures_management(NHD_Junctions_layer, NHD_Junctions_snapped)
#Split the RawFlowlines at these points
arcpy.SplitLineAtPoint_management(RawFlowlines_matched, NHD_Junctions_snapped, RawFlowlines_Junctions_split)

# Cut the RawFlowlines line using the new points
arcpy.SplitLineAtPoint_management(RawFlowlines_Junctions_split, points_snapped, RawFlowlines_split)
#print("Cut Matched RawFlowlines Lines with snapped points")

# Create search cursor for each split RawFlowlines
RawFlowlines_rows = arcpy.UpdateCursor(RawFlowlines_split)
print("Create update search for split lines.")
# Searches for features that have already been processed
first_qry = "\"IS_Processed\"='Y'"
```

```python
try:
    for RawFlowlines_row in RawFlowlines_rows:
        #Advance Counters
        count_row += 1
        #print("************")
        #print("RawFlowlines Row Count: " + str(count_row))
        feat = RawFlowlines_row
        # Select the current feature from the flowline layer
        nhdSearch = '"' + "OBJECTID" + '"' + ' = ' + str(feat.OBJECTID)
        #print(nhdSearch)
        if arcpy.Exists(Line_layer):
            arcpy.Delete_management(Line_layer)
        arcpy.MakeFeatureLayer_management(RawFlowlines_split, Line_layer, nhdSearch)
        # Create layer that contains the all the features in the points layer
        if arcpy.Exists(points_snapped_layer):
            arcpy.Delete_management(points_snapped_layer)
        arcpy.MakeFeatureLayer_management(points_snapped, points_snapped_layer)
        arcpy.SelectLayerByLocation_management(points_snapped_layer,"INTERSECT", Line_layer,distance_text,"NEW_SELECTION")
        result = int(arcpy.GetCount_management(points_snapped_layer).getOutput(0))
        psl_rows = arcpy.UpdateCursor(points_snapped_layer)
        point_row = psl_rows.next()
        #make sure only one point selected
        print("Result: " + str(result))
        is_error = 0
        error_text = ""
        if result > 1:
            # Remove any points that have already been processed
            arcpy.SelectLayerByAttribute_management(points_snapped_layer, "REMOVE_FROM_SELECTION", first_qry)
            result = int(arcpy.GetCount_management(points_snapped_layer).getOutput(0))
            # Test if result == 0 if it does flag this entry
            if result == 0:
                is_error = 1
                error_text = "Could not identify a point that had not been already processed. Please verify that the proper attributes have been applied."
            # Grab the first point in the list returned
            if result != 0:
                IDs =[]
```

```python
ID_counts = []
selected_points = []
number_of_IDs = 1
object_ID = point_row.ORIG_FID
IDs.append(object_ID)
ID_counts.append(1)
selected_points.append(point_row)
#Search the results to determine if there is more than one object ID
#If there is maintain a count of all the object ID values and a copy of one of the points of each value
#This information will be used to find the NHD attributes that most likely represent the raw flowline
for psl_row in psl_rows:
    if object_ID != psl_row.ORIG_FID:
        is_error = 1
        error_text = "More than one NHD feature's attribute was matched to this feature. Verify correct attributes recorded."
        is_new = "Y"
        for i in range(number_of_IDs - 1):
            if psl_row.ORIG_FID == IDs[i]:
                ID_counts[i] += 1
                is_new = "N"
        if is_new == "Y":
            IDs.append(psl_row.ORIG_FID)
            ID_counts.append(1)
            selected_points.append(psl_row)
            number_of_IDs += 1
    else:
        ID_counts[0] += 1
if number_of_IDs > 1:
    #get the object ID with the biggest points and than and then select a point with that ID from the existing search results layer
    highest_ID_index = 0
    highest_ID_value = 0
    for x in range (number_of_IDs - 1):
        if ID_counts >  highest_ID_value:
            highest_ID_index = x
            highest_ID_value = ID_counts[x]
    print ("Multiple Results:")
    print ("Number of IDs: " + str(number_of_IDs))
    print (str(ID_counts[highest_ID_index]))
```

```python
            print (str(highest_ID_index))
            print (str(highest_ID_value))
            #set point_row to that feature
            point_row = selected_points[highest_ID_index]
    # Update the values for the choosen point
    result = int(arcpy.GetCount_management(points_snapped_layer).getOutput(0))
    if result == 0:
        #Do not process this feature - starts at the begining of the for loop
        continue
    else:
        point_row.setValue("IS_Processed", 'Y')
        psl_rows.updateRow(point_row)

        # Once one point has been selected find the NHD line that the point was created from
        arcpy.MakeFeatureLayer_management(NHDFlowline_select, NHDFlowline_Layer)
        NHD_ID = str(point_row.ORIG_FID)
        #print("NHD_ID: " + NHD_ID)
        second_qry = '"' + "OBJECTID" + '" = ' + NHD_ID
        nhd_rows = arcpy.UpdateCursor(NHDFlowline_Layer, second_qry)
        #Using NHD_Flowline_Select_Layer cursor set the NHD_Flowline Features to processed
        for nhd_row in nhd_rows:
            nhd_row.setValue("IS_Processed", 'Y')
            nhd_rows.updateRow(nhd_row)
            #print("Set NHD IS_Processed in for")
        del nhd_rows, nhd_row
        arcpy.Delete_management(NHDFlowline_Layer)
        #print("Set NHD IS_Processed")

        # Create the new row in the Conflate_Flowline using RawFlowlines geometry and point attributes
        rowInserter = arcpy.InsertCursor(Conflate_Flowline)
        newIncident = rowInserter.newRow()
        # Populate attributes of new row
        newIncident.Shape = feat.Shape
        newIncident.Permanent_Identifier = point_row.Permanent_Identifier
        newIncident.FDate = point_row.FDate
        newIncident.GNIS_ID = point_row.GNIS_ID
        newIncident.GNIS_Name = point_row.GNIS_Name
```

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```python
            newIncident.ReachCode = point_row.ReachCode
            newIncident.FlowDir = point_row.FlowDir
            newIncident.WBArea_Permanent_Identifier = point_row.WBArea_Permanent_Identifier
            newIncident.FType = point_row.FType
            newIncident.FCode = point_row.FCode
            newIncident.Enabled = point_row.Enabled
            newIncident.Is_boundary = point_row.Is_boundary
            newIncident.ORIG_FID = point_row.ORIG_FID
            newIncident.setValue("IS_Processed", 'Y')
            newIncident.setValue("NO_MATCH", 'N')
            if is_error == 1:
                # Advance Flag Counter
                NHD_Lines_Flag += 1
                # Set Flag Details
                newIncident.setValue("NEEDS_Review", 'Y')
                newIncident.setValue("NEEDS_Review_Details", error_text)
            # Insert the new row into the shapefile
            rowInserter.insertRow(newIncident)
            #print("Insert New Row")

            # Update RawFlowlines row's IS_Assigned to 'Y' this allows for tracking of any of these that aren't processed in the end
            RawFlowlines_row.setValue("IS_Assigned", 'Y')
            RawFlowlines_rows.updateRow(RawFlowlines_row)
            #print("Set RawFlowlines IS_Assigned")

            # Clean up the cursors
            del rowInserter, newIncident
        del psl_rows, point_row
        # Clean up layers
        arcpy.Delete_management(points_snapped_layer)
        arcpy.Delete_management(Line_layer)

finally:
    del RawFlowlines_rows, RawFlowlines_row
    #print("End of for loop")

# Get NHD flowlines with unsnapped points
```

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```
arcpy.MakeFeatureLayer_management(NHDFlowline_select, NHDFlowline_Layer)
arcpy.MakeFeatureLayer_management(points_not_snapped, points_not_snapped_layer)
arcpy.SelectLayerByLocation_management(NHDFlowline_Layer,"INTERSECT", points_not_snapped_layer)
#print("Retrieve NHD flowlines that contain unsnapped points")


### Get NHD flowlines that were already assigned geometry from RawFlowlines processing
##NHDFlowline_Layer2 = conflag_results_gdb + '\\NHDFlowline_Layer2'
##arcpy.MakeFeatureLayer_management(NHDFlowline_select, NHDFlowline_Layer2)
##arcpy.SelectLayerByAttribute_management(NHDFlowline_Layer2, "NEW_SELECTION", first_qry)
##result = int(arcpy.GetCount_management(NHDFlowline_Layer2).getOutput(0))
###print("Get NHD Flowlines that have been assigned new geometry.")


### Add flags to the conflated geometry that match the object ID
##if result > 0:
##    arcpy.MakeFeatureLayer_management(Conflate_Flowline, Conflate_Flowline_layer)
##    nhd_rows = arcpy.SearchCursor(NHDFlowline_Layer2)
##    for nhd_row in nhd_rows:
##        nhd_feat = nhd_row
##        nhdSearch = '"' + "ORIG_FID" + '"' + ' = ' + str(nhd_feat.OBJECTID)
##        arcpy.SelectLayerByAttribute_management(Conflate_Flowline_layer, "NEW_SELECTION", nhdSearch)
##        conf_rows = arcpy.UpdateCursor(Conflate_Flowline_layer)
##        for conf_row in conf_rows:
##            NHD_Lines_Flag += 1
##            conf_row.setValue("NEEDS_Review", 'Y')
##            conf_row.setValue("NEEDS_Review_Details", "Not all NHD Vectors snapped to digitized lines. Check geometry for issues.")
##            conf_rows.updateRow(conf_row)
##            #print("Flag Conflate Geometry for review.")
##    del conf_rows,conf_row
##    del nhd_rows, nhd_row
##    arcpy.Delete_management(Conflate_Flowline_layer)
###print("Completed the Flags")
# Get all other NHD flowlines and add to conflate layer
arcpy.SelectLayerByAttribute_management(NHDFlowline_Layer, "REMOVE_FROM_SELECTION", first_qry)
nhd_flag_rows = arcpy.UpdateCursor(NHDFlowline_Layer)
for nhd_flag_row in nhd_flag_rows:
   count_row += 1
   # Advance Flag Counter
```

```python
    NHD_Lines_Flag += 1
    # Get current Row Object
    nhd_feat = nhd_flag_row
    # Create the new row in the Conflate_Flowline using RawFlowlines geometry and point attributes
    rowInserter = arcpy.InsertCursor(Conflate_Flowline)
    newIncident = rowInserter.newRow()
    # Populate attributes of new row
    newIncident.Shape = nhd_feat.Shape
    newIncident.Permanent_Identifier = nhd_feat.Permanent_Identifier
    newIncident.FDate = nhd_feat.FDate
    newIncident.Resolution = nhd_feat.Resolution#don't include in successful
    newIncident.GNIS_ID = nhd_feat.GNIS_ID
    newIncident.GNIS_Name = nhd_feat.GNIS_Name
    newIncident.LengthKM = nhd_feat.LengthKM#don't include in successful
    newIncident.ReachCode = nhd_feat.ReachCode
    newIncident.FlowDir = nhd_feat.FlowDir
    newIncident.WBArea_Permanent_Identifier = nhd_feat.WBArea_Permanent_Identifier
    newIncident.FType = nhd_feat.FType
    newIncident.FCode = nhd_feat.FCode
    newIncident.Enabled = nhd_feat.Enabled
    newIncident.Is_boundary = nhd_feat.Is_boundary
    newIncident.ORIG_FID = nhd_feat.OBJECTID
    newIncident.setValue("IS_Processed", 'Y')
    newIncident.setValue("NO_MATCH", 'Y')
    newIncident.setValue("NEEDS_Review", 'Y')
    newIncident.setValue("NEEDS_Review_Details", "No matching Geometry was found in digitized lines.")
    # Insert the new row into the shapefile
    rowInserter.insertRow(newIncident)
    #print("Insert New Row")
    # Clean up data connection
    del rowInserter, newIncident
# Clean up data connnection
del nhd_flag_rows, nhd_flag_row
#Create artificial paths for conflated waterbodies and NHD areas - make this a seperate script

#Clean up Layers
arcpy.Delete_management(NHDFlowline_Layer)
```

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```python
arcpy.Delete_management(NHDFlowline_Layer2)
arcpy.Delete_management(points_not_snapped_layer)

#print out results
# Report Statistics
#print("--------------------")
#print("Line Conflation Processing Completed.")
#print("--------------------")
#print("")
#print("Lines Processed: " + str(count_row))
#print("Flowlines Flaged for Analyst: " + str(NHD_Lines_Flag))
#print("")
#print("********************")
#Show the messages if script run from a toolbox
arcpy.AddMessage("--------------------")
arcpy.AddMessage("Flowline Conflation Processing Completed.")
arcpy.AddMessage("--------------------")
arcpy.AddMessage("")
arcpy.AddMessage("Polylines Processed: " + str(count_row))
arcpy.AddMessage("Polylines Flaged for Analyst: " + str(NHD_Lines_Flag))
```

Appendix C: Draft Guidelines for Updating Interior NHD – Part 1

NHD Standards for Updating

The NHD dataset is being updated so it can be incorporated into the next generation of the US TOPO National Maps. These maps will be created at the same 7.5-minute (1:25,000) scale as previous 24K quad maps. As these maps will be available to the general public they should be of best quality in line work and correctness while remaining within the standards.

In an effort to maintain some consistency throughout the dataset this protocol discusses the mapping standards developed through conversations with NPS and the experience of GSS.

Scale plays a major role throughout the editing process. A scale of 1:10,000 is used to pan and make decisions based on accuracy, aesthetics, and the need to add or remove features. A scale of 1:3,000 is used when manually editing specific features. However, at times it can be helpful to zoom out to 1:24,000 to get a view of the "big picture" and overall scope.

The main base dataset for decision making is the SPOT 5 imagery that was collected through the Alaska Statewide Digital Mapping Initiative (SDMI) and the UAF Geographic Information Network of Alaska (GINA), which is currently being acquired for the entire state of Alaska. This SPOT 5 imagery dataset consists of three different types of renderings. Color Infrared (CIR) has proven to work the best when editing hydrography features. This is mainly due to the fact that the CIR filters out blue light, which makes blue objects appear black, thus making water features easier to interpret. CIR is also helpful in distinguishing various types of vegetation through health and density. CIR shows vegetation in a series of red tones, healthy vegetation appearing bright red to diseased or sparse vegetation appearing light pink. Panchromatic (PAN) is also useful to view while editing, especially in areas where there is excessive shadowing or a majority of dark features. PAN shows the imagery in a series of gray tones ranging from black to white and is able to "see through" these questionable shadowed areas to better depict what is truly happening on the landscape. True color (RGB) shows the actual true color of the landscape, but has not proven helpful to use for editing purposes.
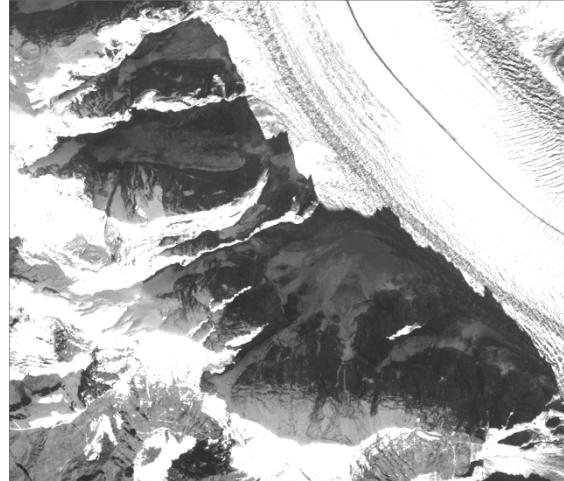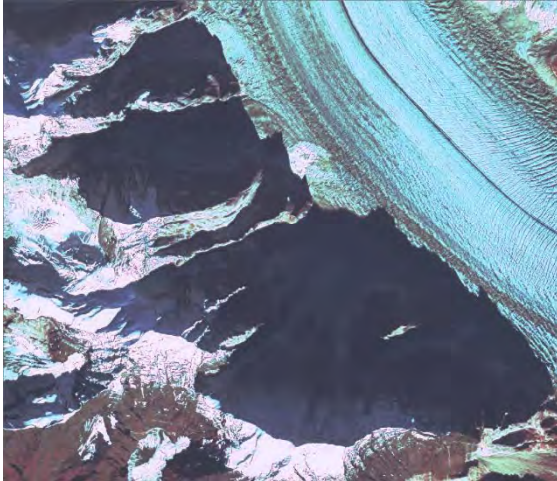
Other datasets that have been beneficial to consult with when making decisions about adding or removing data include DRG's and DEM's. DRG's are helpful when comparing the current landscape to what it consisted of in the past. DEM's are useful to show elevation and contours, which help emphasize drainages and flowline locations.

Minimum Mapping Unit

Polygon = 2 acres   or   8093 square meters   or   0.809 hectares

Positional Accuracy

Positional accuracy is dependent on the accuracy standards of the SPOT 5 imagery.

Updating in ArcGIS 10.1:

1. If there is not a definite change, default to the original NHD data
2. If reshaping is needed and feature is below the Minimum Mapping Unit (MMU), keep it if the feature is clearly discernible on the SPOT imagery

One way to edit is to update the polygons first and then the linear features. While completing this update, also add missing features. Scan the quad area in a grid like pattern possibly starting in the NW corner and moving west to east and then south. This is done for the entire quad of polygons and then repeated again for the linear features. For areas with large and/or complex polygons, it is suggested to update the largest one first and then do the smaller ones within that feature.

Adding features:

1. SPOT 5 is the primary image dataset
2. Consult the DRG and DEM for additional information
3. Stick to the standards (MMU), if feature will be smaller than MMU do not add it.

DRG's can differ from the SPOT for location of linear features. In these cases, the streams on the DRG may show an alternate path from contour lines on DRG and the DEM. For example, you are in a mountain area, you see flow patterns on the edge of the river and going uphill and you can see where the flow is. Turn on the DRG and examine the contour lines. Do they support this?

TIPS

1. Set a standard for the SPOT histograms. Default is standard deviation of 2. You can change the histograms to better locate, for example, linear features going through vegetated areas. BUT you must put it back to a standard deviation of 2 or you might be inclined to change the line work you already updated!!

2. If a definite change cannot be seen on the imagery, default to the original NHD/DRG

3. Default to the feature type used in the quad you are working on. For example, polygon stream/rivers versus linears.

4. Delineate at a scale of 1:3,000. As this NHD product is intended for a national map, the line work should look clean and smooth.
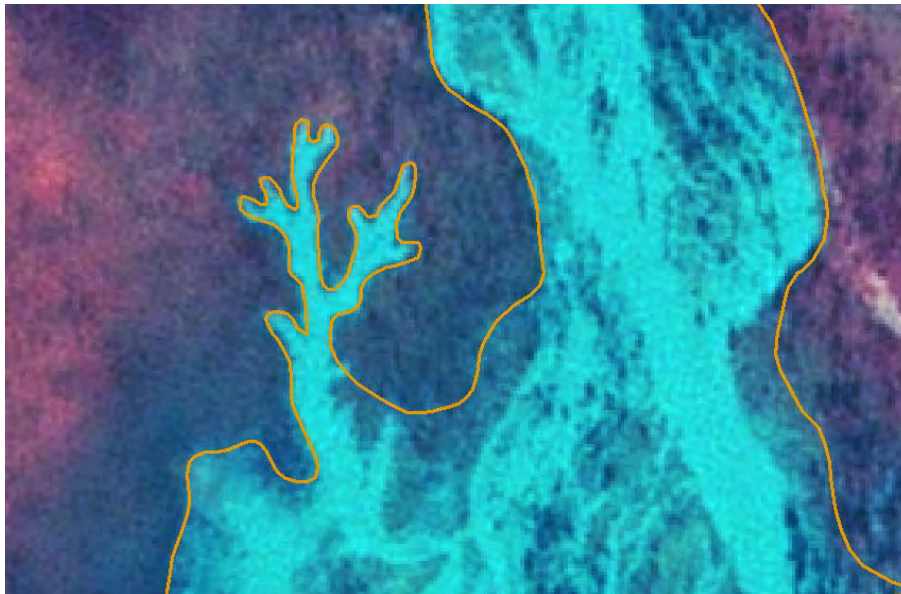
Correct - A tight area delineated at 1:3,000. Do not zoom into 1:500, but do not leave it like picture below.
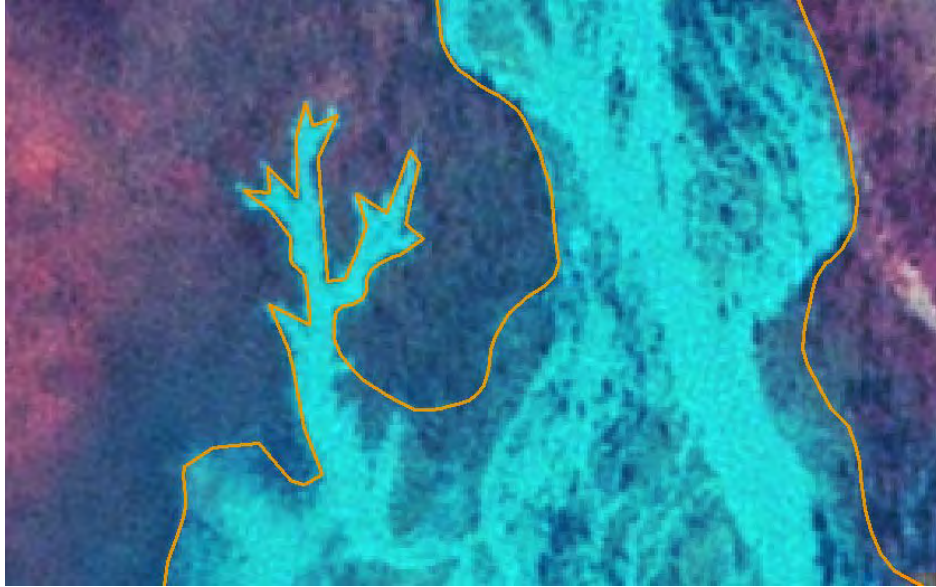
Not correct – Even at 1:3,000 this can be made to look better.

5. Look at default when transitioning from polygon to linear. You do not want to create a "string of pearls" with poly, line, poly, line etc.

6. If existing polygon is smaller than MMU you would not delete it if the feature is still there on the SPOT imagery, reshape if needed. Of course, if a new feature on the SPOT image is smaller than MMU, don't add in polygons.
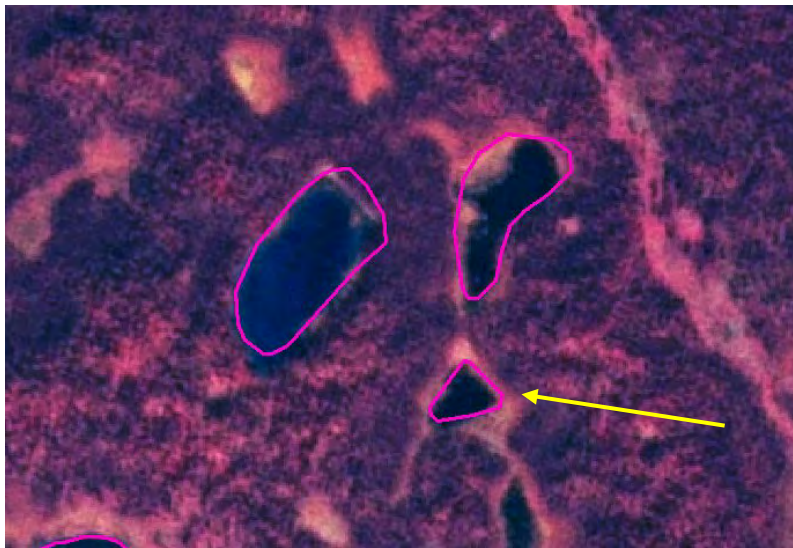
Original NHD - Yellow arrow shows polygon less than 2 acres
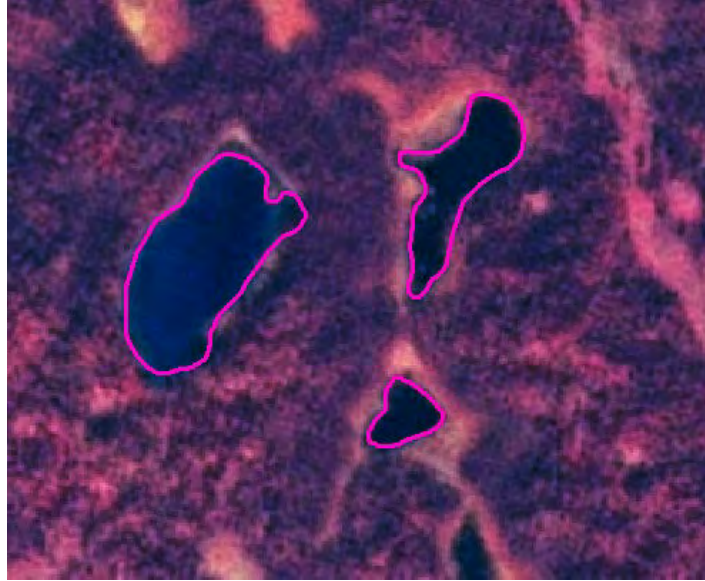
It is in the original and can be reshaped at 1:3,000 so keep it

7. If there is a lake/pond polygon in the original NHD dataset, but the feature is not on the new imagery you can delete the lake/pond.

8. You may see a dark spot on the SPOT image, turn on the DRG and see if there is a wetland (swamp/marsh) symbol to support the decision to add a polygon. ** In meetings with the NPS it was decided these will not be added in at this time regardless of size due to time/budget.
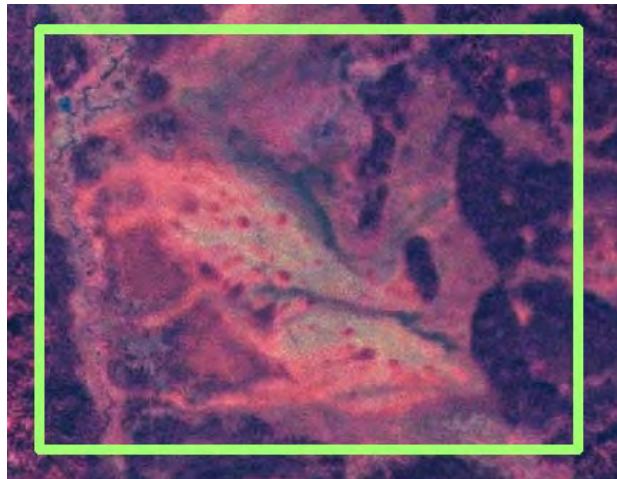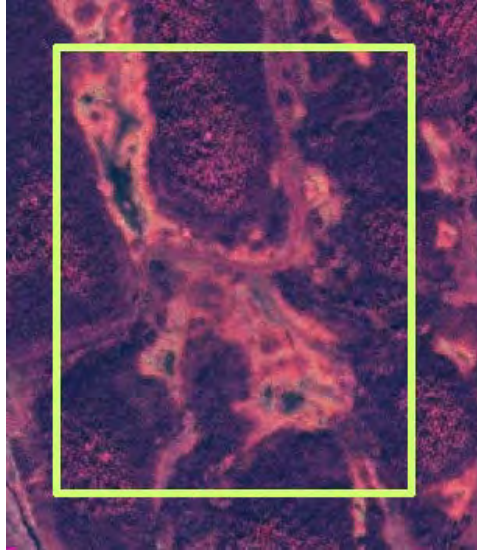
These examples would not be added at this time even though the DRG shows swamp/marsh

9. The MMU of 2 acres is to be used for the adding in of lake/pond polygons. If a noticeable dark (wet) spot is on the SPOT and meets MMU, add it.   ** Number 8 pertains to the swamp/marsh areas and not open water.

10. Channels are added as or remain polygons when they are complex channels. Artificial paths will be present in these areas in order to maintain connectivity within the linear network.

11. Shoreline is denoted by persistent vegetation (red signature). You want to cut/leave this out. Sand bars can still be part of the complex channel.

12. Islands in the complex channels or lake/pond follow the MMU rule. Look for and cut out by the persistent vegetation (red). These islands are not to be part of the NHD dataset - these areas will be holes or open uplands. Sand bars can still be included as part of the complex channel.

13. If an island in a complex channel has a large enough water way through it you can split it and make that water way part of the complex channel. As seen below

Complex channel splits the two islands

14. Use SPOT, DRG, and DEM for editing and adding linears. In areas of topographic relief, the DEM can be useful. Keep in mind, however, that it does not always agree with the DRG. In flat areas you will need to rely on the SPOT as DRGs and 30 meter DEM's do not provide much assistance. In these cases you are looking for distinct stream/river features on the image and not consulting the secondary datasets.

15. Add linears when they show up clearly. For example, along a complex channel you see areas that look like there is drainage into it. Follow it past the "scar" and see if it can be seen clearly. As seen below
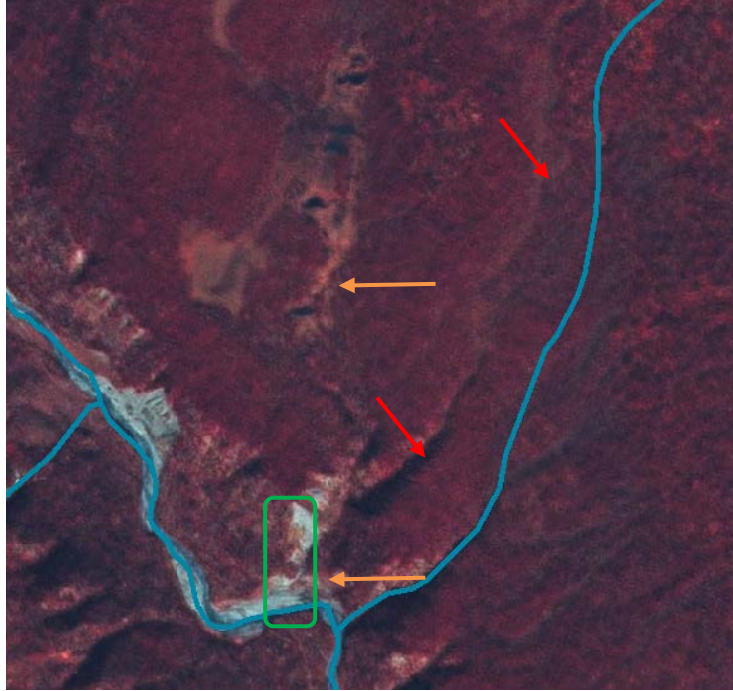
Original NHD – missing linear and not accurate location. In green polygon area, drainage "scar" can be seen on SPOT

Edited NHD – linears added in correct locations. Contour lines on DRG support these edits as well.

16. Linears are priority and should be added when visible on the SPOT. If valid linears can be seen they should be added even if the DRG, DEM, etc. do not support it. This is very much the case in flat areas where the contours and the DEM may show nothing, but the SPOT clearly shows a linear feature should be added.
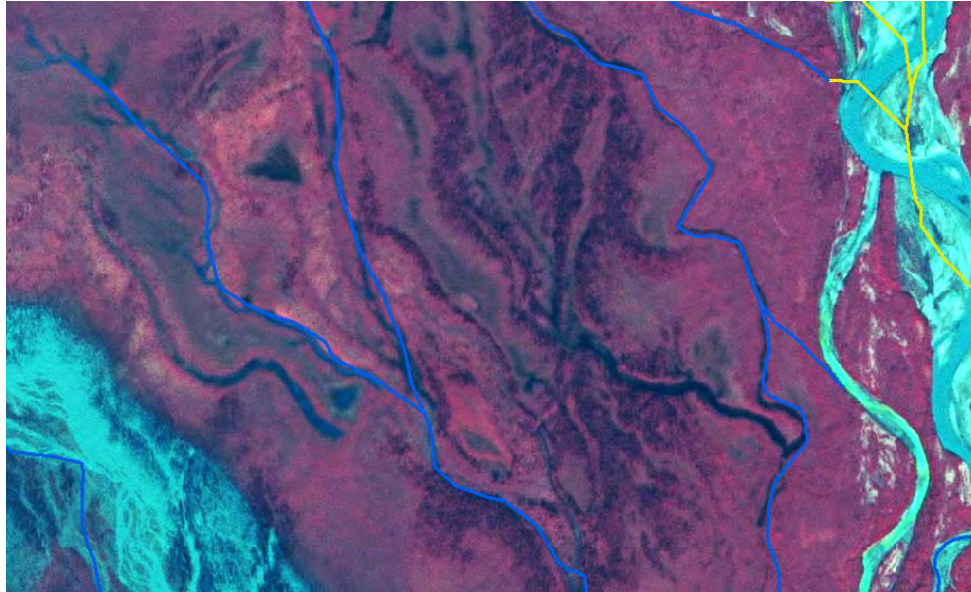
Original NHD - You can see a need to add linear features since this area is flat it may not have much, if any, displaying of flow on DEM. Persistent vegetation would prevent this from being a complex channel.

17. You may need to add or reshape artificial paths when polygons are added in the path of flowlines. For example, a new lake/pond polygon may have a linear go through it. Line work going through a lake/pond needs to be made an artificial path

18. Artificial paths and linears may need to be reshaped and vertex snapped to the boundary of polygons. Because of this, work on polygons first and then do linears after.   Artificial paths do not need to follow the path of a channel features.

19. Stream/River will be polygons if the width is 60 feet (20 meters) or more.

This is a WRST linear feature and the actual water width is not much more than the vector line on the SPOT.
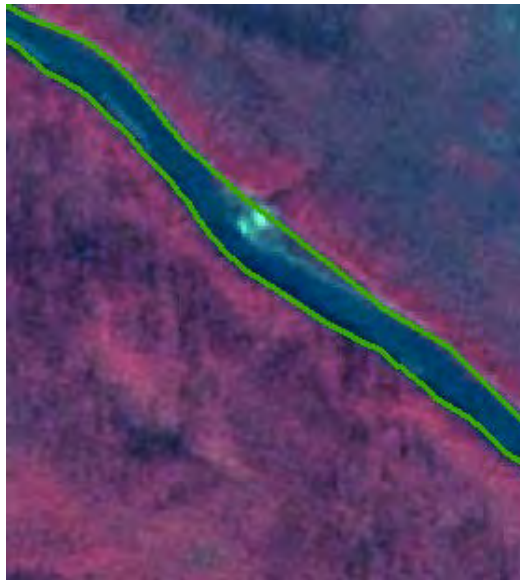
This is a DENA stream polygon and the water is more than 20 meters wide.

20. Stream/River will be linear if less than 60 feet wide.

21. Complex channel = 5 or more - less than 5 channels use stream/river polygon or linear.

This stream has 2 paths within the same channel, but it isn't complex

22. *GLIMS data is the NPS standard for the glaciers. Features will come up to and be coincident with the glacier boundaries as are the rules with other linear and polygons features in the NHD dataset. We will not be running linears through glaciers. ** Make sure the GLIMs data is the most up to date.*

23. When linears run alongside of a glacier - if there is no definite river, cut the lines at the bend and snap linear to the glacier. All linear in-between the cuts or left over can be deleted. For example, cut at red arrow and delete linear in yellow circle, snap linear to glacier
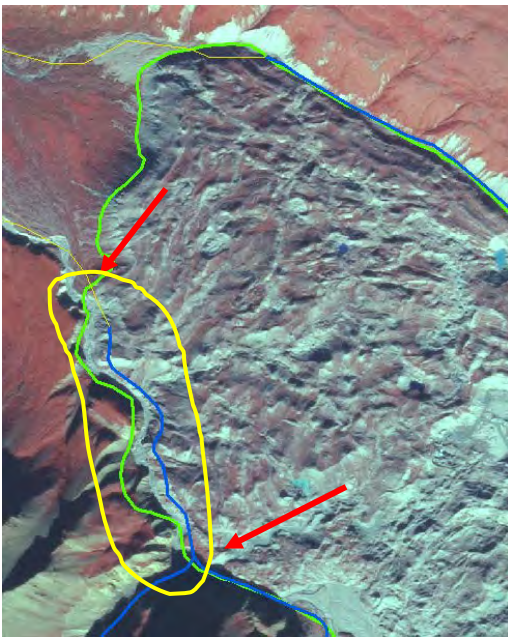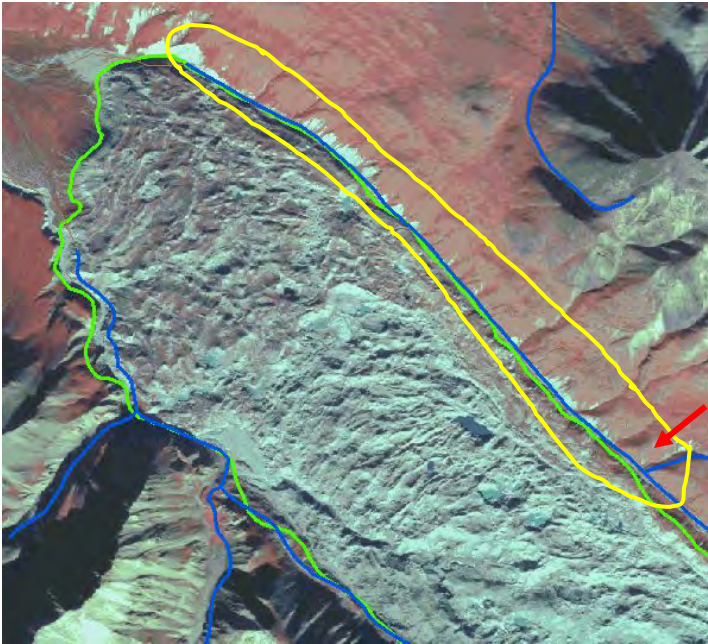
Green lines are glacier boundaries

Appendix D: Draft Guidelines for Updating Interior NHD – Part 2

Saint Mary's University of MN
NHD Editing Standards and Methodologies

The purpose of this document is to record editing standards and methodologies used in all Saint Mary's University of Minnesota (SMUMN) NHD editing projects. This is a working document and will be updated to as standards and methodologies change. If you feel something is missing from this document or if any of the contents of this document is out of date please contact a NHD project lead and changes will be made accordingly. All screenshots are taken during various editing projects as we add to the document as questions are brought to our attention.

Table of Contents

General NHD Project Information

NHD Website - http://nhd.usgs.gov/userguide.html this site contains tutorials, training videos and general information about what NHD is in terms of a national dataset as well as introduces people to the concepts and standards inherit in the NHD process. The standards and methodologies below are enhancements on these but everything must comply with the NHD standards as well as any additional standards developed in this document and those pertaining to a specific project.

For editing NHD in any Alaska location editors will be provided a separate document outlining the Alaska editing standards. This second guideline provides more specific information to editing in the state of Alaska, more documentation will also be provided based on region or client requirements.

Base Imagery

Base imagery can be different across projects. Things to keep in mind as you delineate are:
1. The resolution of the imagery. In some cases the project area may transition from half meter to 5 meter.
2. The time of the year or THE year the imagery was acquired. You can deal with shifting, seasonal changes, etc. This where the collateral data comes into play even more.

Base Imagery types typically used:

High resolution Satellite Imagery (Pleiades)

Low resolution Satellite Imagery (ORI)

Medium/High resolution Satellite Imagery (SPOT)
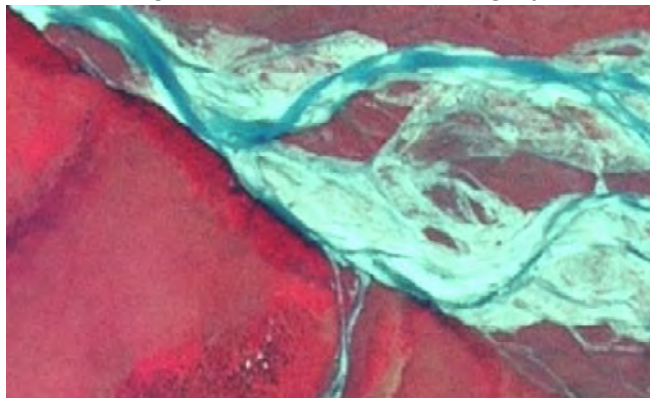
Editing Standards

Acceptable error

Acceptable error is different for every project and is dependent on the resources and data that is available for delineation. Consult your project lead about what is considered acceptable error for each project.

Delineation Smoothness

Selection and Editing tools

1D Features

These features represent a continuous flow network and has many different types of components. Depending on the editing being done (i.e. AK Hydro versus USGS NHD) what is delineated, what is captured in the attribute table and where these are stored may be different. Not everything is updated at the same time so there are various features that may be included for reference only. Your team lead will tell you what should be captured and what should be used to clip and snap other features. The coastline is a good example, as many coastline projects are done separately to all other NHD editing.

Coastline\Intertidal

Lines representing the Mean High Water Mark, CUSP data is often used to update these lines. All lines and many polygons must be clipped and/or snapped to the coastline. Some of the exceptions are Foreshores and Sea Ocean. Please ask you team lead what the requirements are for each project as they can change depending on the needs of the client/cooperating agency.

Artificial Paths

These are paths that represent the general flow within a polygon feature. All Lakes, 2D Streams and Complex Channels that have channels running either too, from or through them must have artificial paths representing their internal flow. NHD standards also allow editors to create artificial paths that run through Foreshores, Glaciers and Swamps whenever a stream channel can not be added but flow is present. Your team lead will tell you when artificial paths can be used within Foreshores, Glaciers and Swamps. Please refer to the Lakes, 2D Streams and Complex channels sections of this document for more information on when to add Artificial paths for each of these.
1. Single in flow
2. Single through flow

3. Multiple in flow
4. Multiple out flow
5. Myltiple Inflow and Outflow

Streams/Rivers

Are wet channels less than 20 meters wide that would be used to represent streams and rivers in the project study area.
1. The only "dry" channels that should be delineated are when a small section of a channel appears to be dry or cannot be delineated using the imagery but the contours and/or hillshade show that a channel exists and connects two channels with standing water (i.e. do not add disconnected arcs). The channel delineation should end at the point where the visible water ends at both the beginning and ending of the channel.
2. All channels that are delineated should match perennial classification. The only time a stream is classified as intermittent is if there is some question on the lines inclusion or if you feel strongly that the channel has significance even though the channel appears to be dry on the imagery (snow covered channels being one example). During the final QC and Edge Matching process we will check each intermittent stream for validity and determine whether or not it will be included in the deliverable.
3. Channels that exist on the hillshade and/or the contours and are snow covered on the imagery can be added as perennial streams as it is possible for the snow melt to feed the channel for regular intervals and because of the snow its designation as intermittent or perennial can't be determined with the given data.
4. It is important to use the contours to weed out avalanche pathways in the mountain areas, these will be appear to be possible snow covered channels on the imagery but will not have crenellations in the contours. Avalanche pathways are not valid stream channels.
5. Flowlines should always be snapped with other polygons or lines using vertex and end snapping. No other snapping should be turned on. If needed add a vertex to the polygon or line if there is not one in the location you need to snap the line to.
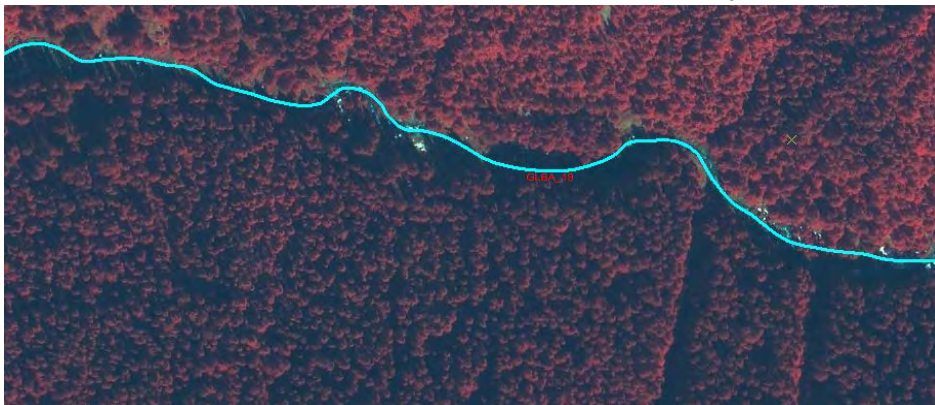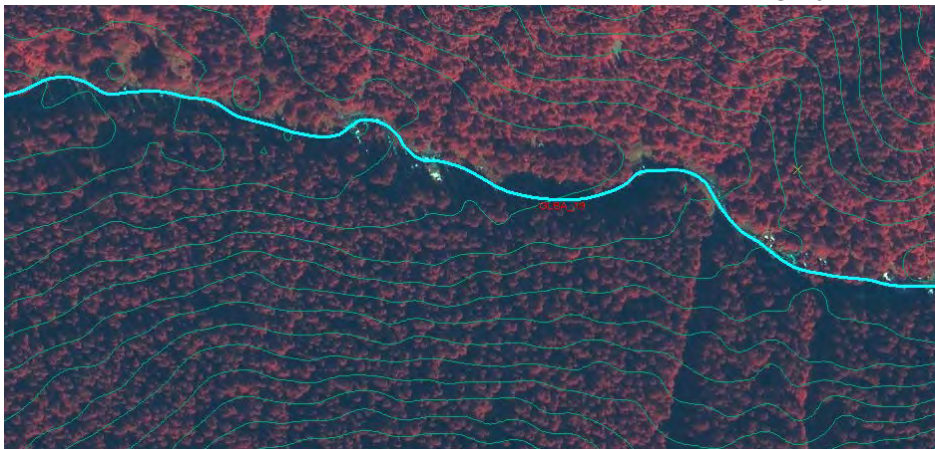
Original NHD Stream (blue line):
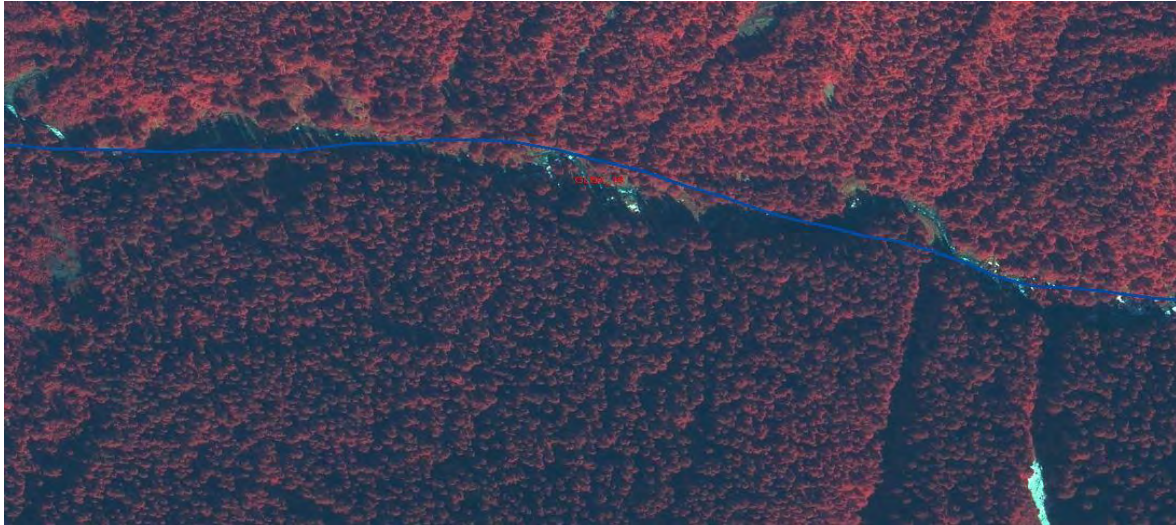
How stream looks after delineation (bright blue):
Follow the stream bed to delineate the stream, should try to follow the center of the stream.

Stream (bright blue) with Contour lines(light green lines):
See how the stream follows the contours as well as the imagery. Both should be in agreement.

Example of a line snapped to a poly
Other Line Types

2D Features

Lakes

Are the open water bodies within the study area that are greater than 2 acres.


Example of Lake
Example of Lake with islands greater than 2 acres.

StreamRivers

All wet channels that are bank to bank 20 meters wide or greater in width must be created as a Stream Polygon. The exception being features that routinely narrow to below 20 meters than to avoid a string of perls you can either maintain this as a 1D stream or have sections that are smaller. Consult the project lead on what the requirements are for the project to determine which method should be used for these exceptions.

Bank to Bank Stream Delineation:
Banks should include open water only, banks are defined by vegetation and dry land boundaries. Islands and sandbars can be left unless they are greater than 2 acres than they should be clipped from the polygon.
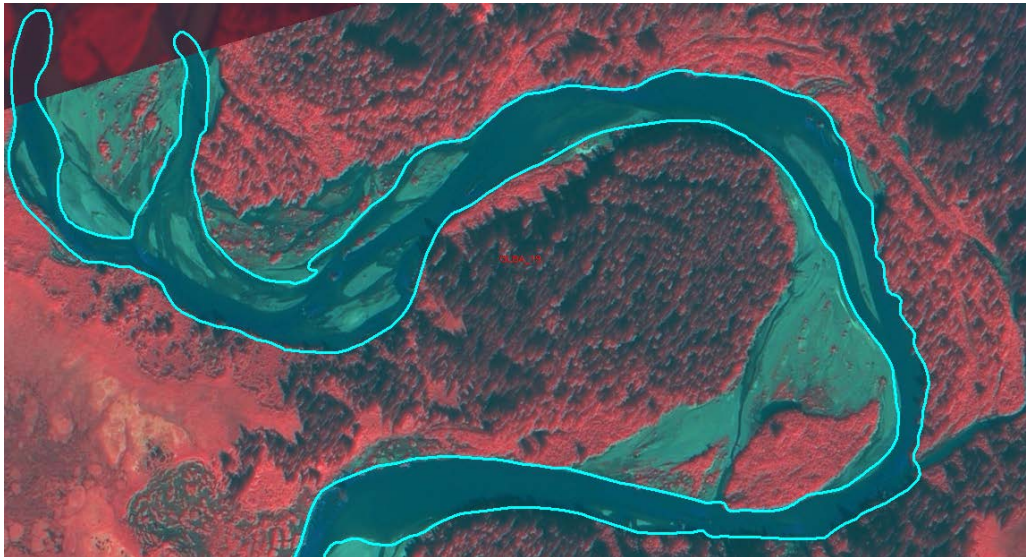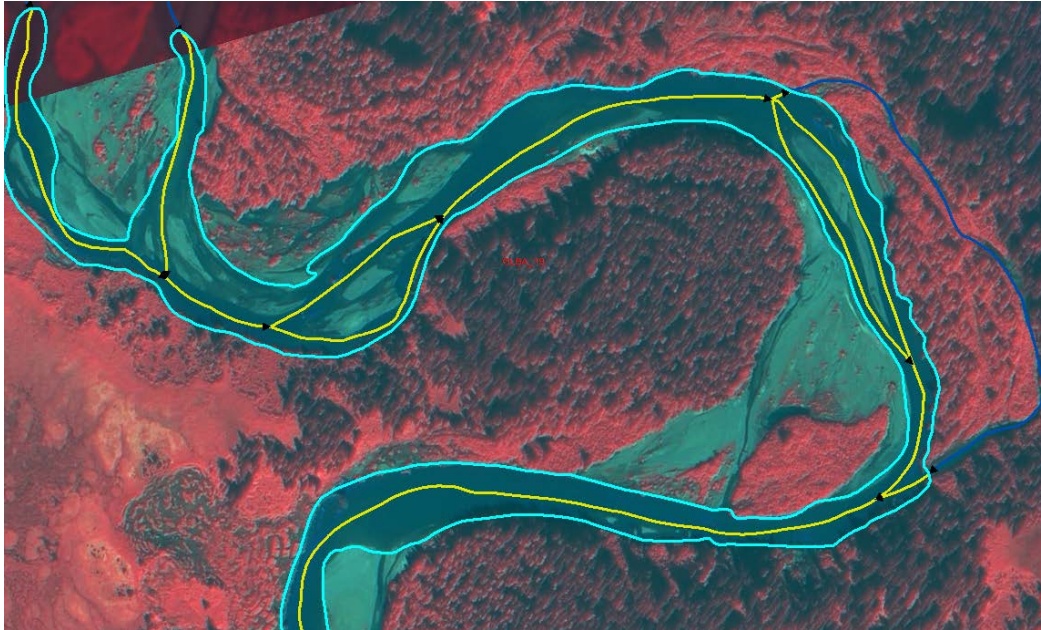

Stream Delineation with 1D lines:
All streamlines (dark blue) end at the boundary of the 2D stream (bright blue). Notice how the line is split to represent in and out flow lines using artificial lines. The artficial lines should follow

the main channel of the stream except when there is more than one channel then it splits.

Example of Stream Delineation with island greater than 2 acres.

Complex Channels

Stream Networks with 5 or more channels that run together and overlap each other.

Glacial Boundaries
(sometimes designated as Ice Masses)
Delineation and boundary interaction with other features:
1. Nothing should be delineated within the boundaries of the glacier except for any exceptions listed in the items below.
2. Lakes and streams that appear in the imagery but are completely within the boundaries of the glaciers should not be delineated. See #5 on this list for how to deal with Lakes and 2D features that share a boundary and/or cross the boundary of a glacier.
3. Artificial Paths may be added to connect channels that flow into or out of a glacier but cannot be directly connected to any other flow network - discuss with team lead before making any paths as this may change for each project.
4. All flowlines should be snapped to the glacier boundary, artificial paths would start and end at the glacier's boundary.
5. No edits should be made to the glacier boundaries unless to an updated boundary provided by the Client. This may change based on feedback from the client, verify the procedure that should be followed with your team lead before making any changes to the glacier boundaries.
6. Ignore the glacier boundaries when delineating Lakes and 2D streams. Delineate the boundaries using the imagery. This means there will be times when there is a gap

between the glacier and the poly while other times the lake poly will overlap the glacier boundary. The boundaries to these polys will be updated during QC and edge matching based on feedback from the client on how they wish us to proceed with the glacier boundaries. The project lead will be able to provide guidance on what process should be followed.

Appendix E: Steps for Interaction with AK Hydro Regional Databases

NHD AK Hydro Synchronization Process

Create Two Replica of AK Hydro Database

- Using CITRIX VPN Client and remote desktop, log into AK Hydro server with credentials provided by the AK Hydro data steward.
- Using the distributed geodatabase tool create a two way replica of the AK Hydro region that represents the project area of interest.
- Prepare the replicate for transfer to local environment using the Zip tool
- Copy the zip file to local workstation
- Disconnect from the AK Hydro VPN

Build Local Editing Environment

- Create a new database in PostgreSQL database using the PostGIS template.
- Setup ArcSDE user and other administration permissions needed for creation of an ArcSDE schema.
- Using ArcCatalog, connect to the new database and then, using ArcCatalog tools, apply the ArcSDE schema to the new database making it an ESRI ArcSDE database.
- Unzip the AK Hydro replica to a local hard drive
- Using ArcCatalog import the replica database into the prepared database. This will import the schema and data exported from the AK Hydro source database.
- Apply additional user permissions for access to the database by editors.
- Configure and apply backup strategies for maintenance of database integrity.

Updating AK Hydro Data

- Create a polygon representing the total extent of the project area of interest using the using the boundary provided in the AK Hydro checkout template.
- Fill out attributes and send the AOI to the AK Hydro data steward. This will be added to the editor service that shows all active editing study areas in the AK Hydro system.
- If the replica hasn't been synchronized with the AK Hydro version within the past two months, it is suggested that the local administrator synchronize the data back to AK Hydro before proceeding with the creation of editing replicas for users.
- Open and editing session in ArcMap and add data that you wish to checkout (do not need to include all layers in the AK Hydro database just ones that will need editing). Using the area of interest and the distributed database tool create a checkout from the local two way replica.
- If multiple editors are using the tool, create copies of the data for a subset checkout using the distributed geodatabase tool in ArcMap. When possible use watershed boundaries to create the checkouts.

- Once editing is complete each check out has a visual quality control check done. If there are any concerns the checkout is sent back to the editor for updates.
- Once one or more checkouts have been completed each checkout is run through the AK Hydro data reviewer tool and the rules in the AK Hydro batch review file.
- When two or more checkouts have passed initial QA/QC, then the two checkouts are loaded together into the same layer,
  - seams are checked to make sure that the features match up along the checkout boundaries
  - the batch reviewer rules are rerun to validate features
  - flow direction is checked using the reviewer tool's "trace upstream" option
- Once all the check outs have been combined into a single file geodatabase, the contents of the original checkout are replaced with the contents of the new file geodatabase.
  - Care must be taken to make sure that no data outside the study area is lost in the process of replacing the new data. If any edits are necessary to features outside the study area then the AK Hydro data review batch file is run one more time before going on to the synchronization with the two way replica.
- The checkout is then synchronized to the local two way replica using ESRI default process control through ArcCatalog.
- Once all changes have been synchronized then the edits are exported from the two way replica into a xml file. A copy of this file should be saved locally as a backup.

Synchronizing Replica Back To AK Hydro

- Log into AK Hydro server using CITRIX VPN Client and Remote Desktop.
- Copy the xml file to the AK Hydro server.
- Using ArcCatalog, open a connection to the remote version of the AK Hydro database.
- Import the edited changes into the database using the local xml file.
- Export a message received report from the AK Hydro database as a different xml.
- Copy the xml to the hard drive of your local machine.
- Log out of the AK Hydro server and disconnect from VPN
- Import the xml file to the database.
- Log into AK Hydro server using CITRIX VPN Client and Remote Desktop.
- Export changes from the QC version of the AK Hydro geodatabase as an xml file.
- Copy the xml file to a local hard drive.
- Log out of the AK Hydro server and disconnect from VPN
- Import the xml file into the local two way replica.
- Export a message received report into a xml file
- Log into AK Hydro server using CITRIX VPN Client and Remote Desktop.
- Copy new xml to the server
- Import the message received.
- Inform the AK Hydro Coordinator that synchronization process has been completed.
- AK Hydro Coordinator then compresses the database.

- Creates a Quality Control Checkout matching changes currently synced using the local two way replica.
- Sends QC checkout to us as a personal geodatabase. We run the Data Reviewer QC batch script and check the flow network and then send back to AK Hydro Coordinator.
- AK Hydro Coordinator makes final changes and syncs QC Checkout with the QC version of the AK Hydro geodatabase.
- QC Version of the AK Hydro geodatabase is posted to the production version of the AK Hydro geodatabase

Appendix F: Draft AK Hydro Editing Standards

AK Hydro Data Editing Standards
As defined by the Alaska Hydrography Technical Working Group
v0.6 – 04/16/2014

General Requirements

Minimum Mapping Units

Lake, Pond, Swamp, Glacier, Ice and 2D Stream polygons must be ≥ 2 acres in size, or they should not be mapped

1D Stream arcs must be ≥ 4 meters in length

2D Stream feature must be ≥20 meters in width, otherwise they should be represented as a line

Not all streams ≥20 meters in width must be mapped as a 2D stream polygon

Concurrent editing of 1 Dimensional (Stream_LN) and 2 Dimensional (Stream_PL) stream feature

All 2D stream polygons must contain a corresponding 1D stream arc

When editing a 1D stream feature, the corresponding 2D feature should also be updated, ensuring consistency between 1D and 2D features.

When editing a 2D stream feature, the corresponding 1D feature should also be updated, ensuring the 1D feature remains an accurate representation of the stream thalweg (thread), and located within the 2D feature.
Note – 1D features occurring within a 2D feature should follow the thalweg where it position is apparent, but centerline mapping is an acceptable substitute where thalweg position is unclear.

Maintaining connectivity between 1D and 2D features intersecting any edited feature(s)

Where edits are made to a 1D or 2D stream feature, any intersecting features must then be appropriately modified to ensure topologic connections are maintained. Best practice entails modifying the arcs of the intersecting feature at the junction and a short way beyond the intersection of the 2D features.

2D feature relationships within AK Hydro:

Polygons within the same featureclass are not allowed to overlap

Polygons within separate featureclasses are not allowed to overlap, <u>with the following exceptions</u>:
2D stream features (e.g. Stream_PL) are allowed to overlap Upper Intertidal areas (e.g. within Intertidal_PL)
2D glacier features (e.g. Glacier_PL) are allowed to overlap Upper Intertidal areas (e.g. within Intertidal_PL)

Adjacent polygons with a shared edge should have coincident vertices (e.g. where lakes adjoin glaciers)

Lake_PL features should not occur within, nor intersect with Intertidal_PL features

Stream_PL features should not occur within, however, are allowed to intersect the landward extent of Intertidal_PL features.

Glacier_PL features should not occur within, however, are allowed to intersect the landward extent of Intertidal_PL features.

Minimum Editing Extent

Hydrologic features can be edited either feature by feature, or on a geographic area basis, depending on organizational business needs. It is not required that all features within a checkout extent get updated or modified.

- Note: When checking more than 1 large feature out for editing, it is recommended that editors select all of the features within the particular area of interest (e.g. a HUC12) even though not all of the content is subject to update.

Acceptable Types of Digitizing References and Resources (e.g. range of DataSource attribute values)

Digital Orthophotos

1) Digital Planimetric Data
2) Digital Elevation Data

Digital SDMI Imagery

Field Verified Reference Data

Other (*source to be identified in Comments attribute*)

Acceptable horizontal accuracy standards as defined by the Alaska Hydrography Technical Working Group (e.g. range of SourceImage attribute values)

Level 1 - Medium Resolution Satellite Derived

Level 2 - Photo Interpretive Imagery

Level 3 - IfSAR or LiDAR Derived

Level 4 - GPS Hand Held Reconnaissance

Level 5 - Continuous Map-Grade Survey

Level 6 - Controlled Land Survey

Stream connectivity

In watersheds where Intertidal_PL features exist, all Stream_LN features should flow into and terminate at the landward boundary of Saltwater polygons (e.g. Intertidal_PL)

All Stream_LN segments within a given stream network must be connected – disconnected stream arcs are not allowed in AK Hydro

Where Stream_LN segments flow sub-surface, the mapped stream segments should be approximated with straight lines and their TypeClass attribute coded with one of the following values:

Pipe – man-made underground watercourse

Connector – common sub-surface flow

Underground Conduit – sub-surface flow through karst or subterranean caves

Segregating 2D hydrographic features

All distinct 2D water bodies should be segregated at the point of junction with another water body.

Rivers & streams

Individual 2D linear features (rivers, streams and sloughs) should be segregated whether named or not. A feature may include sections of complex channels.

2D features of the same feature type/classification may adjoin one another – e.g. the confluence or 2D tributaries should be segregated at the point of confluence

Sloughs, distributaries, side channels

Individual linear features which may be significant large channels connected at one or two points to other river or stream features, but are of sufficient size (width or length) to be best mapped as a unique feature

Individual features of sufficient human significance to be named

Lakes and wetlands

Individual water bodies of sufficient size

Large distinct expansions of linear water bodies that clearly appear as a lake

Estuaries & Lagoons

Distinct expansions of linear water bodies occur at the outlet of a river or stream prior to outlet to open marine waters

Islands

Mapping to a minimum size of 2 acres and/or a minimum length of 150 meters but does not preclude mapping smaller features.

Establishing appropriate closing lines

tributary junctions – straight line from headland to headland

tributary junctions w intervening islands – straight line from mainland headland to island headlands or endpoints to mainland headland

river / shoreline junctions – straight line from headland to headland where a river abruptly enters the ocean

river / bay junctions – straight line from headland to headland where a river abruptly enters a bay

river / estuary junctions – straight line from "headland to headland" across a river where the bank character changes widening from parallel river banks to an expanded estuary character

estuary / marine junctions – straight line from "headland to headland" across the mouth of an estuary where the bank character changes from a confined estuary to either an open marine bay or open ocean.

Abandoned channels

Abandoned stream channels hydrologically segregated at both ends from the active stream channel should be removed from the river feature class. If these features are of sufficient size and still retain water, they should be added to the lake feature class.

Abandoned stream channels hydrologically segregated at only one end from the active stream channel should be considered sloughs and if sufficient size should be mapped as a separate slough as described above.

Updating 1D linear stream features

Automated Generation

LiDAR and IFSAR (or similar) generated hydrography needs to be completed by someone with appropriate technical expertise

Requires modification of the Surveyed attribute domain values from "Yes" or "No" values to "Field", "Digital", or "None"

Heads-up Digitizing

Determining and mapping the primary channel (thalweg or thread of stream)

Visually identify the primary channel based on observed water volume, depth, and hydrologic flow pattern

Map the thread of the stream based on observed water volume, depth, and hydrologic flow patterns where possible.

Where water depth or flow patterns cannot be clearly determined, map the thread at the center of the channel

Maintaining tributary intersections

Ensure any intersections with the linear stream feature being edited are maintained or reconnected after feature edits are completed.

Where visible, modify tributary intersections to more accurately represent the actual stream flow connections

Field Collected/Surveyed

Field Surveys using GPS

Use corrected data of highest resolution available. Capture point quality attributes (accuracy, HDOP, # of satellites, etc…). Take advantage of open areas with good satellite coverage to produce accurate points. Use data averaging.

Use point features over a "best data layer" image backdrop to assist heads-up digitizing.

Aim for a smooth, best-fit line that balances GPS and visible stream locations. Keep in mind that observers usually walk around objects, deep pools, beaver ponds but the linear feature should go through it. Don't just "connect the dots".

Avoid the direct import of GPS tracks. If GPS captured lines are used they should be smoothed to remove major jogs.

Use the AK Hydro "DataSource" attribute to document the use of Field Verified Reference Data (GPS).

Geometric Networks traversing 2D features within AK Hydro

1D Stream_LN features must break (i.e. begin or end) at the intersection with the boundary of any 2D polygon feature(s)

1D Stream_LN features must not bisect islands occurring within the boundary of any 2D polygon feature(s)

1D Stream_LN features that occur within or traverse 2D Stream_PL features should follow the thalweg based on clear visual cues where available, rather than a minimum route artificial path.

1D Stream_LN features that occur within or traverse 2D Lake_PL or Glacier_PL features should utilize a minimum route artificial path/connector where possible. Examples shown in bold red below.
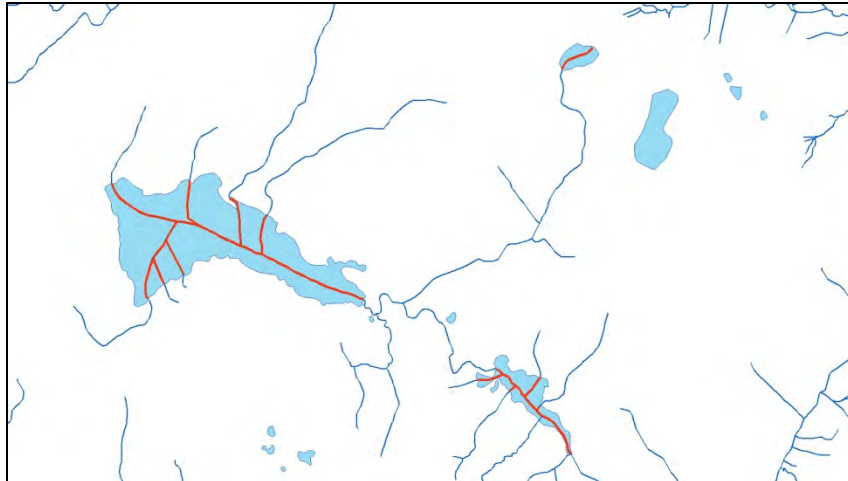
1D Stream_LN features that occur within headwater lake or glacier polygons do not have to traverse the width of the lake or glacier polygon. Either examples A or B below ARE acceptable.
Headwater polygons are Lake_PL or Glacier_PL features that intersect Stream_LN features, but have boundaries that extend further upstream than the 1D stream network does.
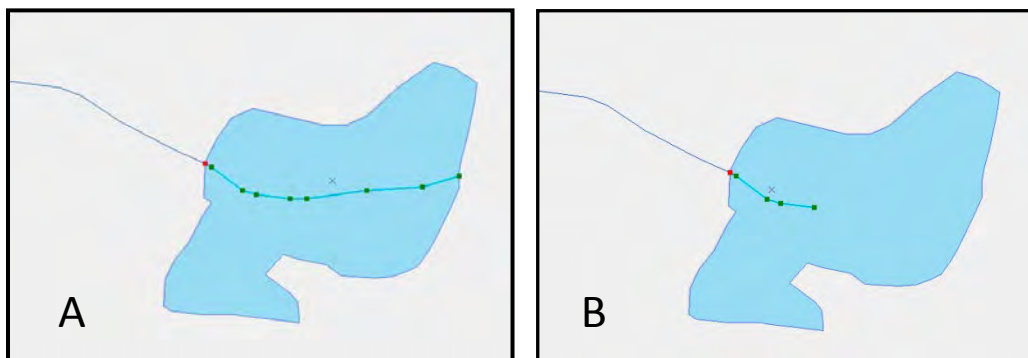
Headwater Lake_PL and Glacier_PL features must contain a Stream_LN feature to demonstrate its connectivity to a particular stream drainage/network. Example C below is NOT acceptable – examples A or B above ARE acceptable.
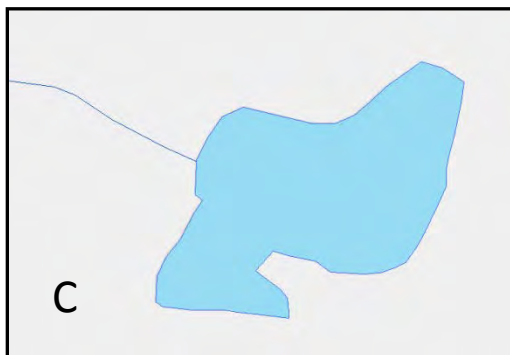
Best practices: Editing Environment and Map Document Settings

Coordinate System

When beginning an AK Hydro edit session, bring the AK Hydro content into the map document first. This ensures the data frame properties are then set to the NAD_1983 Alaska Albers Equal Area Conic projected coordinate system. Although the subsequent addition of certain reference data (e.g. imagery) may cause the data frame properties change, the practice of first adding AK Hydro data into the map document helps to ensure AK Hydro data are edited in their native coordinate systems when possible.

Editor toolbar settings

Prior to editing AK Hydro data ensure the "Sticky move tolerance" has been set to at least 1000 – it's preferable this is set as high as allowable, but not required. This is done on the Editor toolbar drop down menu > Options > General tab of the Editing Options window > Sticky move tolerance. This setting ensures that selected features do not get moved inadvertently during an edit session.
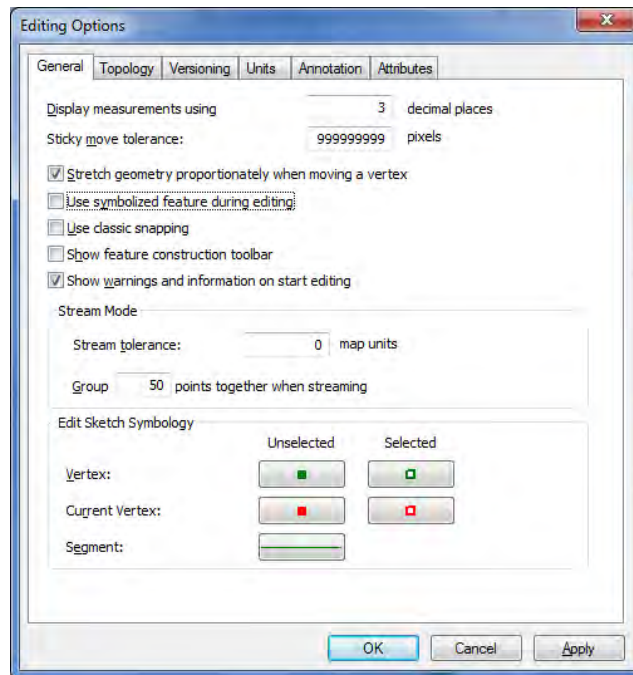
Prior to editing AK Hydro data ensure the "Snapping tolerance" has been set are between 10 and 15 pixels. This is done on the Editor toolbar drop down menu > Snapping > Options > General > Tolerance. It is advisable that "Snap tips (same location as Tolerance) are also ticked/turned on, including the "Layer name" and "Snap type" options. These settings help to ensure editors are snapping features to an endpoint or vertex and NOT just snapping to an edge.
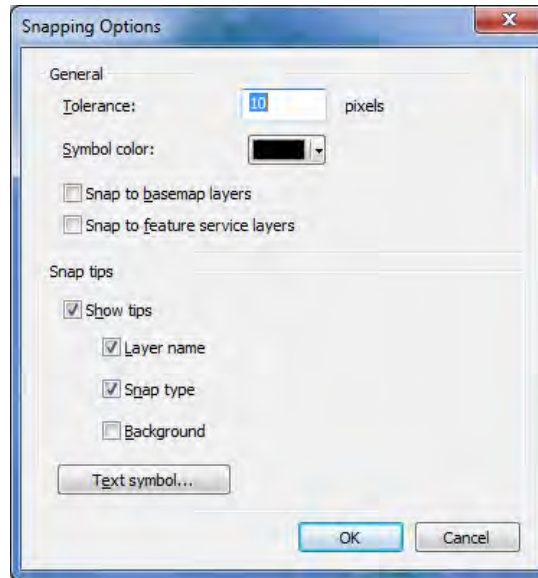
General practice

It is recommended that editors use the selection tool for selecting and the edit tool for editing. While each tool allows editors to select features during an edit session, the edit tool allows editors to inadvertently move selected features if not careful. See setting sticky tolerance above.

It is recommended that editors features at a map scale of 1:2,500 and 1:5,000 when possible.

It is recommended that editors make use of the "List by Selection" functionality in the map documents Table of Contents (show below). This ensures editors are actively aware which layers they are selecting while editing and helps to prevent unintended edits to other layers.