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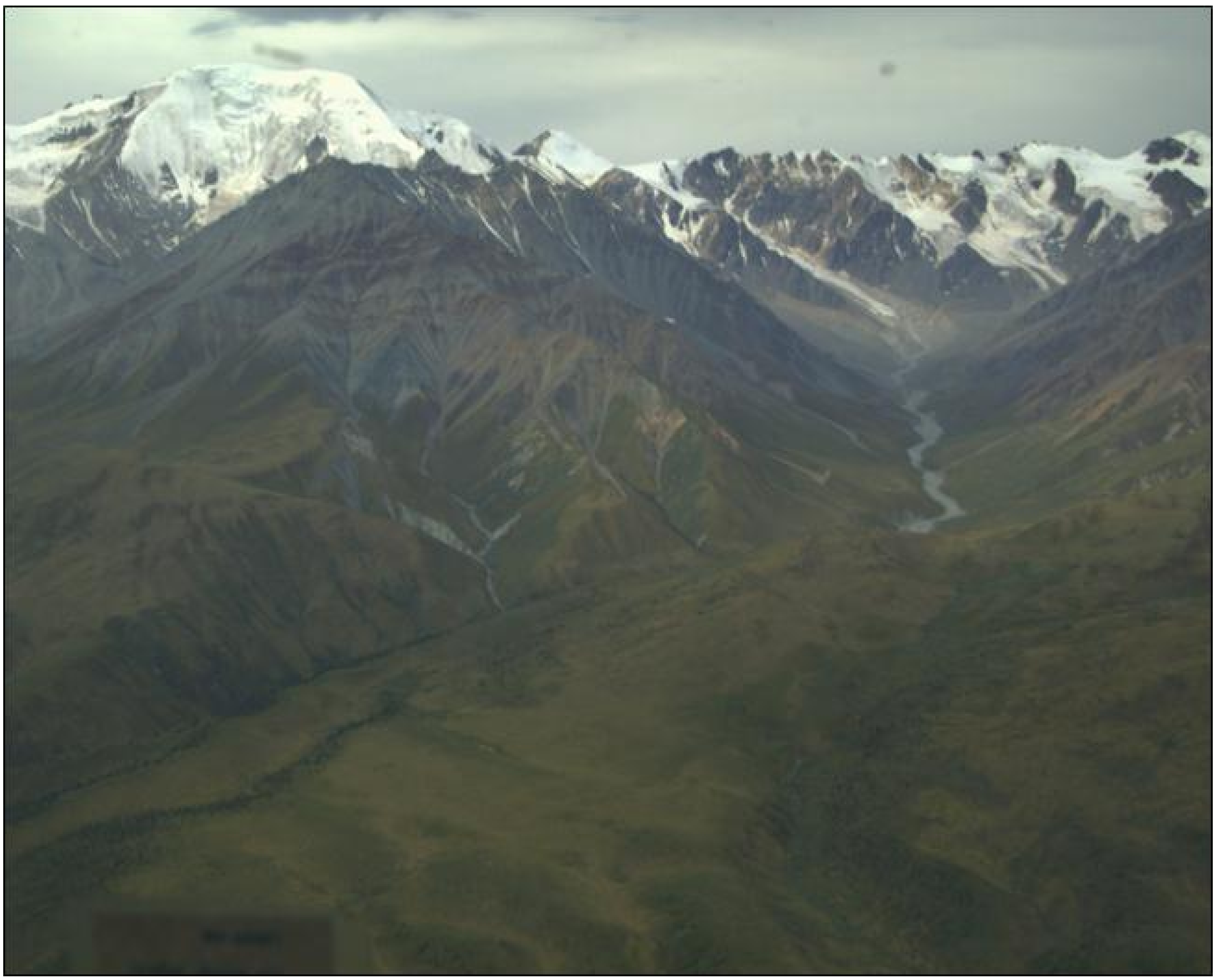
Natural Resource Stewardship and Science

National Wetlands Inventory (NWI) Standard Mapping of the Gold Hill Mining District in Wrangell-St. Elias National Park & Preserve

Natural Resource Data Series NPS/WRST/NRDS—2015/750



ON THE COVER
Wrangell St. Elias National Park
Photograph by: Kevin Stark, SMUMN/GSS

National Wetlands Inventory (NWI) Standard Mapping of the Gold Hill Mining District in Wrangell-St. Elias National Park & Preserve

Natural Resource Data Series NPS/WRST/NRDS—2015/750

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Abstract

This project was undertaken by the National Park Service (NPS) in collaboration with Saint Mary's University of Minnesota to complete updated mapping and classification of wetlands for approximately 46,000 acres of the Chisana Mining District of Wrangell – St. Elias National Park and Preserve (WRST) in southeastern Alaska.

The Chisana Mining District has been used for gold mining activities since the early 20th Century (Feldman 1997, Bleakley 2007). Active mining continues there today on federal unpatented mining claims that pre-date the formation of the park in 1980 (NPS 1990). The NPS regulates this mining and associated activities to minimize damage to the environment and other park resources based on the Mining in the Parks Act of 1976 (PL-94-429). To assess and authorize proposed mining plans of operation and access, the NPS must complete environmental and cultural resource assessments. Understanding the scope and classification type of wetlands contributes to important baseline information for these assessments and for minimizing the impacts to wetlands of mining operations and associated activities.

Mapping and classification efforts were completed using existing digital layers and ancillary datasets stored by the National Park Service and other available historical imagery and collateral information. Remotely collected imagery and geospatial technologies were used to produce an updated spatial layer with a minimum mapping unit of between 0.5 and 1 acre. Wetlands were mapped and classified using the U. S. Fish and Wildlife Service Classification of Wetlands and Deepwater Habitats (Cowardin et al., 1979); produced using standards established by the Federal Geographic Data Committee for inclusion into the National Wetland Inventory database. Approximately 1,400 acres of wetlands were mapped then classified for the project area; 80% were classified in the Riverine System and 20% in the Palustrine System. Field verification of these delineations were conducted to further refine the wetlands classification and to modify the resulting maps.

Acknowledgments

Thank you to Miranda Terwilliger, Eric Veach, and Bruce Rogers, from the National Park Service who provided insight, guidance and review for all aspects of this project. These staff members of Wrangell – St. Elias National Park and Preserve contributed to the scientific expertise and local and regional ecological knowledge available for this report. The authors would also like to thank Kevin Stark from SMUMN who participated in the field review portion of this project. To all those who reviewed and commented on this report, thank you. Your contributions increased its professional value for mapping and classifying the wetlands of Alaska.

List of Acronyms

AHAP – Alaska High Altitude Aerial Photography Program

BLM – Bureau of Land Management

CIR – Color Infra-red Aerial Photography

DEM – Digital Elevation Model

DRG – Digital Raster Graphic

DSM – Digital Surface Model

DTM – Digital Terrain Model

FGDC – Federal Geographic Data Committee

GIS – Geographic Information System

IfSAR – Interferometric Synthetic Aperture Radar

IKONOS – Commercial earth observation satellite capturing high quality panchromatic and multispectral images, now owned by Digital Globe

IA – Image Analysis

NWI – National Wetland Inventory

NPS – National Park Service

OHV – Off Highway Vehicles

ORI – Orthorectified Radar Image

PI - Photointerpretation

SDMI – Alaska Statewide Digital Mapping Initiative

SMUMN – Saint Mary's University of Minnesota, GeoSpatial Services

TMU – Target Mapping Unit

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

Introduction

The Chisana Mining District has been used for gold mining activities since the early 20th Century (Feldman 1997, Bleakley 2007). Active mining continues there today on federal unpatented mining claims that pre-date the formation of the park in 1980 (NPS 1990). The National Park Service (NPS) regulates this mining and associated activities to minimize damage to the environment and other park resources based on the Mining in the Parks Act of 1976 (PL-94-429). This requires that claimants submit a mining plan of operations to the park for approval prior to beginning mining detailing their proposed means and methods (36 CFR 9A). Due to steep terrain and a general scarcity of accessible water in this area, large scale hydraulic mining has traditionally not been viable.

The NPS is obligated to provide claimants reasonable access to these claims (ANILCA 1110(b), NPS 2008). Claims within this district are typically accessed via aircraft to the Chicken Airstrip and from there on foot or all-terrain vehicles via a network of unimproved trails. Over time, these trails have created a variety of specific and cumulative impacts on the area including: changes to floristic composition; soil compaction and rutting; disruption of soil and surface drainage; and, development of thermokarst features. To assess and authorize proposed mining plans of operation and access, the NPS must complete environmental and cultural resource assessments. Understanding the scope and classification of wetlands contributes to important baseline information for these assessments and for minimizing the impacts to wetlands of mining operations and associated activities.

To provide baseline condition information on the environmental resources in the Gold Hill area of the Chisana Mining District, the first phase of the project focused on completing an updated digital spatial layer documenting current wetland location and classification. Wetlands were digitally mapped and classified using the Federal Geographic Data Committee (FGDC) National Wetlands Mapping Standard. To achieve these standards, image analysis was based on high-resolution aerial and space-based imagery including: IKONOS pan-sharpened multi-spectral satellite imagery, Bureau of Land Management (BLM) 1:40,000 scale aerial photos, and Alaska High Altitude Photography (AHAP) 1:63,360 scale aerial images (USFWS, 2009). The NPS worked cooperatively with Saint Mary’s University of Minnesota in the planning and development of the project that included the incorporation of collateral mapping products and related information previously gathered for the study area.

The second phase of the project focused on ground truthing the results of the digital mapping to refine wetland location and classification. Wetlands were classified using the Federal Geographic Data Committee National Wetlands Mapping Standard during a two-day, helicopter-based reconnaissance level wetland inventory of the project area (Figure 1). Mapping and classification of wetlands was completed per the project specifications for approximately 45,000 acres of the Chisana Mining District. This included the Gold Hill project area as defined by the NPS and adjacent lands extending to the Chisana River in the west and the headwaters of Chathenda Creek in the east (Figure 1**)**.

Final wetland data resulting from this project will be incorporated into the National Map through the U.S. Fish and Wildlife Service National Wetland Inventory master geodatabase for public use. It will

also be added to the NPS Alaska Regional GIS data store. Digital spatial data delivered as part of this project included the following:

- SDMI IfSAR digital elevation model (DEM) and orthorectified radar imagery (ORI);
- 2009 IKONOS imagery covering the Gold Hill project area orthorectified using IfSAR DTM as horizontal and vertical control;
- 2008 BLM aerial imagery orthorectified using IfSAR DTM and ORI as control;
- 1984 AHAP aerial imagery from USGS orthorectified using IfSAR DTM and ORI as control;
- Topographic contours and hill shades developed from IfSAR DTM for support of wetland mapping;
- Potential field verification points for investigation in support of wetland mapping.

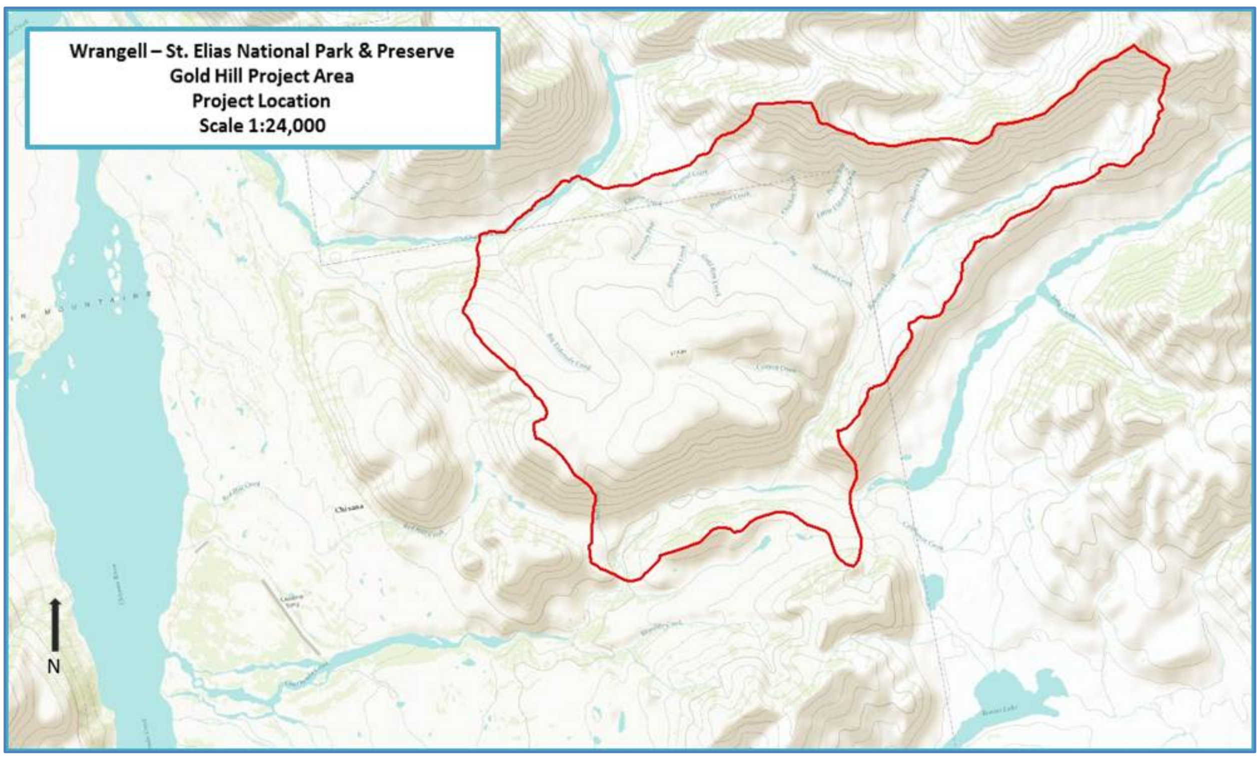

Figure 1. The project was located in southeastern Alaska and included approximately 46,000 acres in the Chisana Mining District of Wrangell – St. Elias National Park.

Phase 1: Image Analysis

Methods

This project used geospatial techniques and image interpretation processes to remotely map and classify wetlands within and adjacent to the Gold Hill project area of the Chisana Mining District in Wrangell-St. Elias National Park and Preserve. Wetlands were mapped according to the FGDC National Wetland Mapping Standard which included a Target Mapping Unit (TMU) of five acres or smaller, a feature accuracy of 98% and a classification accuracy of 85%.

The project was collaborative and dynamic including consultations in the planning, development and execution phases of the project between members of both the NPS and Saint Mary's University of Minnesota (SMUMN). The NPS provided guidelines, standards and research materials as well as local expertise for the project area. They also made available IKONOS satellite imagery and Bureau of Land Management aerial imagery for the project in addition to applicable spatial layers and reports for the Gold Hill project area. These imagery and collateral data sources were used to support image interpretation decisions related to wetland mapping and classification throughout the course of the project.

Saint Mary's University applied a geographical information system developed for wetland mapping and classification projects using a combination of digital datasets. Imagery from the Alaska High Altitude Photography (AHAP) program was acquired to further inform the mapping process. SMUMN provided technical expertise in wetland delineation from aerial imagery as well as the knowledge of wetland biology and hydrogeomorphic characteristics required to map and classify wetlands using the United States Fish and Wildlife Service Classification of Wetlands and Deepwater Habitats (Cowardin et *al*., 1979). All work efforts were completed following the Wetlands Mapping Standard established by the FGDC Wetland Subcommittee in 2009. Final data was submitted to the US Fish and Wildlife Service for inclusion in the National Map through the National Wetland Inventory master geodatabase and the National Park Service permanent spatial dataset.

Available Image Data and Image Selection

Primary imagery sources used for the study area came from a combination of aerial imagery supplied to Saint Mary's University by the NPS and other imagery acquired directly from federal sources by SMUMN. The NPS provided both IKONOS satellite imagery and Bureau of Land Management digital aerial photography of the project area and a GIS layer including park boundaries and the outline of the Gold Hill area and adjacent areas of interest.

Saint Mary's University acquired digital versions of AHAP aerial imagery from the US Geological Survey Earth Explorer website and digital elevation data from the Alaska Statewide Digital Mapping Initiative (SDMI) in the form of IfSAR digital surface models (DSM) and Orthorectified Radar Imagery (ORI). SMUMN staff also reviewed and selected relevant ancillary spatial data including available National Wetland Inventory (NWI) data, vegetation mapping, USGS topographic maps in DRG form and National Hydrography Dataset (NHD) features. Collateral data helped to define

upland/wetland boundaries and provided additional information needed to populate polygons with appropriate NWI attributes.

IKONOS Satellite Imagery

GeoEye IKONOS is a commercial earth observation satellite launched in 1999. It was the first satellite to offer publicly accessible high resolution imagery for mapping purposes. IKONOS images are available in one meter resolution panchromatic and four meter resolution multispectral bands. Over a period from 2005 to 2010, the NPS purchased IKONOS imagery coverage for several national parks in Alaska. IKONOS imagery covering Wrangell-St. Elias National Park and Preserve included both georeferenced and fully orthorectified images for almost the entire park extent. Complete coverage of the Chisana Mining District was only available in non-orthorectified imagery, however.

This imagery dataset was a composite mosaic of multi-date IKONOS images captured in 2007 and 2008 (Figure 2). The data was purchased by the NPS Alaska Region Inventory and Monitoring Program in 2010. Once orthorectified using IfSAR digital surface models, IKONOS imagery provided image analysts with a horizontal accuracy of approximately five meters, and data resolutions of one meter. The final image data was pan-sharpened, 4-band, multi-spectral with an effective mapping resolution of one meter. Image atmospheric distortion was minimal and image cloud coverage was approximately ten percent. There was sufficient cloud cover present on the imagery to occlude portions of the study area due to cloud location and shadow; rendering these areas un-interpretable. In addition, because the imagery dataset was compiled as a mosaic of multiple dates, color and tone balance change along image seam lines.

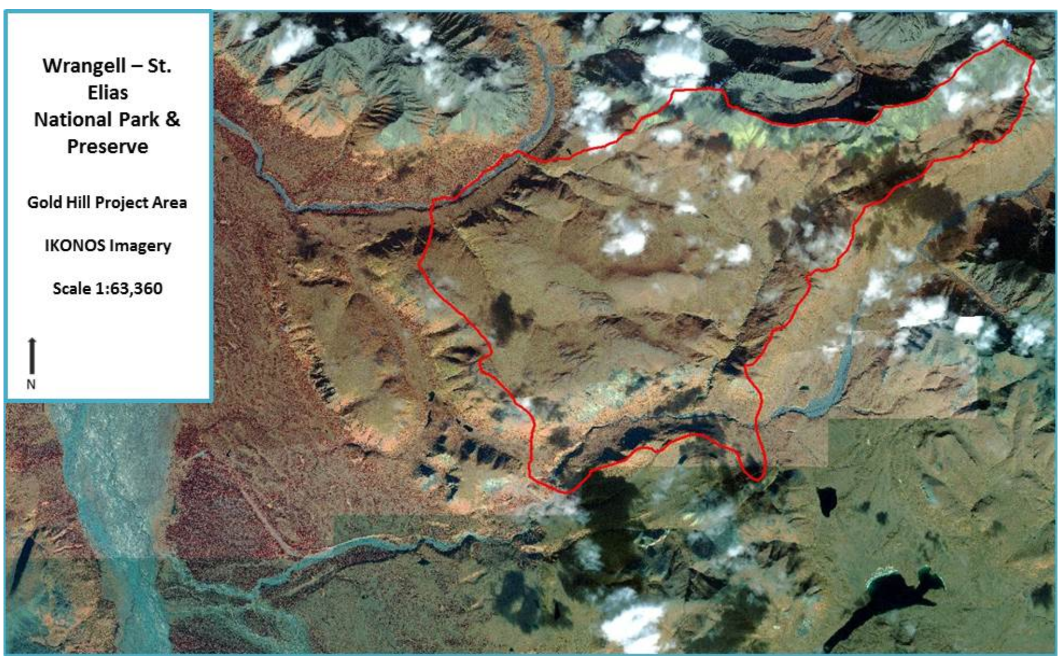

Figure 2. A composite mosaic of multiple IKONOS scenes provided by the NPS was used during the project. The Gold Hill project area within the greater Chisana Mining District is outlined in red. Cloud cover is present in several of the scenes.

SPOT5

The acquisition and processing of SPOT 5 imagery is currently underway as part of the Statewide Digital Mapping Initiative (SDMI) for Alaska (Figure 3). Source imagery is gathered by Spot Image Inc. and processed by Fugro Earthdata and Aerometric Inc. into multi-band, orthorectified, mosaiced and color balanced image tiles. SDMI acquisition of source SPOT data started in 2009 and is scheduled for completion by 2016. SPOT 5 is the fifth generation of SPOT (Système Pour l'Observation de la Terre) satellites. The satellite was launched May 3, 2002 from Guiana Space Center, French Guyana. The SPOT 5 platform has an oblique viewing capability with an adjustable angle of +/- 27 degrees. Some improvements over its predecessors include multiple image types with 10, 5 and 2.5 meter resolution and a wider acquired scene swath. SPOT 5 also has a high resolution stereoscopic (HRS) stereo viewing instrument which allows for simultaneous acquisition of stereo pairs. SPOT 5 sensors gather spectral bands in the panchromatic and multispectral (green, red, near-infrared, short-wave infrared) spectrum.

Ultimately, SPOT5 imagery will be available for the entire extent of Alaska through the SDMI acquisition program. Pilot projects already completed in other parts of the state have demonstrated that this imagery is of suitable resolution and emulsion for wetland mapping to the FGDC standard. Unfortunately, SPOT imagery was not available for the Chisana Mining District project area at the start of this project so image analysis was supplemented with other datasets.

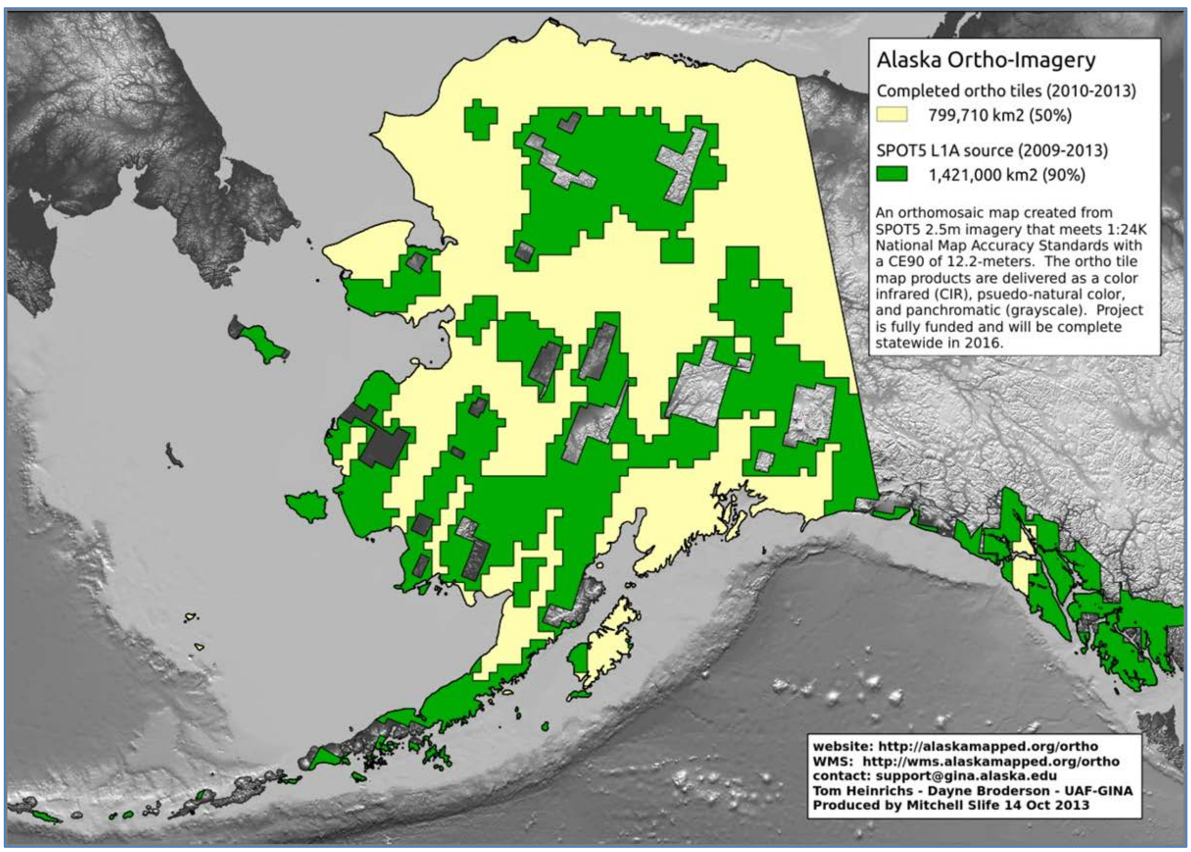

Figure 3. The status of Alaska's SDMI orthorectified imagery, anticipated for completion statewide in 2016. Source: AlaskaMapped.org.

<u>BLM Aerial Images</u>

In 2008 the Bureau of Land Management (BLM) captured true color aerial imagery at scales of 1:24,000 and 1:3,000 in support of environmental impact studies within the Chisana Mining District. This imagery covered the Gold Hill project area and was available from the NPS in non-georeferenced digital format (Figure 4). Images were captured in late summer (August) and were ice and snow free with vegetation in full leaf-on condition.

The BLM imagery did not represent the best data source for wetland mapping in the Chisana Mining District project area. Even though the acquisition scales were of sufficient detail, the true color emulsion and smooth tones and textures evident in the digital scans did not provide sufficient differentiation between wetland and adjacent upland for mapping purpose. Further there was considerable variation in color and tone across individual image frames which made it difficult for the image analyst to establish consistent signature descriptions for wetland features when transitioning between photos. Finally, the BLM imagery was not available in orthorectified form and the volume of orthorectification processing required in order to establish complete image coverage at the 1:3000 scale (approximately 200 frames) was too much for the available project budget.

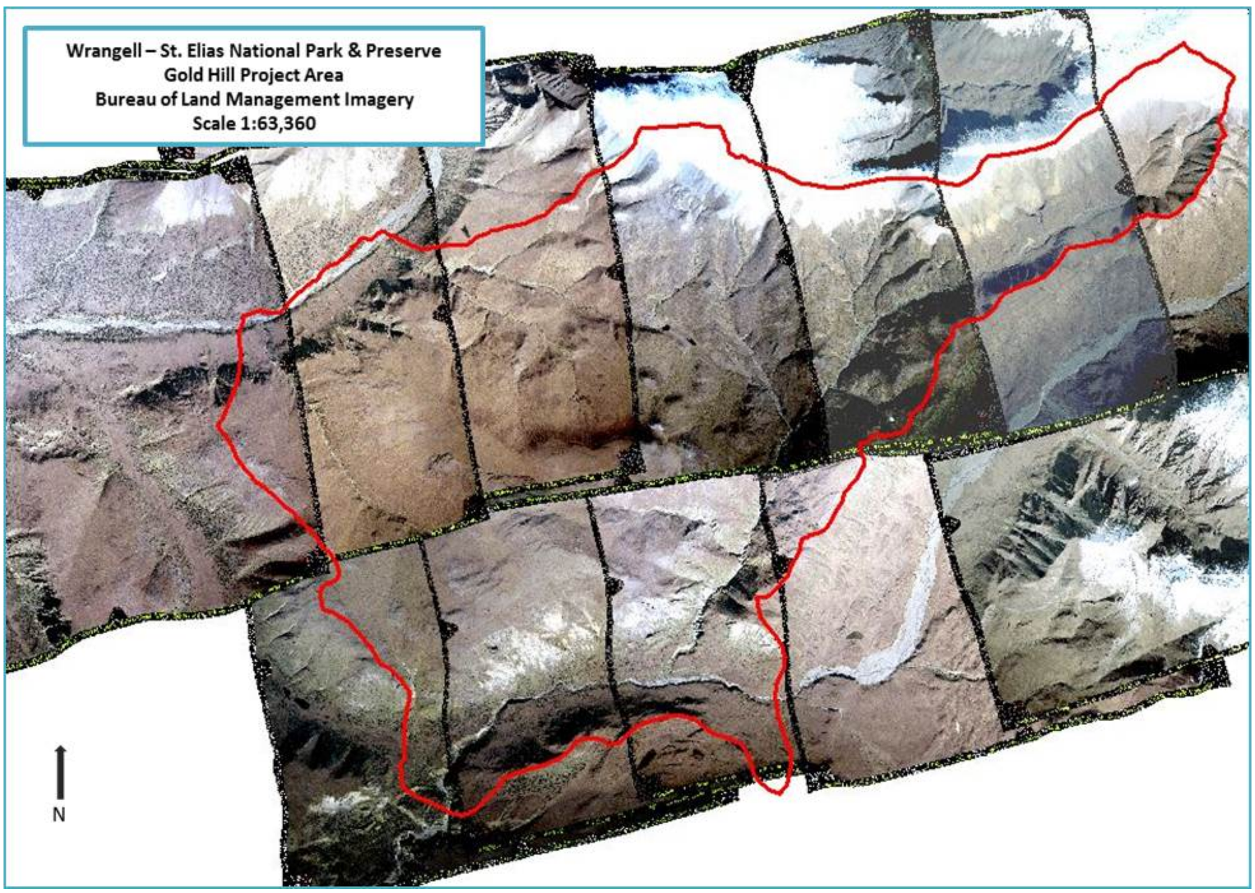

Figure 4. Aerial images captured for the Bureau of Land Management in 2008.

AHAP

Alaska high altitude aerial photography (AHAP) of WRST was captured in the 1980s as part of a statewide aerial image acquisition program (Figure 5). The 1:63,360 scale images used in this project were available from the USGS in digital format, scanned at a resolution of 300 dots per inch. Typically imagery that is used for wetland delineation and classification is scanned at resolutions greater than 1000 dots per inch to preserve the fine detail of the original photography. Unfortunately, over the years many of the original hardcopy prints of AHAP imagery have been lost and the only easily accessible digital copies were the low resolution scans from USGS.

AHAP aerial images were typically collected during mid to late summer so that plant communities would be exposed as much as possible, given typical seasonal conditions. This high resolution imagery allowed the image interpreters the use of photographic texture as a key to distinguish saturated wetland from upland. In the study area, upland knolls and other areas appeared to have a "rougher" texture than adjacent herbaceous wetland, possibly due to thermokarst slumping. When corroborated with topographic contours and/or DEM derived hillshades, upland/wetland interfaces were correctly delineated. However, because of the spectral properties and lower resolution scanning of this imagery, saturated and seasonally flooded wetlands were less distinctive and difficult to differentiate from each other, and also from surrounding upland. Moist soils and surface water were generally not visible during mid-summer when vegetation was more likely to obscure the ground's surface.

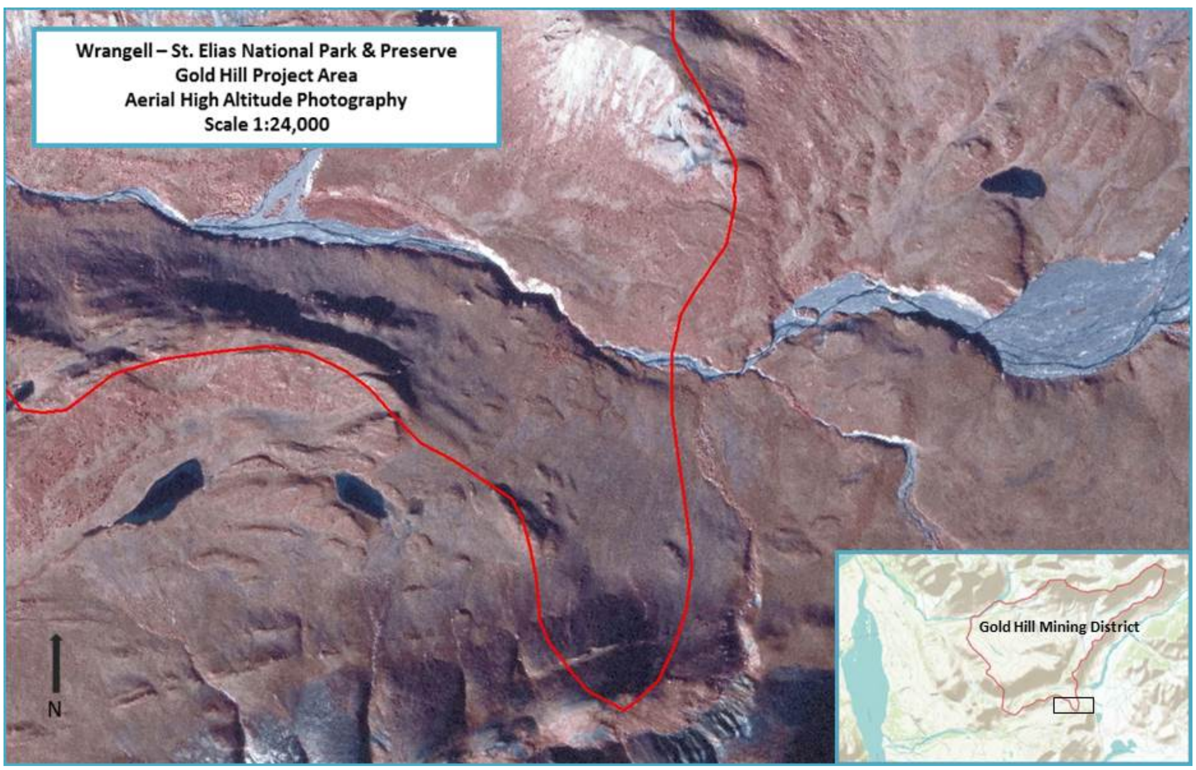

Figure 5. AHAP imagery captured in the 1980s of Chathenda Creek located in the project area.

IfSAR DTM and ORI

Several agencies in Alaska have been working to update topographic information as part of the Statewide Digital Mapping Initiative program. In recent years the application of interferometric synthetic aperture radar (IfSAR) technology has helped to produce digital products including an updated digital surface model (DSM), digital terrain model (DTM), and orthorectified radar image (ORI). The DSM is a first return image that contains topographic features such as vegetation and man-made structures. The DTM is an elevation dataset corrected for terrain; vegetation and buildings have been removed and bare earth is displayed. An ORI resembles a visible spectrum black and white image and is produced by radar backscatter signals as opposed to visible light. This updated elevation information from SDMI provides an opportunity for increased accuracy in new mapping projects within Alaska.

Since the inception of the SDMI project in 2008, IfSAR elevation products have been acquired for approximately 35% of Alaska. This coverage includes almost 24 million acres of NPS lands with the northern 25% of WRST and also the Chisana Mining District as part of the dataset (Figure 6). The IfSAR elevation datasets have the equivalent of five meter spatial resolution, a vertical accuracy of approximately three meters and a horizontal accuracy averaging twelve meters. One of the most important opportunities created by the availability of this data is the application of IfSAR DTM data for georeferencing and orthorectification of existing aerial imagery. The horizontal and vertical accuracy of this data is significantly better than previously available base data sources for Alaska.

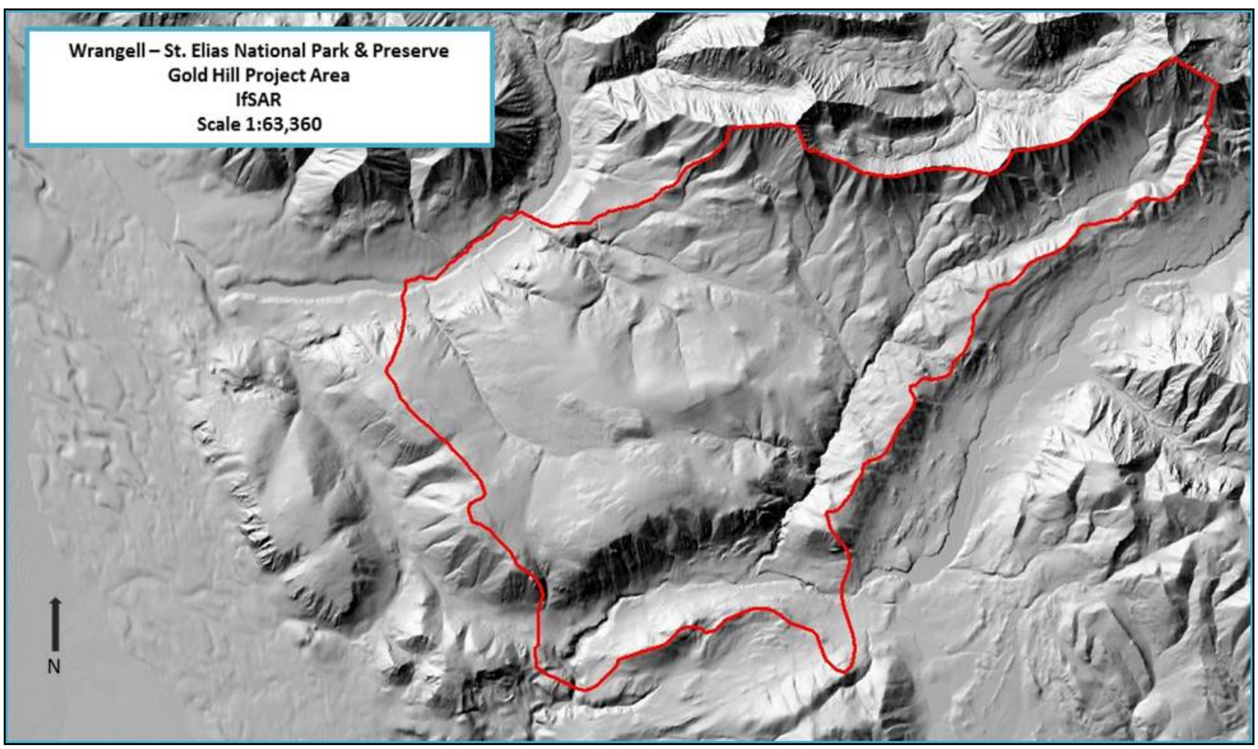

Figure 6. IfSAR data provides a new state wide elevation model for use as collateral data in mapping projects.

Georeferencing and Orthorectification of Imagery

A total of twenty aerial images were georeferenced and orthorectified for use as the wetland interpretation base on this project. Of these, five frames were AHAP imagery and fifteen were BLM imagery. In addition, IKONOS imagery for the study area was georeferenced and orthorectified using new IfSAR digital elevation data to provide consistency between image products for decision support.

Georeferencing is the process by which known ground control points are used to provide geographic reference for a scanned aerial image. This process involves choosing ground control points from an existing digital base map reference layer; identifying those same points on a scanned aerial photo; and, then assigning the coordinate value for the control point on the base layer to the equivalent point on the scanned image. A minimum of five control points are required for basic georeferencing; however, for most of the scanned aerial photos in this project fifteen or more points were used to improve the accuracy of the georeferencing process.

Because GPS-derived ground control points were unavailable for use in the georeferencing; all control points were registered from the base imagery. Geographic registration of available image sources for this project required additional control due to the mountainous terrain and various flight-line altitudes that were used in these sets of photography. NPS worked cooperatively with SMUMN to identify and resolve problems associated with processing over the course of the project.

The primary base image layer used for this project was IKONOS 1 meter resolution, 4 band, TIFF imagery. When IKONOS images were made available with rational polynomial coefficient (RPC) files, images were run through an automatic orthorectification process in the ESRI ArcGIS program utilizing high resolution IfSAR DEM for improved locational accuracy. The RPC file contained a sensor calibration model which stored vital information in an *xxx_rpc.txt* file. This file included the satellite ephemeris data required for accurate georeferencing of the image. The RPC data, combined with an IfSAR DEM of higher resolution than what was used originally, created a more accurate base image to georeference the scanned photography against.

The base data that was used for georeferencing on this project was primarily the IfSAR ORI image. Where sufficient geographic control could not be derived from the ORI imagery, control points were extracted from the georeferenced IKONOS imagery as a supplement.

The final step in the digital conversion process was to *orthorectify* the georeferenced aerial images. Orthorectification was the process by which a digital elevation model (DEM) and camera calibration reports were used to correct image displacement caused by topographic variation and camera lens aberrations. This processing ensured that scanned images resided in both their correct topographic and geographic space. The primary input for the orthorectification process involved the use of a digital elevation model (DEM).

Quality control was managed in several different ways. During the georeferencing phase, the amount of error associated with the selection of individual control points was monitored and points that had too much error were eliminated from the final rectification. In addition, as mentioned previously, an

average of fifteen to twenty control points were chosen per photo in order to ensure that spatial correlation was the best possible.

A second, quality control review was conducted on every photo following the orthorectification process. This review was completed in digital form within ArcMap by displaying the corrected scanned aerial photo on top of the base layer that was used for deriving the control points used in the georeferencing process. The locations of random features that were visible on both images (e.g. rivers, lakes, mountain peaks, etc.) were then visually reviewed and measured to determine the amount of relative shift in feature position between the base layer and the georeferenced photo. These shifts typically ranged from two to thirty meters and were dependent on a variety of photo characteristics including topographic variation, proximity of measured features to the photo edge, accuracy of the base layer used for georeferencing and adequacy of control point selection. When excessive shift was encountered, the image was reassessed and additional control points were added to achieve a better fit between the base image and orthorectified image.

<u>RMS Error Summary</u>
For every orthorectified image, a text file was generated to document the approximate error of the georeferencing process. Root Mean Square (RMS) error values were used as the metrics to assess a level of accuracy. RMS values examined the consistency across all the control points and produced a numeric value the analyst used to determine if control points provided a favorable geo-location for the resulting output image. Essentially, a high RMS error caused more shift and less overall accuracy in the output georeferenced image. High RMS errors required the deletion and re-entering of control points to bring RMS error down to an acceptable level. Typical Root Mean Square errors for areas georeferenced to the IfSAR and IKONOS imagery were between 5 and 12 meters.

Orthorectified photos were in the projection Alaska Albers for delivery. All aerial photographs were georeferenced to North American Datum of 1983 (NAD83-CORS96 or CORS94) and as further specified below.

```
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GEOGCS["GCS_North_American_1983"],
DATUM["D_North_American_1983"],
SPHEROID["GRS_1980",6378137,298.257222101],
PRIMEM["Greenwich",0],
UNIT["Degree",0.0174532925199432955],
PROJECTION["Albers"],
PARAMETER["False_Easting",0],
PARAMETER["False_Northing",0],
PARAMETER["Central_Meridian",-154],
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PARAMETER["Latitude_Of_Origin",50],
UNIT["Meter",1].
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Collateral Data Sources

Collateral datasets typically consist of hardcopy maps, photographs, scientific reports, and spatial databases that provide insight into the ecological and anthropogenic conditions of the project study area. While not created primarily for wetland mapping purposes, various datasets provide additional information which image interpreters may use to support wetland delineation and classification decisions during the mapping process. Records of this type are particularly valuable for projects on which there is insufficient funding for the interpreter to visit the project study area during the course of the mapping exercise.

For this project, primary collateral data sources used by the image analyst included: park-wide landcover derived from analysis of thirty meter resolution LANDSAT satellite imagery; site specific information from an OHV trails data layer; USGS topographic DRG layers; National Hydrography Dataset (NHD); and, a NPS report produced specifically for the Gold Hill area known as the "Monitoring Report for Access to Mine Claims in the Gold Hill Area in Wrangell-St. Elias National Park and Preserve, Alaska," (Cook and Mullen, 1990). Methods used to utilize the information from these additional resources are described in more detail below.

<u>WRST ABR Landcover</u>

The Wrangell-St. Elias Land Cover Mapping Project was a National Park Service project completed in 2008. Project accomplishments included the creation of digital information for the vegetation throughout Wrangell – St. Elias National Park and Preserve. Resulting spatial layers of the park's land cover continue to be used for various monitoring programs throughout the park. This digital layer provided some ancillary information for use by the image interpreter while mapping the wetlands in the Gold Hill project area of the Chisana Mining District. Information about the types of vegetation is useful in the identification of hydric soils and hydrophytic plant communities for use in wetland delineation and classification.

<u>Existing NWI</u>

National Wetland Inventory data was available for select portions of the Park and Preserve adjacent to the McCarthy and Nabesna Road corridors. This data was created by Saint Mary's University of Minnesota using aerial imagery and IKONOS satellite data in 2008. While this dataset was somewhat removed geographically from the project area, it did provide some value as a reference to expected wetland types and locations for this project.

ATV Trail Locations and Descriptions

As noted, the Off Highway Vehicle (OHV) trail data was one of the primary collateral data layers used for this project. The OHV data was provided by the NPS and this trail data indicated surface hydrology and vegetation for specific points (Figure 7). Unfortunately, the site specific nature of these data points and small geographic footprint of the associated trail features limited the value and utility of these points for wetland mapping from aerial and satellite imagery. The "Monitoring Report for Access to Mine Claims in the Gold Hill Area in Wrangell-St. Elias National Park and Preserve, Alaska," (Cook and Mullen, 1990), noted that OHV trails in the project area confirmed that wetlands occurring along the OHV trail were very narrow, ranging from 15 to 60 meters. These features were too small to discern using the project imagery.

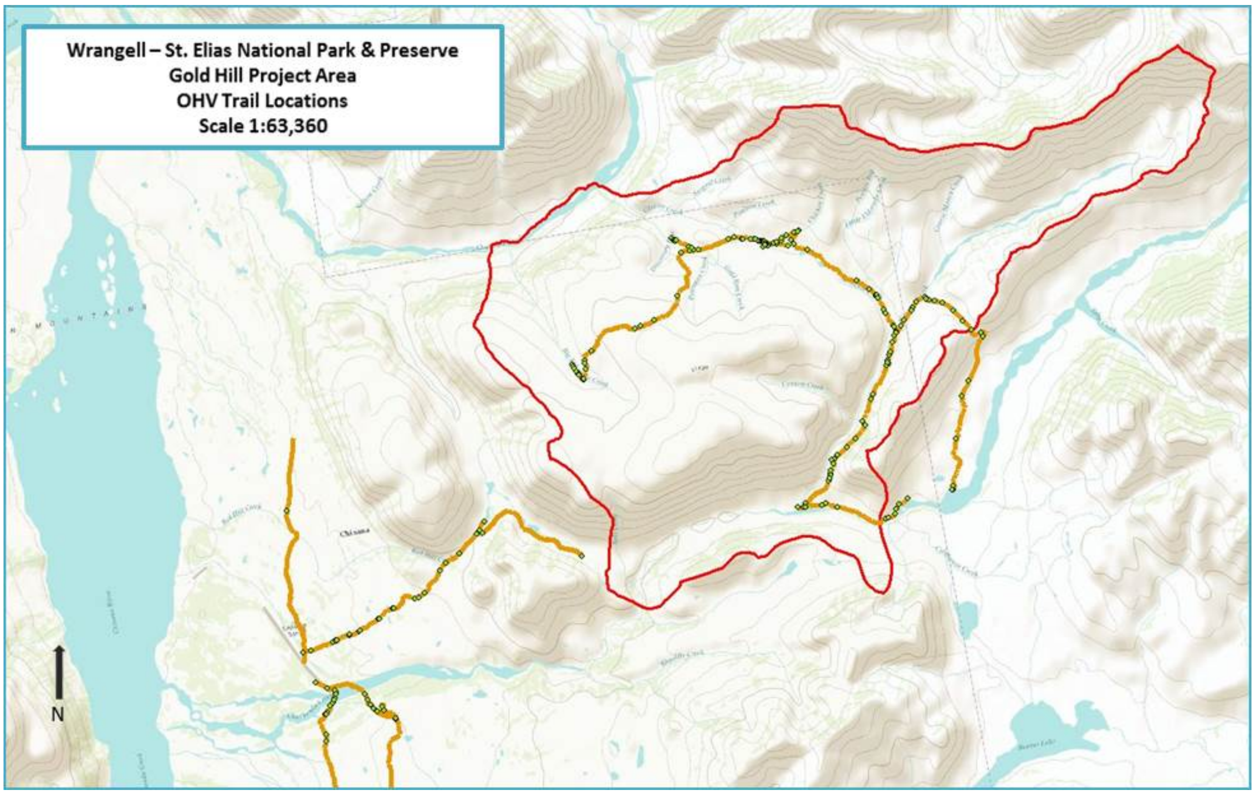

Figure 7. The attribute table for the OHV Trail Features layer as well as a monitoring report provided by the NPS noted surface hydrology for specific locations in the project area. These areas, however, could not be discerned as wetland from aerial or satellite imagery.

Vegetation Transects from Mining Report

The "Monitoring Report for Access to Mine Claims in the Gold Hill Area in Wrangell-St. Elias National Park and Preserve, Alaska," (Cook and Mullen, 1990), contained vegetation, soil, topographic and hydrologic summaries for numerous survey transects within the project study area. These transects were established as permanent sample locations to monitor and quantify specific and cumulative environmental impacts along surface access routes to mining claims in the Gold Hill area. Unfortunately, due to the site specific nature of these linear transects, it was impossible to correlate this information to locations and signatures on the project imagery.

DRG and NHD

Additional digital layers used during the project included Digital Raster Graphics (DRG) and National Hydrology Data layers provided from the United States Geological Survey (USGS). The DRG data showed 100' contour intervals throughout the project area and also documented steep vertical relief. The NHD data layer did not, however, include typical hydrological symbols (e.g. marsh), except for streams.

Elevation Datasets – Exaggerated Hillshade and Contours

Hillshade images are not a part of the IfSAR data download from SDMI; however, they were readily created in ArcMap when necessary. Hillshade images are used as a collateral elevation source to aid the image analyst in identifying surface depressions, water flow paths, terrain breaks and other features indicative of potential wetland landscapes. Base elevation values used to derive these hillshades can also be exaggerated to provide the image analysts with a clear picture of surface undulations and indicators of wetland potential.

Topographic contours have traditionally been an important collateral data source for wetland interpretation. These isolines representing continuous change in surface topography were also used for decision support in situations where the image signature alone was ambiguous. For this wetland mapping project, topographic contours were generated from the IfSAR DTM data using a ten foot interval. These contours were then used to assist the imager interpreter in understanding the landscape position of wetland and upland features throughout the study area.

Image Analysis (Photo Interpretation) Process

Given the size and relative inaccessibility of the project area, it was determined at the outset of the project that the most cost effective method of developing digital wetland data for the area was through image analysis. A variety of imagery was available for the area from numerous agencies and collateral spatial data used to support interpretation decisions was also accessible.

Unfortunately, the project budget was insufficient to allow the image analyst to travel to the project study area and inventory field check sites for corroboration of image signatures. A summary of the methodology typically employed for wetland mapping is provided for review. The challenges experienced in using imagery only for the Gold Hill project are discussed in the phase I results section

Wetland Mapping Basics

For many years, the primary method of developing cost effective wetland mapping over large geographic areas has been the interpretation of remotely sensed imagery. Image interpretation (IA) is defined as the art of analyzing terrain features as recorded on aerial or spaced based imagery and, through deductive reasoning, developing thematic mapping based on those characteristics. Image interpretation techniques are based on three fundamental assumptions:

- Remotely sensed imagery is a record of the longtime natural and man-made processes which are reflected on the image as surface features;
- The surface features on an image can be grouped together to form patterns that are characteristic of particular environmental conditions; and,
- The environmental conditions and their reflected patterns are repetitive; that is, similar environments will produce similar image patterns while different environments will usually produce different image patterns.

The terrain elements that collectively produce patterns on remotely sensed imagery include: topography (surface geometry); vegetation; regional drainage; local erosion; and anthropogenic features. All of these elements are essentially interrelated; however, they can be separated through interpretation to facilitate analysis, description, evaluation and classification of thematic features (such as wetlands) that are visible on an image.

Interpretation of remotely sensed imagery is a subjective process. Before attempting to interpret terrain characteristics and thematic features, the interpreter must understand the properties inherent in the images themselves (emulsion, tone, texture and scale). In addition, because image characteristics relate most strongly to physical science, the interpreter must have and understanding of the basic concepts of climatology, geomorphology, geology, ecology, and hydrology. Deductive reasoning, based on the physical characteristics of the imagery being assessed and the scientific characteristics of the terrain elements that are represented on the image, allows a skilled interpreter to develop and map thematic information from remote sensing.

The advent of digital spatial data and Geographic Information Systems (GIS) technology has provided image interpreters with a suite of tools that can be used to support and enhance the process of deductive reasoning that leads to thematic mapping. For the most part, imagery is now available in digital form which provides interpreters with considerably more flexibility in the examining and reasoning process. In addition, GIS technology provides interpreters with the ability to load and assess various types of collateral scientific data that can be used to support and inform interpretation decisions (e.g. topography, soils, hydrology, vegetation, ground samples etc.). Finally, digital techniques also provide the potential to automate certain portions of the interpretation process (e.g. delineation and classification of obvious terrain elements such as open water) and allow the human interpreter to focus on decisions that require extensive deductive reasoning.

Traditional Mapping Methodologies in Alaska

Wetland and deepwater habitat mapping in Alaska by the NWI has, since its inception, relied upon ground-truthing to assure quality accurate information. The process for capturing (mapping) the data, however, has changed dramatically. Traditional interpretation of aerial photographs starting in the late 1970's, involved hand-drawing wetland/upland boundaries and labeling wetland classifications on clear acetate overlays taped to nine inch by nine inch aerial photographic frames. Technical drawing pens filled with India ink were the primary drawing instruments.

Photos were viewed and interpreted using 3X magnification power mirror stereoscopes that required overlapping frames to view imagery in three dimensions. Three dimensional views provided aerial photographic interpreters with an enhanced view of topography, vegetation profile (structure, silhouette), vegetation height, and wetland drainage pattern.

Completed line-work was then transferred to a stable Mylar base by cartographic technicians. Cartographic technicians would again hand-draw the photo interpreter's line-work and labels from the smaller format photographs to large format frosted Mylar, taped to hard-copy, 1:63,360 USGS Quadrangle Topographic Maps using a Zoom Transfer Scope (ZTS). This provided a stable base from which hand-drafted data was converted to digital form through table digitization.

Over time, conversion of hand-drawn wetland boundaries and labels gave way to computer-based heads-up digitizing using scanning, orthorectification and georeferencing processes. In 2004, the first large scale heads-up wetland mapping project was initiated in Alaska to map portions of the Yukon-Kuskokwim Delta (Y/K Delta) (Robertson et *al*., 2014).

The Y/K Delta project utilized various traditional methodologies including: pre-mapping site visits to confirm image signatures, development of photo interpretation conventions, interpretation and classification of wetlands from high resolution aerial imagery, and post mapping field validation. However, all of the interpretation and mapping work was completed in a digital environment using scanned, orthorectified aerial imagery and heads-up digitizing. Time and cost savings resulting from the adoption of these digital processes were significant with data production times decreasing by up to fifty percent.

Color infrared aerial photography (CIR) acquired in 1984 by the Alaska High Altitude Photography Program (AHAP) was used in initial mapping phases of the Y/K Delta. This color-infrared, 1:60,000 scale emulsion provided the contrast needed to differentiate wetland and upland signatures. However, due to changes in landscapes and land cover, and incompatibility with newer technology this imagery is out of date. It remains useful as a collateral data source and for trend analysis purposes.

Increasingly over the past two decades, satellite imagery has become the baseline source for wetland mapping. Satellite imagery has good utility for this purpose and traditional methods developed for use with aerial photography work equally well when applied appropriate (i.e. high resolution, false color-infra-red or true color, cloud and snow free, atmospherically corrected, orthorectified) satellite images.

Central to accurate mapping of wetland and deepwater habitat, acquired from either aerial or spaced-based platforms, is the field verification of imagery signatures. Wetland habitat types in Alaska (and indeed in most jurisdictions) can be very complex with mixes of vegetation types; different durations, types and frequencies of tidal influences; varying landscape positions; and, fluctuating periodicity of inland ponding, flooding, and/or soil saturation. These variables change frequently across all landscapes and, along with variability resulting from conditions present during date of acquisition and differences in image processing; significantly affect the spectral properties of aerial and space-based imagery.

Field verification procedures consist of comparing imagery to on-the-ground conditions in order to determine whether a signature represents wetland, deepwater habitat, or upland at pre-selected sites. Questions are also answered as to appropriate wetland classifications for commonly encountered or "typical" signatures as well as anomalous or "atypical" signatures. Imagery characteristics and their corresponding, site specific, physical features are documented in the field using NWI Field Data Forms (Appendix A).

The accuracy of this ground-truth information is further corroborated (validated) through consultations with local wetland experts, USFWS-NWI staff and biologists from a variety of agencies who are familiar with the project study area. Each site is documented using a standard field data sheet on which wetland and deepwater habitat signatures are described in detail. Image signatures consist of one or more keys; color, tone, texture, pattern, association, and shadow. Associated physical evidence including hydrological observations, dominant plant species, soil properties, and collateral information are recorded.

This field information is then compiled into a document of "Photointerpretation Conventions." These standards are a listing of Cowardin classifications encountered in the field, their signatures, and general physical descriptions (dominant plant species, water levels). These conventions serve to guide image interpreters throughout the course of the project and ensure mapping consistency and accuracy. An example of PI Conventions developed for a previous mapping project for the Bristol Bay area is available as an example (Appendix B).

Interpretation is conducted in a fully digital, heads-up environment using GIS software. For many projects, image interpreters will capture both polygonal wetlands (those large enough to be area features at 1:18,000 scales) and linear wetlands (those too small to be captured as areas at 1:18,000 scale). Periodic examination of interim data and feedback is solicited from local resource experts as part of the project quality assurance procedures. Mapping specialists (imagery interpreters and data processing analysts) conduct internal quality assurance to ensure mapping protocols are being followed. They also perform quality control tasks to eliminate remaining errors of omission and commission.

Quality control of digital data includes additional procedures to ensure topologically clean digital data. Generally, the daily and weekly self-run quality assurance and quality control steps involve: explosion of polygons, geometry examinations including the fixing of null features and erroneous attribution as well as the removal of polygons not exceeding minimum quality assurance and quality control standards.

Subsequently, data is prepared for entry and fixes are performed for appearance, topology errors, attribution inconsistencies, anomalous landscape positions and additional format errors. Signature mapping differs slightly from traditional mapping efforts as interpretation is restricted to a generally accepted on-screen zoom scale convention of 1:18,000.

Results and Discussion

Creation of Spatial Datasets

Products for Phase 1 of the project included the following:

- Creation of a digital spatial layer documenting current wetland location and classification for the project area and meeting FGDC National Wetlands Mapping Standard;
- Polygonal and linear wetlands classified according to Cowardin et al. (1979);
- Georeferenced and rectified spatial files in a GIS database using NAD83 datum and Alaska Albers projection;
- FGDC compliant metadata for the GIS geodatabase;
- Provision of full spatial data to the NPS;
- Brief technical report detailing processing methodology and accuracy assessment in the NPS NRSS format.

The primary objective of this project was to create an updated digital spatial layer documenting current wetland location and classification. Wetlands were digitally mapped and classified using the Federal Geographic Data Committee (FGDC) national Wetlands Mapping Standard which calls for a minimum Target Mapping Unit (TMU) of five acres, 98% feature accuracy and 85% classification accuracy. This objective was achieved for the approximately 46,000 acre project study area.

Adherence to the 1:63,360 National Map Accuracy Standard of +/- 32 meters for horizontal accuracy in the wetland data was achieved through the use of IKONOS imagery and IfSAR elevation data for georeference and orthorectification. In fact, the use of the higher quality IfSAR DEM and the incorporation of IKONOS satellite ephemeris data in the rectification process generally led to horizontal RMS errors of between 5 and 12 meters. In addition, the selection of between 15 and 20 control points per photo and the care taken by editors when selecting these points contributed to improved georeferencing.

In total, 1,453 acres of polygonal wetland were mapped for the project in the Chisana Mining District (Figure 8). Linear wetland mapping totaled approximately 20.5 miles. Wetland types in order of dominance included: riverine (80%); palustrine vegetated (14%); palustrine open water (5%); and, palustrine unconsolidated shore (1%).

It was anticipated at the beginning of the project that palustrine vegetated wetlands located on saturated slopes would form a large component of wetlands in the study area. This was not the case primarily because these wetlands were very difficult to reliably delineate from the project imagery without field sample points that correlated ground conditions to image signatures.

Table 1. Summary of Polygonal Wetland Data

Wetland Type	Count	Acres	Percentage
Riverine	24	1163	80%
Palustrine Emergent	18	206	14%
Palustrine Unconsolidated Bottom	45	70	5%
Palustrine Unconsolidated Shore	6	15	1%
Totals	93	1453	100%

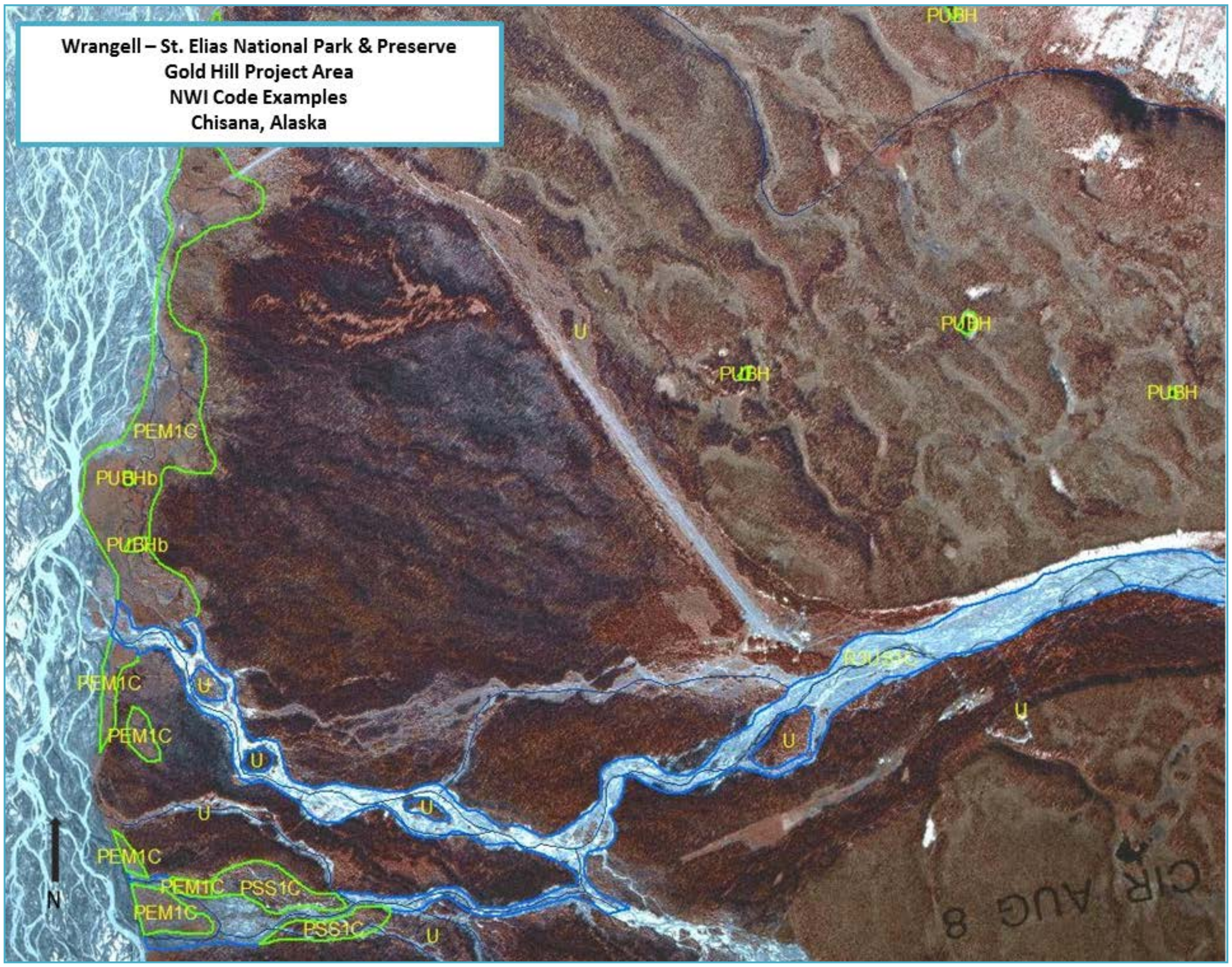

Figure 8. Example of NWI delineation and classification completed near Chisana, Alaska.

Image Analysis
Several challenges were encountered in the image analysis process for this project which resulted in a less comprehensive wetland data layer than was envisioned at the outset of the work. These challenges were primarily related to the quality of the project imagery for wetland delineation and classification which was exacerbated by the subtle differences between vegetated wetlands and wetland/upland sites on elevated slopes within the study area. Various collateral datasets were reviewed in an attempt to clarify some of the questions that arose from subtle image signatures, densely vegetated areas, and permafrost dominated landscapes. Unfortunately, due to the site specific nature of most of these collateral datasets, they did not provide useful information for the mapping process.

IKONOS Imagery
Wetland interpretation and classification from IKONOS imagery of the Chisana Mining District project area was limited by several factors including: image emulsion; ubiquity of wetland and upland signatures; cloud cover plus shadow; and, inconsistencies between mosaiced images. The most significant limitation was the subtlety of change in image signatures between wetland and surrounding upland especially on gradual slopes dominated by either dwarf shrub or herbaceous vegetation. In these areas it was difficult for the image analyst to confirm whether the image tones typically associated with wetland features were a result of soil saturation and standing water (wetland) or bare ground (talus, fine gravels, bare rock etc.) visible through the vegetative cover. This was a consistent challenge across the project area, even when collateral indicators, such as location in or adjacent to a wetland drainage pattern, were true (Figure 9).

Figure 9. Chavolda Creek in the project area viewed with IKONOS imagery; the imagery was limited by several factors, most significantly the subtlety of change between wetland and upland image signatures.

AHAP Imagery

Wetland data was created using 1984 AHAP imagery. AHAP, since it was derived from digital scans of hardcopy aerial images, provided a more consistent presentation of surface features than IKONOS imagery (Figure 10). The imagery was also cloud and shadow free with a balanced near-infrared emulsion. Unfortunately, while this imagery did provide a more 'interpretable' base with additional detail for wetland delineation, signatures were still very subtle and transitions between wetland and upland were difficult to discern. As stated previously, collateral information from sources, such as wetland symbols from USGS DRG's or known wetland locations from published reports were of minimal assistance.

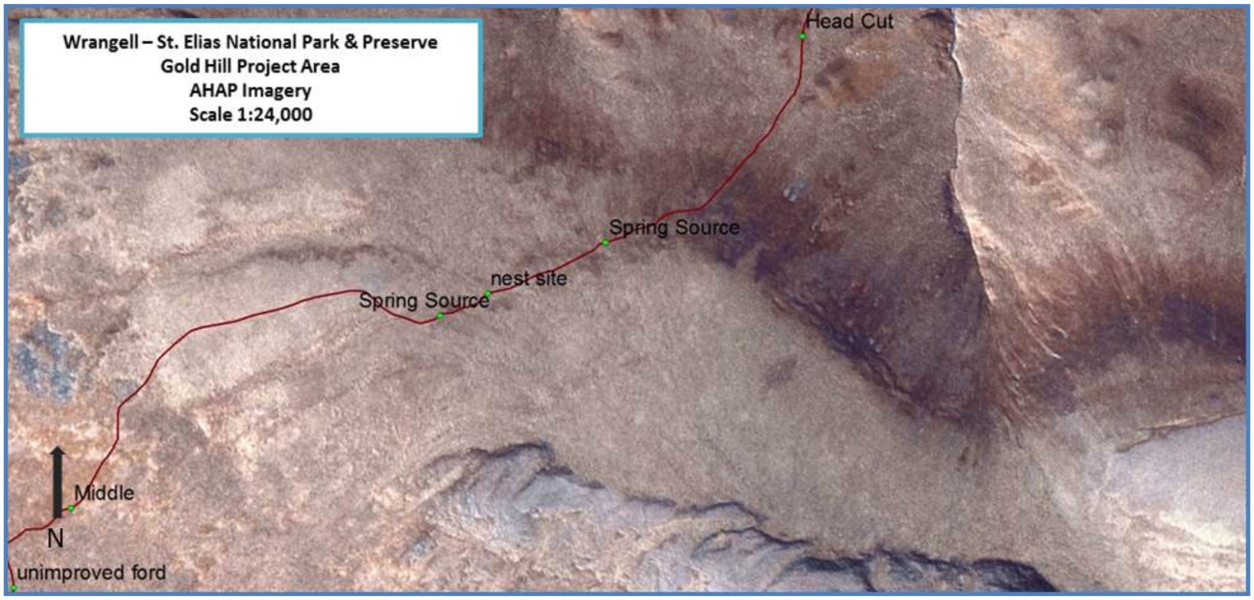

Figure 10. The AHAP base imagery provided a more consistent presentation of surface features than available IKONOS imagery. Location shown is along the Big Eldorado trail.

A NWI wetland type that was consistently captured (Figure 11) was floodplain occupied by Cobble-Gravel (R3US1C). Larger distinctly grey signatures in a wetland drainage pattern were identified, delineated and classified. A few small open water ponds (PUBH) were also captured.

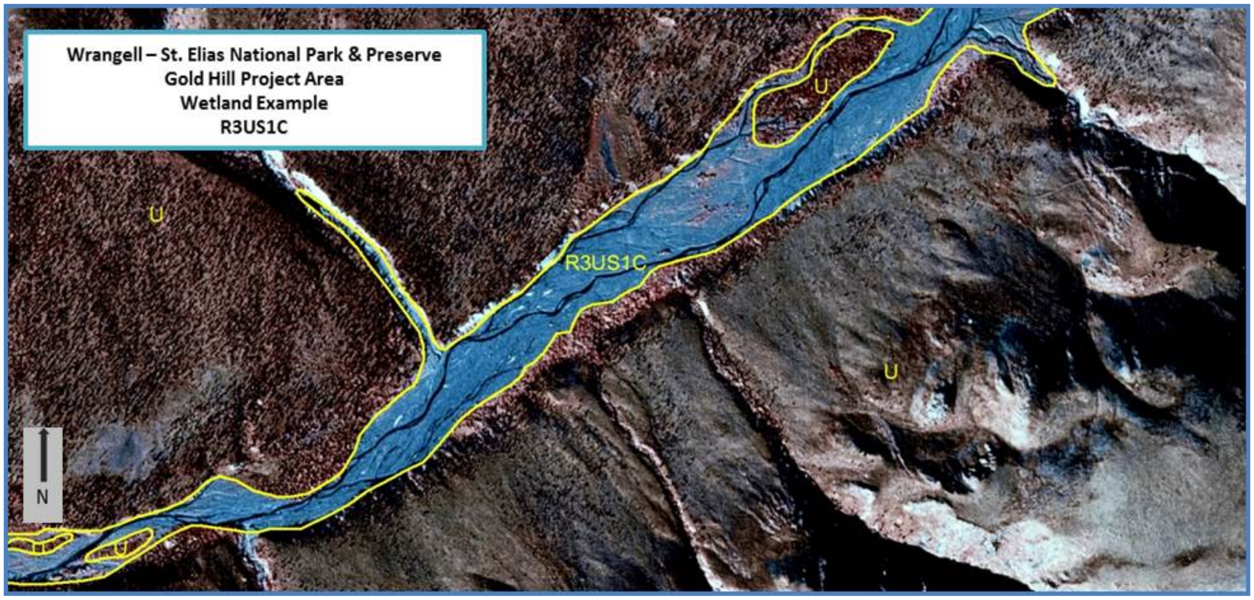

Figure 11. The NWI code for this Riverine, Upper Perennial, Unconsolidated Shore, Cobble-Gravel Floodplain occupied by cobble-gravel substrate is R3US1C.

Phase I Conclusions

Mapping and classification of wetlands from remote sensing imagery in the Chisana Mining District project area was challenging. The landscape was characterized by large river valleys, vegetated slopes and significant changes in elevation. Aerial and space-based image types that were available for wetland interpretation all exhibited the same characteristics that challenged image analysts, the relative ubiquity in image signatures between wetland and upland landscapes. Collateral data sources were of limited use in guiding the image interpretation process due to the fact that they were either too site specific (e.g. know wetland locations from published reports) or too general (e.g. marsh symbols from USGS topographic maps). Strategies were considered for implementation of Phase 2 of the project and included:

1. The establishment of a network of field observations correlating known wetland locations to image signatures on the project base imagery (Figure 12).

2. The utilization of image interpretation conventions derived from field investigations.

3. The acquisition of hardcopy AHAP aerial images in either print or diapositive format for the project area. Due to the photographic production process, these images may provide greater detail for support of wetland delineation and classification decisions.

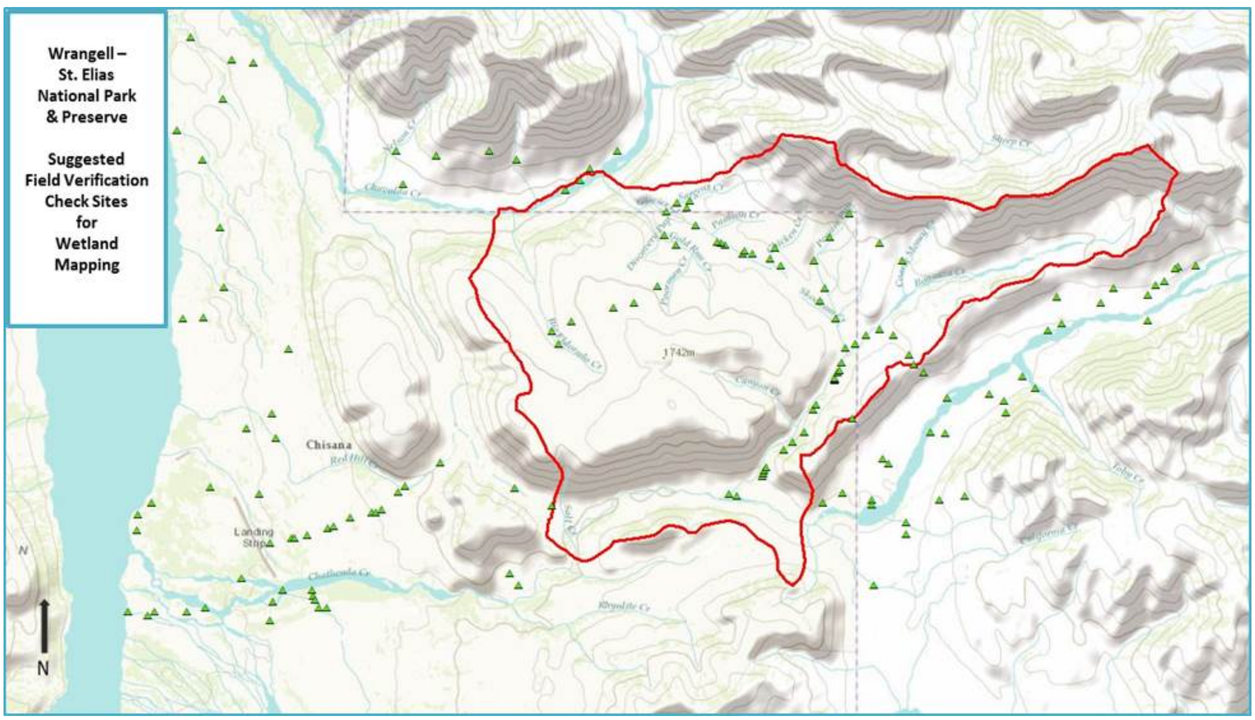

Figure 12. Displayed are recommended field observation points correlating known wetland locations in the project area which might be used in the development of relevant Photointerpretation Conventions.

Phase 2: Field Verification and Mapping

At the conclusion of the first phase of this project, it was recommended that the wetland delineation and classification process for the Gold Hill project area could be enhanced if supported by field investigations. It was further recommended that researchers conduct a series of field visits to predetermined sites which exhibited typical and atypical wetland signatures on the project imagery. Data collected from those sites would then be used to compile a set of image interpretation conventions for guidance on the re-interpretation of wetlands for the project area. Phase two of this project represented the implementation of those recommendations.

Methods

The project was collaborative and dynamic and included consultations in the planning, development and execution phases between members of both the National Park Service and Saint Mary's University of Minnesota. The National Park Service provided guidelines, standards and research materials as well as local expertise for the project area and logistical support for the fieldwork. SMUMN GSS provided technical expertise in wetland delineation from aerial imagery as well as the knowledge of wetland biology and hydrogeomorphic characteristics required to map and classify wetlands using the United States Fish and Wildlife Service Classification of Wetlands and Deepwater Habitats (Cowardin et al., 1979). All work efforts were completed following the Wetlands Mapping Standard established by the Federal Geographic Data Committee (FGDC) Wetland Subcommittee in 2009 (FGDC, 2009).

Acquisition of Available Image Data and Image Selection

Primary imagery sources used for the study area came from a combination of aerial imagery supplied to Saint Mary's University by the NPS and other imagery acquired directly from federal sources by SMUMN. The NPS provided both IKONOS satellite imagery and Bureau of Land Management digital aerial photography of the project area as well as a GIS layer including park boundaries and the outline of the Gold Hill area and adjacent areas of interest.

Saint Mary's University acquired digital versions of AHAP aerial imagery from the US Geological Survey Earth Explorer website and hardcopy original prints of these photos from the National Park Service Alaska Regional Office. Digital elevation data was acquired from the Alaska Statewide Digital Mapping Initiative (SDMI) in the form of IfSAR digital surface models (DSM) and Orthorectified Radar Imagery (ORI). SMUMN also reviewed and selected relevant ancillary spatial data including available National Wetland Inventory (NWI) data, vegetation mapping, USGS topographic maps in DRG form and National Hydrography Dataset (NHD) features. Collateral data helped to define upland/wetland boundaries and provided additional information needed to populate polygons with appropriate NWI classification.

After reviewing all of the imagery available for the project area, it was determined that the AHAP imagery would provide the most suitable base map for wetland interpretation. This was because AHAP aerial images were typically collected during mid to late summer so that plant communities would be exposed as much as possible, given typical seasonal conditions. This high resolution imagery allowed the image interpreters the use of photographic texture as a key to distinguish

saturated wetland from upland. In the study area, upland knolls and other areas appeared to have a "rougher" texture than adjacent herbaceous wetland, possibly due to thermokarst slumping. When corroborated with topographic contours and DEM derived hillshades, the upland wetland interfaces were correctly delineated.

Field Verification in Wetland Mapping

The aerial photointerpretation (API) method, as applied to wetland mapping, is a process by which photographic signatures are delineated and classified in the NWI (Cowardin) Classification System. The Cowardin System has been established as the federal standard by the FGDC.

Wetland photo signatures are composed of one or more of the following signature keys; color, photographic tone or texture, association, stereoscopy, pattern, shape, and size (Avery, 1997). Wetland signatures were studied in the field and at API workstations so that they become systematically matched with the correct combinations of Cowardin System attributes. Photo signature recognition is critical for the delineation of wetland/upland boundaries and also when differentiating wetland types within larger wetland complexes.

<u>Fieldwork Preparation</u>

Check sites were considered prior to, and during, field verification (Figure 13). Check sites selected in the office, prior to onsite field work, were identified with a digital layer of geographic "points" created in an ArcGIS personal geodatabase. Digital AHAP imagery was visually scanned in this heads-up environment. Corresponding hard-copy prints also were nearly simultaneously viewed using a mirror stereoscope. Collateral spatial data consisted of digital raster graphic overlays.

Check sites were selected based on those wetland signatures/habitats that were found to commonly occur in the project area. Wetland habitats represented by unusual signatures that covered relatively large areas or where there was uncertainty as to the appropriate NWI Code (e.g. Scrub/Shrub or Emergent) were also selected. Finally borderline signatures that might represent either upland or wetland (i.e. darker signatures on slopes in mountainous areas) were chosen for review in the field. A list of questions to be answered at each site was concurrently developed with each selection.

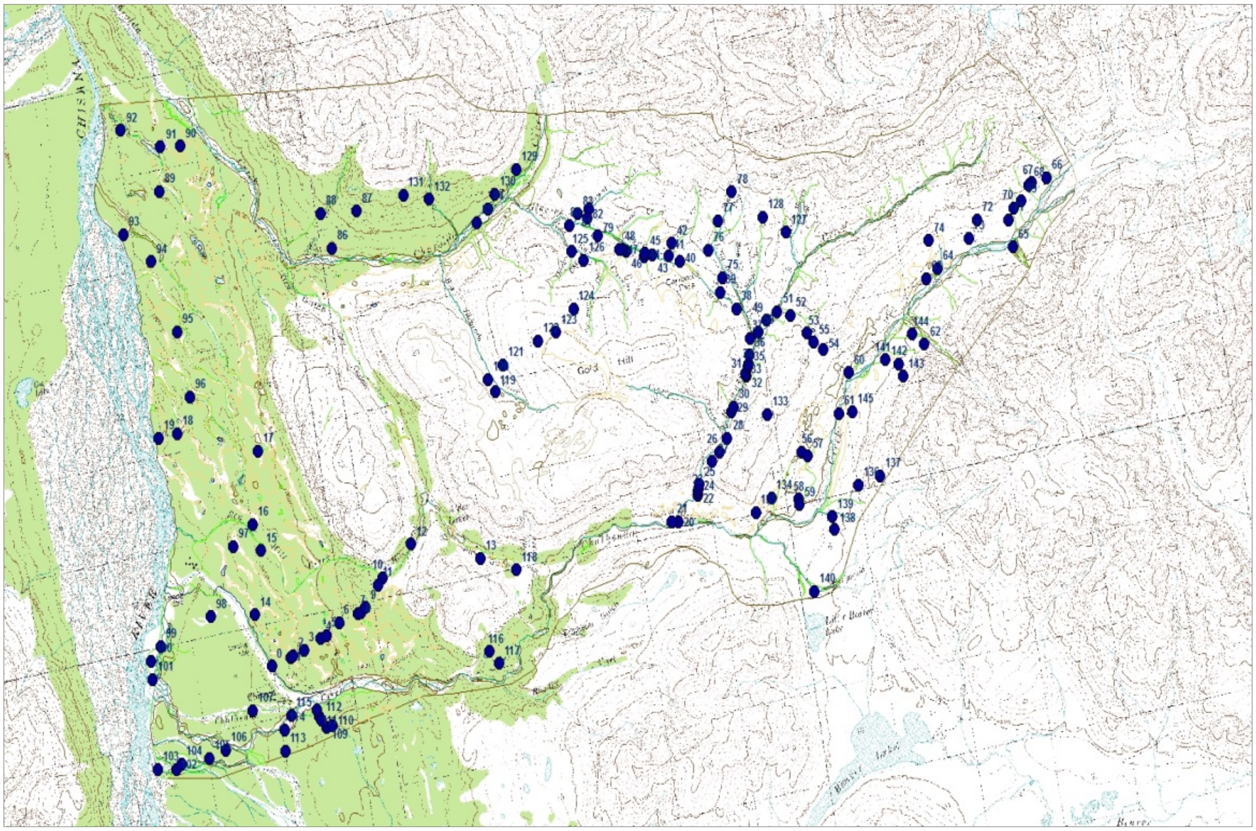

Figure 13**.** 145 check sites were considered prior to field visitation. Additional check sites were also selected in the field. For example, wetlands not clearly visible on aerial photography due to scale or emulsion were added as encountered.

<u>Field Data Preparation</u>

The base imagery and check site points annotated in numerical order were printed on eight and one-half by eleven inch paper and a photographic scale of 1:5000 (Figure 14). Corresponding coverages of USGS topographic maps were also printed and paired with appropriate image copies (Figure 15). All paper images were utilized during ground-truthing as primary data sources for correlation of the presence or absence of wetland and deepwater habitats to corresponding signatures (Figure 16).

Figure 14. Pre-selected check sites were noted with points and numbers in the field verification imagery. The inset figure (lower right) shows the general location (outlined in black) of this figure image within the context of the greater study block (outlined in purple).

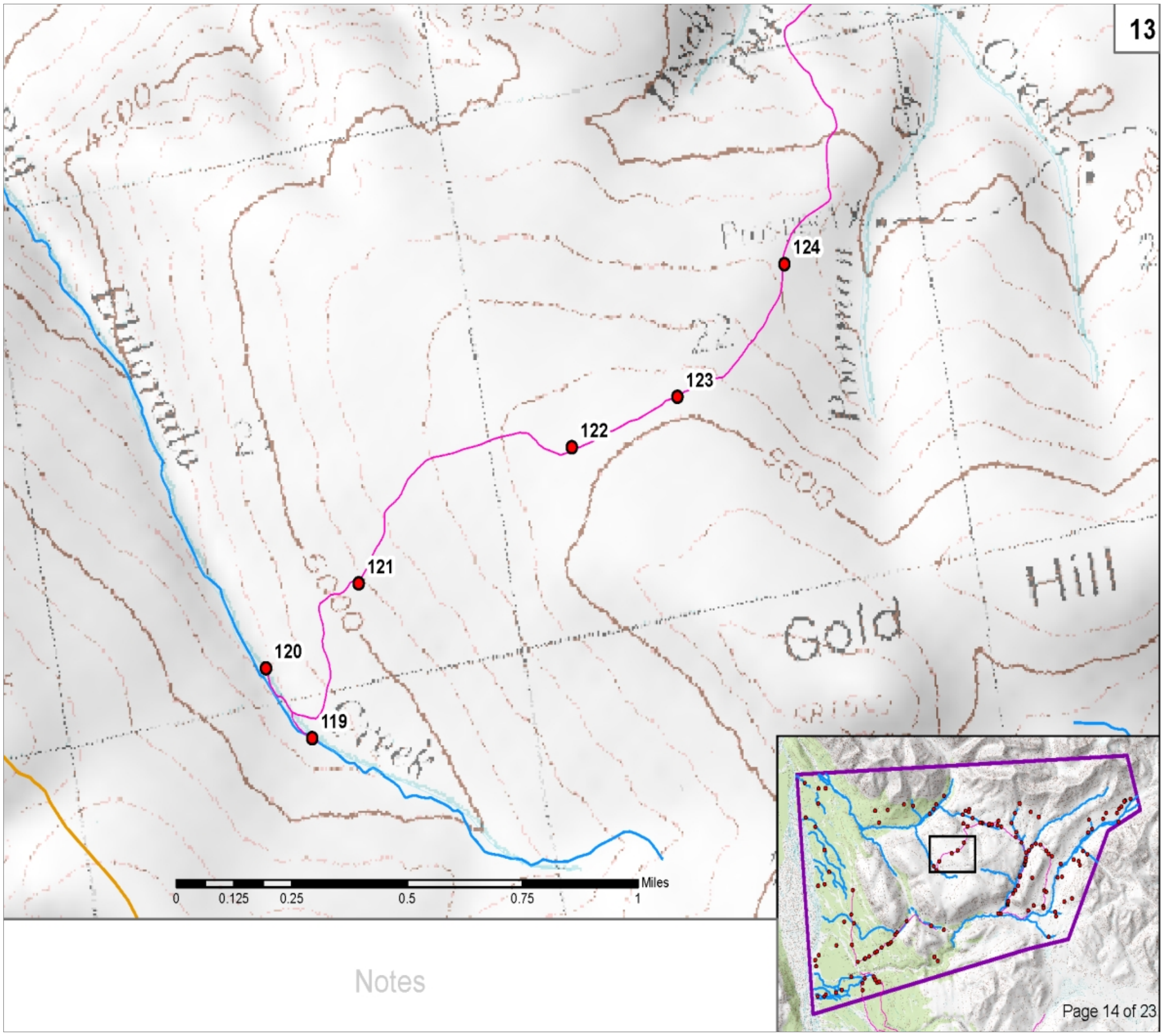

Figure 15**.** The figure above is an example of topographic data which corresponded to a small area portion of the AHAP imagery. The field check sites are noted with points and numbered. Topographic information provides important elevation and historical information.

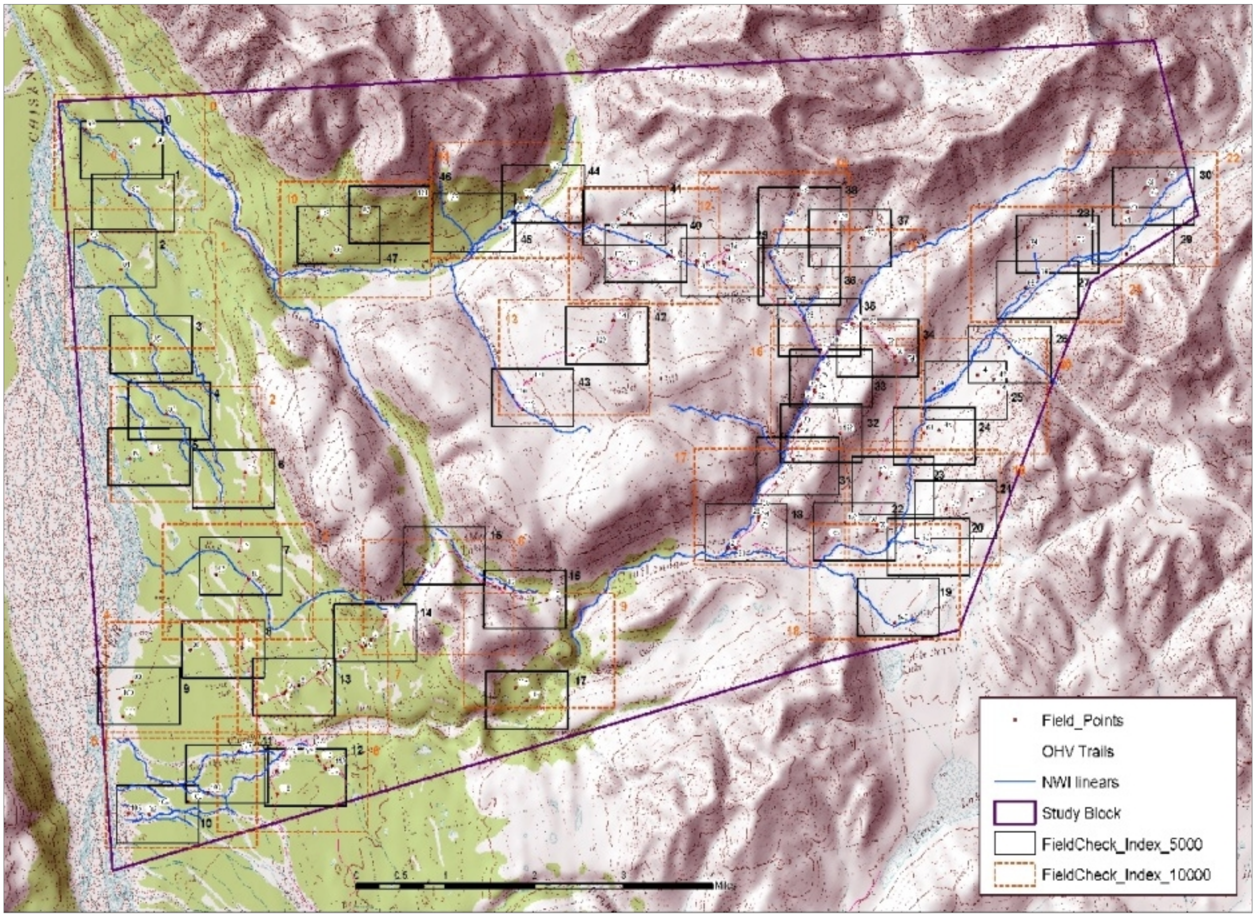

Figure 16. Overview of the entire study block showing locations of field images, topographic maps, and pre-selected field check sites.

Field Equipment

In addition to the large-scale images and topographic maps printed on paper, small scale (1:58,000) AHAP photographic prints were incorporated into the site selection, field verification, and photointerpretation process. AHAP photos were in nine inch by nine inch format with a physical coverage of approximately 16 square miles per frame (Figure 17).

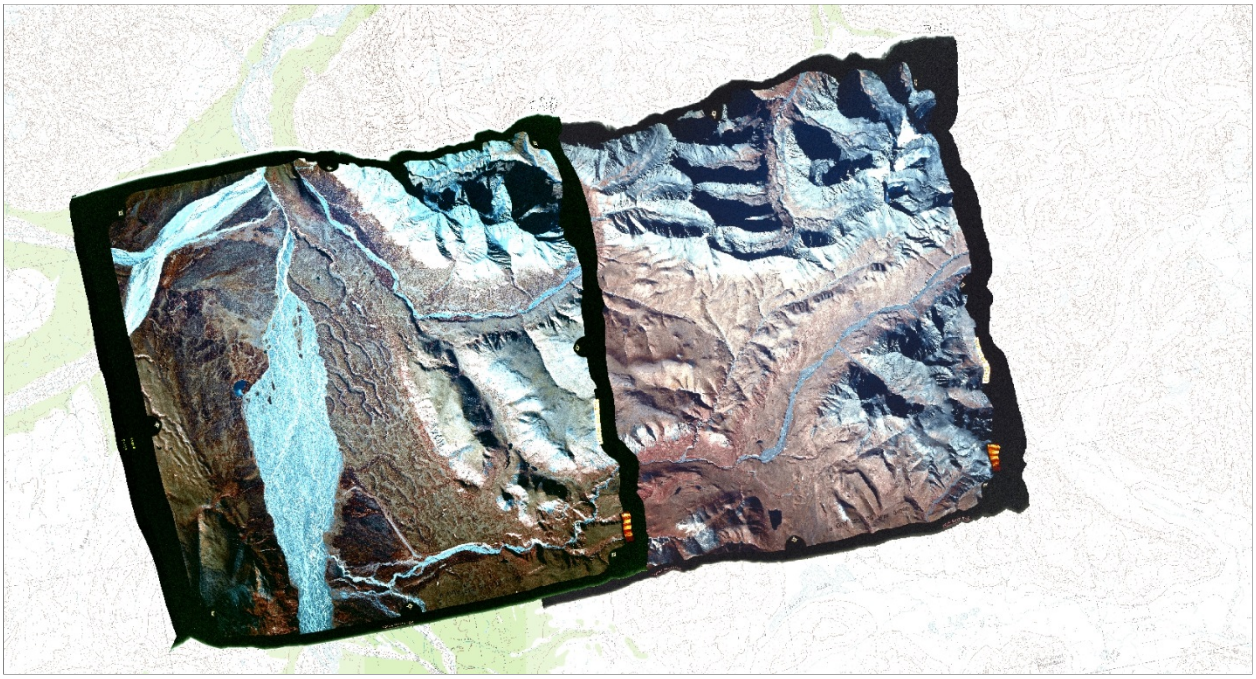

Figure 17. Example of AHAP (9”x9” format) aerial photographic coverage

Other field equipment used during the two day reconnaissance included a magnifying loupe for viewing aerial photographic prints, NWI Field Data Forms; Munsell soils color charts, plant field guides, spade, and clear plastic clipboard, permanent markers, and pens and pencils.

Field Verification

Field verification of wetland and upland signatures, via helicopter, consisted of navigating by sight to locations within the project area that the image analyst recognized as a distinctive wetland signature or as a marginal signature on the aerial photography (Figure 18). Marginal signatures included those the analyst was unable to distinguish between wetlands or uplands. The intention of each site visit was to verify the exact NWI classification of obvious wetland areas.

In some areas, wetlands were found in the field which had not been identified on the aerial photography. For these areas, wetland boundaries were delineated and classified on the AHAP print Mylar jacket during the field verification trip. As a result, many wetland areas were delineated and classified both during overflight and on site.

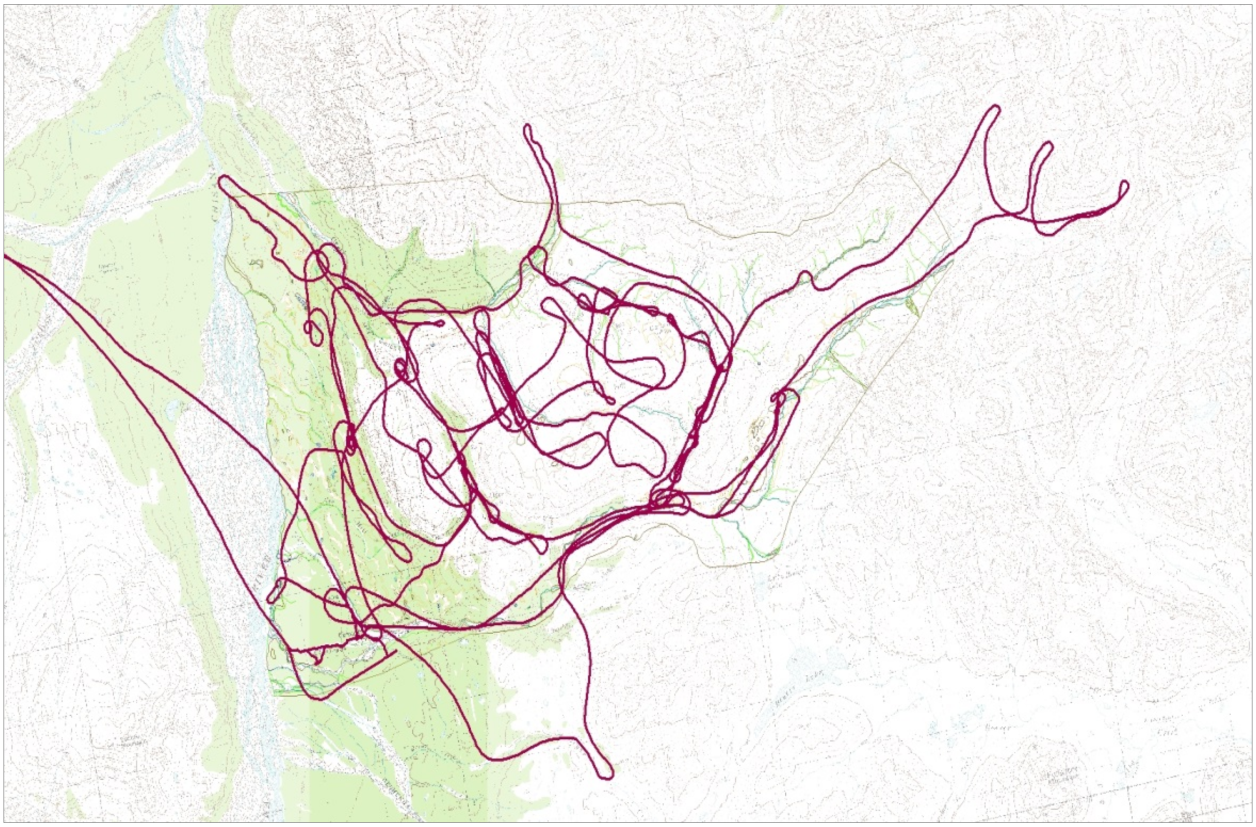

Figure 18. Helicopter tracks – July 21st and 22nd, 2014.

At each check site, the team of professional image analysts correlated imagery with their exact location and recorded its geographic coordinates. The team then made observations of water present at or near the ground surface and the predominance of hydrophytic vegetation and/or hydric soil (Figure 19). The base imagery was again closely examined and signature keys identified with the advantage of field verification. Each wetland site visited during the field trip was then classified in the NWI Cowardin System (Figure 20). This information was documented on NWI Field Data Forms (Figure 21). Geo-referenced ground-level photos were also taken of soil pits and plugs with cardinal directions from each pit to provide a landscape over view (Figure 22).

Figure 19**.** Example of a soil pit and Munsell color guide at one of the project's check sites.

Figure 20**.** Ground level photos were taken at each site visited. Here the analyst checked the soil with a spade and determined the area was a saturated wetland dominated by scrub/shrub (PSS1B).

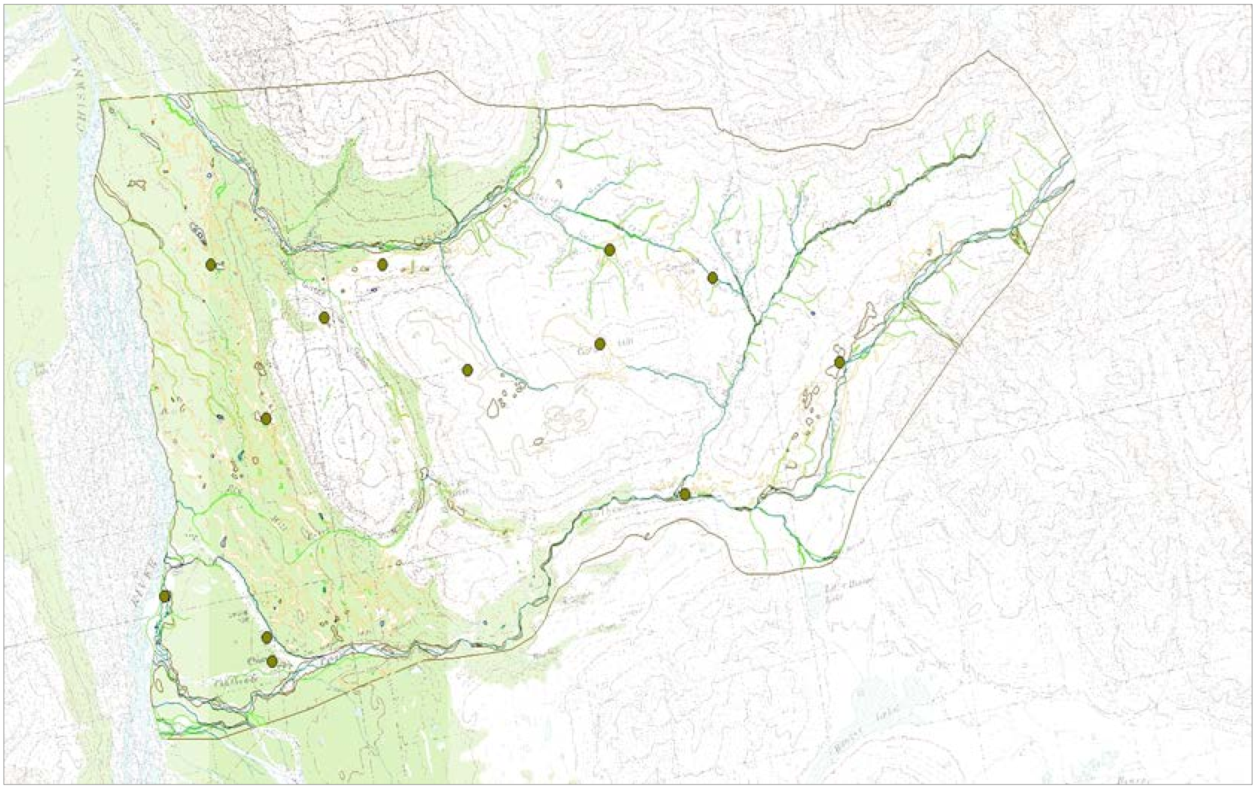

Figure 21**.** A NWI Field Data Form was completed for the above check sites visited during the field verification visit. Completed forms are available in the appendix (Appendix B).

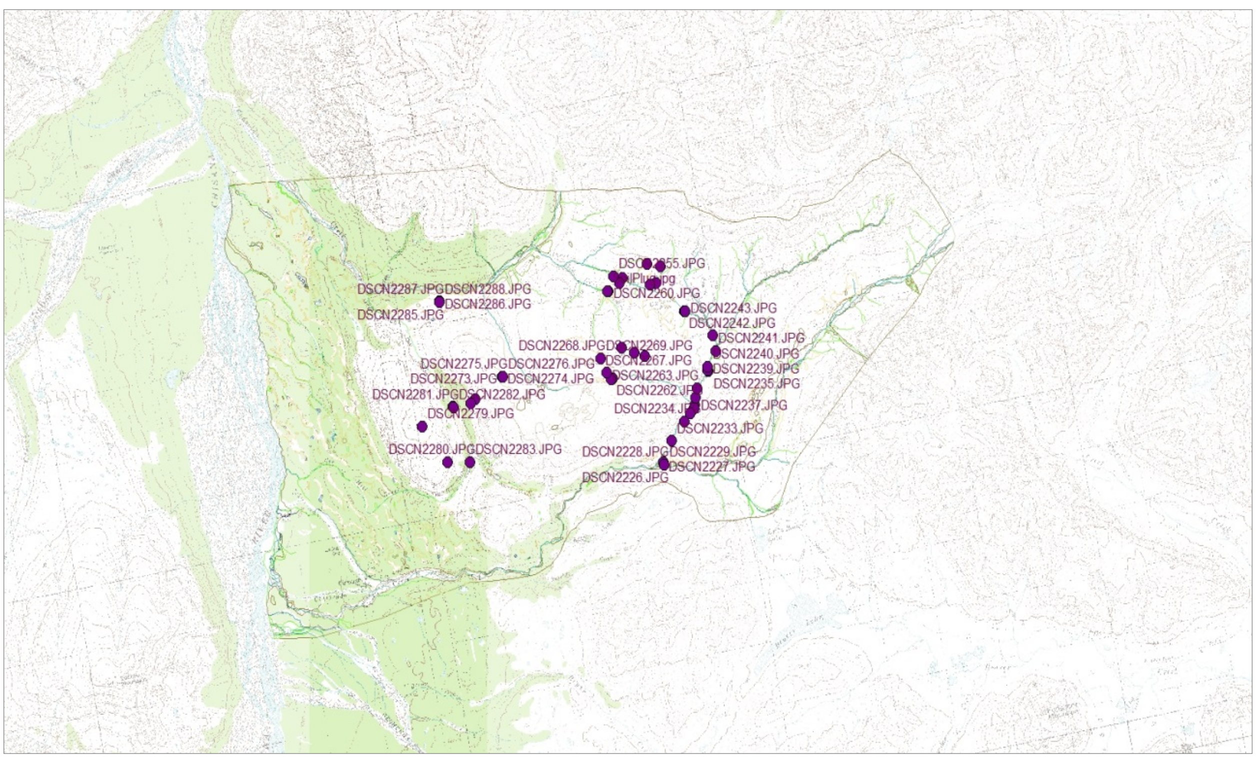

Figure 22. The exact location and direction of each ground level photo was documented.

Field Documentation

A standard NWI Field Data Form (Appendix C**)** was completed for 10 of the check sites. The data collected described the field conditions and composition of each area visited. The information collected included the GPS location, presence of wetland indicators, plant community and soil types, land use practices, disturbances, and, notable characteristics. Completed forms for each documented check site are located in Appendix D.

Interpretation Notes

The field verification process also involved post-trip processing in adherence to standards for the National Wetland Inventory program. A major objective of the field trip was to gather field information to assist the photo interpreter in understanding the regional uniqueness of an area being mapped. The interpreter also noted additional considerations that were then applied throughout the project (Appendix E). These guidelines helped to consistently delineate and classify the wetland features throughout the project area. Most of the interpretation calls were completed without difficulty while unique field circumstances required additional discussion with team members. A list of common wetland classifications and their associated photo signatures was utilized. Additional considerations included information from both historical and collateral datasets.

Image Analysis

Hardcopy Stereo and Heads-up

API was conducted in a heads-up environment using ArcGIS, version 10.2. Hard copy AHAP imagery was viewed three dimensionally using a Bausch and Lomb mirror stereoscope at a side-by-side work station (Figure 23). A photointerpretation scale of 1:5,000 was determined to be optimal as it was close to the interpretative scale used by the National Wetland Inventory. The three dimensional viewing was informative, especially when micro-topography was present (i.e. hummocks) or when plant life forms where unclear (i.e. herbaceous versus shrub or shrub versus trees). The three dimensional viewing also helped to identify the boundaries of wetland drainage patterns viewed on slopes.

Figure 23. A mirror stereoscope was used during the API process. Photo courtesy of SMUMN/GSS.

Collateral Data

In addition to AHAP stereo coverage and field data, Digital Raster Graphic (DRG) topographic map and Digital Elevation Model (DEM) "Hillshade" overlays were the spatial data sets available as collateral. DRG and Digital Elevation Model slope, aspect, and elevation data and DRG land cover symbols (e.g. marsh, forest, over wash) provided confirmation of the existence or classification of wetland in many areas.

Wetland Delineation and NWI Classification

Following the field visit, SMUMN analysts completed the wetland delineation and classification across the entire study block. Collateral GIS data, field derived decision rules, team and wetland expert input and established Photo Interpretation Conventions were incorporated to ensure accuracy and consistency of the wetland database. The AHAP color infrared (CIR) aerial photography was viewed at a scale of 1:18,000. Wetland and deepwater habitat were delineated at a working scale of 1:5,000 on the computer screen using ArcGIS. The photo interpreter used these two platforms in concert throughout the API process.

After the wetlands were delineated, the image interpreter completed the classification for each feature using the NWI Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al., 1979). Written in alphanumeric code, the assignment of a classification was then recorded in the attribute table of the geodatabase. A quality assurance review was also completed, as standard on all wetland mapping projects.

Results and Discussion

Field Data Collection and Photos

Field data sheets were completed for select field verification check sites. These are available for review in Appendix A. Ground photos were also digitally captured at all field check sites. These photos provided additional resource information to the analyst upon return to the office environment.

NWI Data

The final NWI product as delivered was presented in the geodatabase as two areas within the project boundary. The Gold Hill Mining District of Wrangell St. Elias National Park was referred to in this report as the Gold Hill Study Area (Figure 24). This area was a subset found within the larger area known as the “study block”.

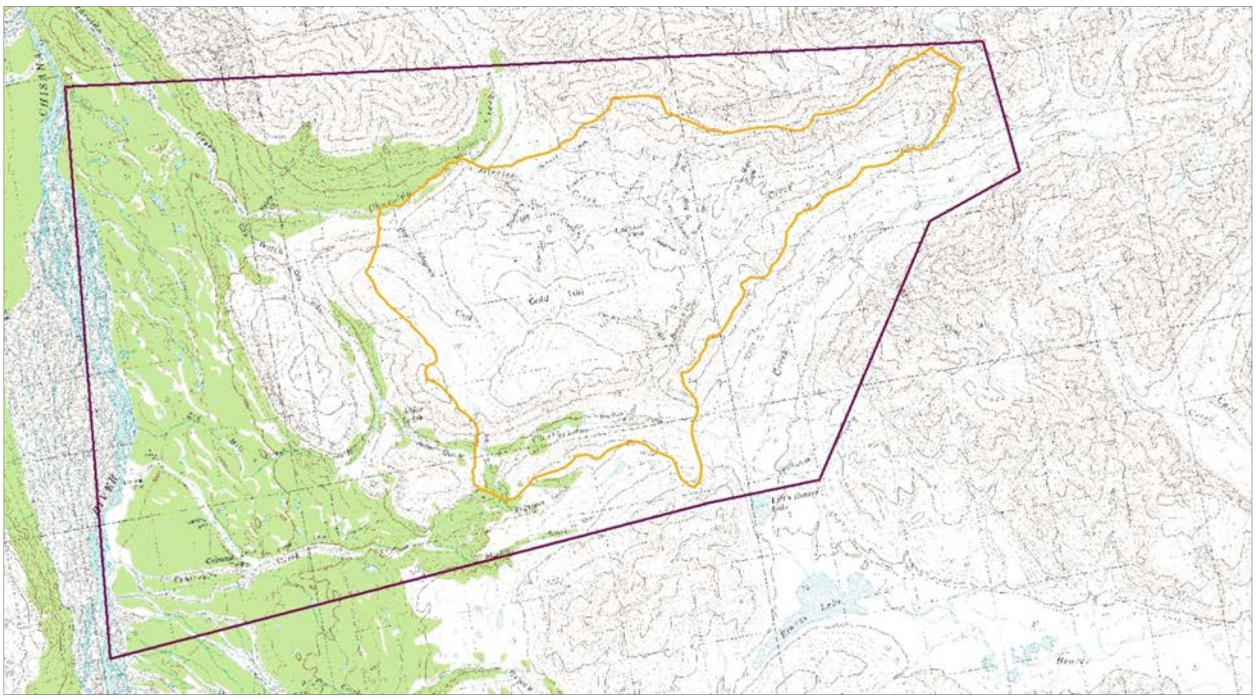

Figure 24. Gold Hill Mining District (outlined in gold) and the boundary of the study block (purple).

Gold Hill Mining District Wetland Summary

For the purpose of this report, wetland types were summarized below using the NWI classification system's "Water Regime Modifiers." Water Regime Modifiers describe the duration and timing of water at or near the surface. Three of the eight NWI Non-tidal Water Regime Modifiers were incorporated into alpha-numeric codes within the Gold Hill Mining District (Figure 25). The NWI Water Regimes included in the project geodatabase are Saturated (B), Seasonally Flooded (C), and Permanently Flooded (H). Wetlands and wetland complexes frequently have common Water Regimes but may be classified within different NWI Systems (e.g. Riverine or Palustrine). They may also have differing vegetation Classes (e.g. Forested or Scrub-Shrub) or Subclasses (e.g. Broad-Leaved Deciduous or Needle-Leaved Evergreen).

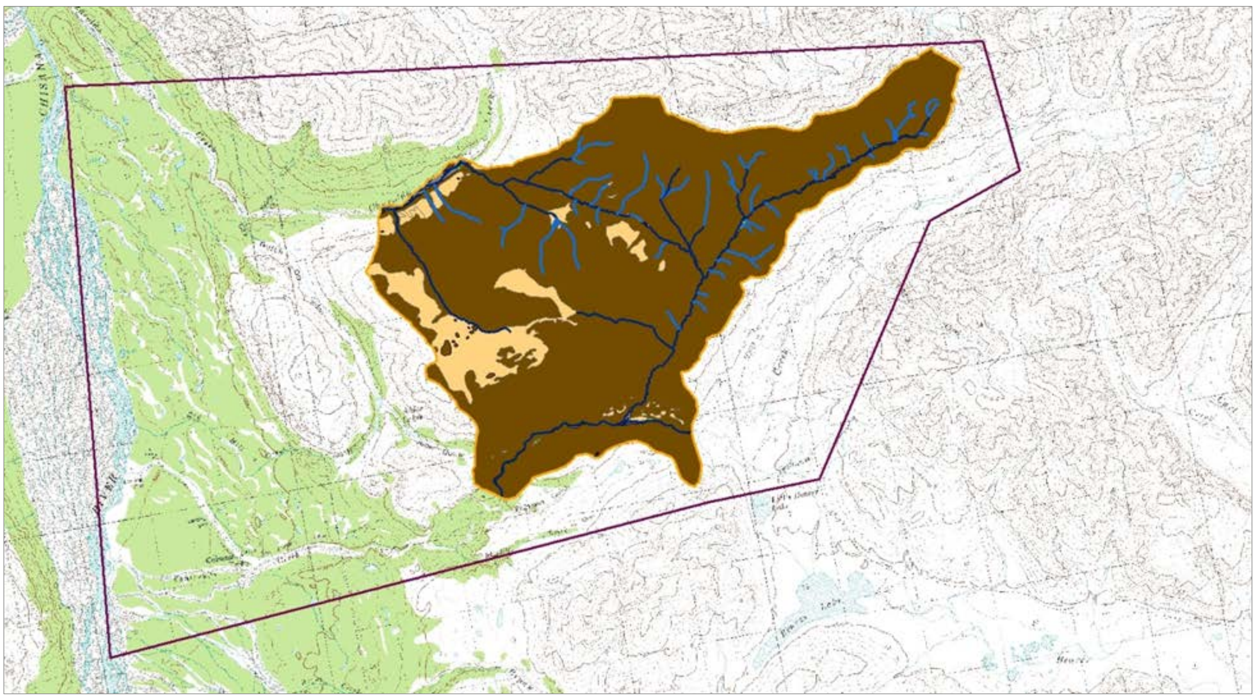

Figure 25. The dark brown color represents areas mapped as Upland in the Gold Hill Mining District portion (outlined in gold) within the greater study block (outlined in purple).

Thirty Five wetland areas, totaling 1,222.81 acres, were characterized with the Saturated (B) Water Regime. The smallest wetland area of this type is 0.13 acres.

Saturated wetlands are determined where the substrate is saturated to the surface for extended periods during the growing season and also where surface water is seldom present. All NWI defined Saturated Wetlands are found within the Palustrine System. The Palustrine System includes non-tidal wetlands dominated by trees, shrubs, and emergent vegetation. The largest areas of Saturated Wetland found in the field were dominated by *Salix* sp. and *Carex* sp. The NWI Classification for these areas was coded as PEM1/SS1B (Palustrine, Emergent, Persistent, or Scrub Shrub, Broad-Leaved Deciduous, Saturated). These wetland areas were predominantly located on north-facing and adjacent slopes of Gold Hill and also at or near the base of other slopes regardless of aspect.

Six Saturated wetland areas (Figure 26) dominated by willow and black spruce were mapped on northwest facing slopes located south of Chavolda Creek and also near an area between Big Eldorado and Glacier Creeks. The NWI Code for these wetlands was PSS1/FO4B (Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, or Forested, Needle-Leaved Evergreen, Saturated).

Two wetlands were occupied, by aerial coverage, with a larger percentage of Scrub-Shrub than Emergent vegetation. Both of these wetlands were located near the confluence of Big Eldorado and Chavolda Creeks. These were coded as PSS1/EM1B (Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, or Emergent, Persistent, Saturated).

One Saturated Wetland whose aerial coverage was dominated by alder was mapped, on a river bench, near the confluence of Bonanza Creek and Cathenda Creek. The NWI classification for this area was PSS1S (Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Saturated).

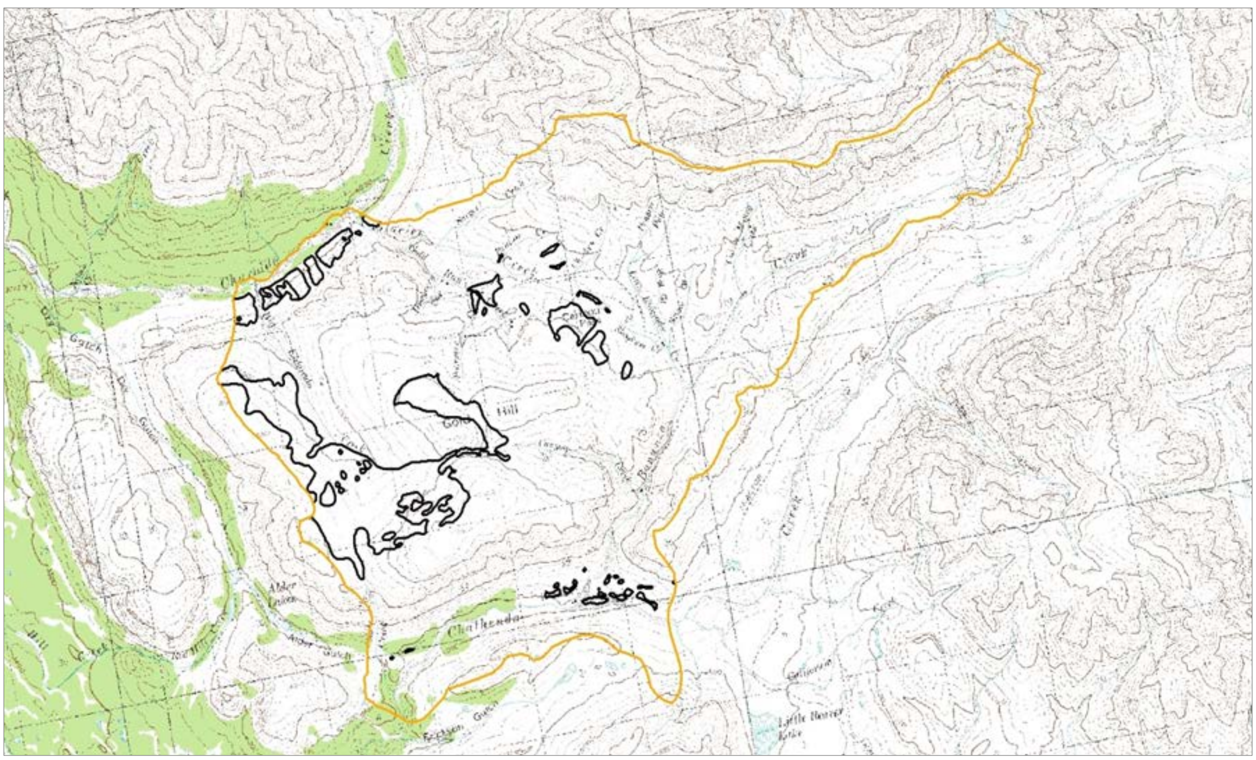

Figure 26. Locations of wetlands with Saturated Water Regime attributes.

The Seasonally Flooded Water Regime (C) in the NWI classification system includes wetlands where surface water is present for extended periods, especially early in the growing season, but water is absent by the end of the season in most years. When surface water is absent, the water table is often near the land surface.

Seasonally Flooded wetlands, within the Gold Hill Mining District totaled to 176.53 acres. These were classified within either the Palustrine or Riverine Systems. Those within the Riverine System were located within defined channels where water was usually (but not always) flowing.

Eleven areas of vegetated, Seasonally Flooded (C) wetlands were mapped along Bonanza, Chavolda, Chathenda, Glacier, and Gold Run Creeks (Figure 27). These wetlands were classified as PSS1C (Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded) and were dominated by either *Salix* sp. or *Alnus* sp. The total area was 11.92 acres and the average size of each wetland was 1.08 acres. One Seasonally Flooded basin (1.3 acres) dominated by herbaceous vegetation and classified as Emergent was also mapped here. This wetland was coded as PEM1C (Palustrine, Emergent, Persistent, and Seasonally Flooded).

Twenty one Seasonally Flooded (C) wetlands characterized by cobble/gravel were located within study block floodplains. The total area for these wetlands was 164. 24 acres (the average size was 7.8 acres, the minimum size 0.14 acres). These cobble/gravel areas were assigned as Unconsolidated Shore at the Class level in the NWI classification system. Unconsolidated Shore (US) substrates have less than 75% areal coverage of stones boulders or bedrock with less than 30% coverage of vegetation. The NWI Code for this wetland type was R3USC (Riverine, Upper Perennial, Unconsolidated Shore, Seasonally Flooded) or R5USC (Riverine, Unknown, Unconsolidated Shore, Seasonally Flooded). The R3USC designation included cobble/gravel areas along streams with defined channels. The R5USC designation included areas within a braided stream or river channel. Areas mapped with these codes were found along Bonanza, Chavolda, Chathenda, Gold Run, Little Eldorado, and Skokum Creeks. Thirty Five Seasonally Flooded creek beds were mapped as linear features. These riverine wetlands were located in channels and are generally second or third order streams. These areas were classified as R4SBC (Riverine, Intermittent, Stream Bed, and Seasonally Flooded).

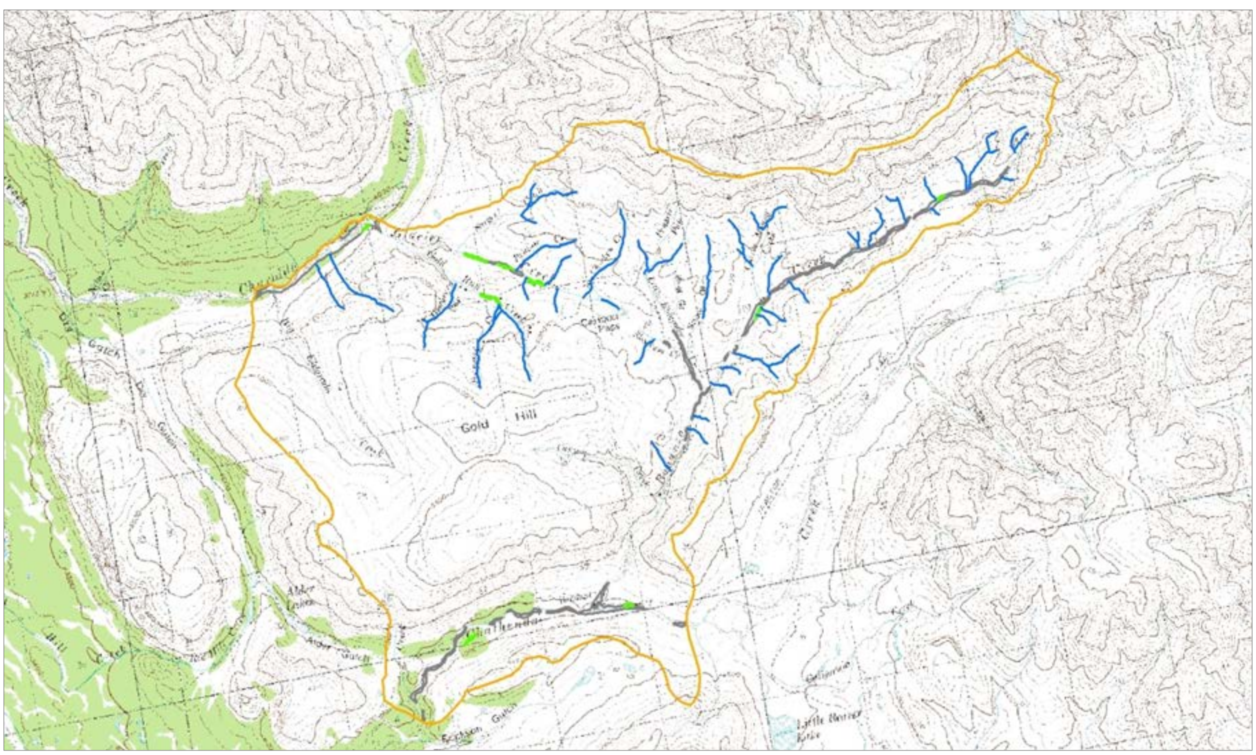

Figure 27. Seasonally Flooded Wetlands and Streams (green vegetation; gray-cobble gravel floodplains; blue second and third order streams).

Chavolda Creek and its tributaries; Big Eldorado, Glacier, and Gold Run Creeks were classified with the Permanently Flooded Water Regime (H). These stream channels have water that covers the land surface throughout the year in all years. The wetlands are represented in the geodatabase as R3RBH (Riverine, Upper Perennial, Rock Bottom, Permanently Flooded) or R5RBH (Riverine, Unknown, Rock Bottom, Permanently Flooded). Linear features coded as R3RBH were tributaries to braided R5RBH third and fourth order streams. Channels were presumed to be dominated by cobble sized stones or larger and so were assigned Rock Bottom (RB) at the Class level.

Five small open water ponds totaling 4.3 acres were also mapped. The minimum mapping unit was 0.07 acres. These Permanently Flooded ponds (Figure 28) were labelled as PUBH (Palustrine, Unconsolidated Bottom, and Permanently Flooded). The UB (Unconsolidated Bottom) code was assigned to these polygons as they likely have a substrate composed of fine sediment particles. The total wetland area mapped within the Gold Hill mining district occupies 12.6 % of the total land area.

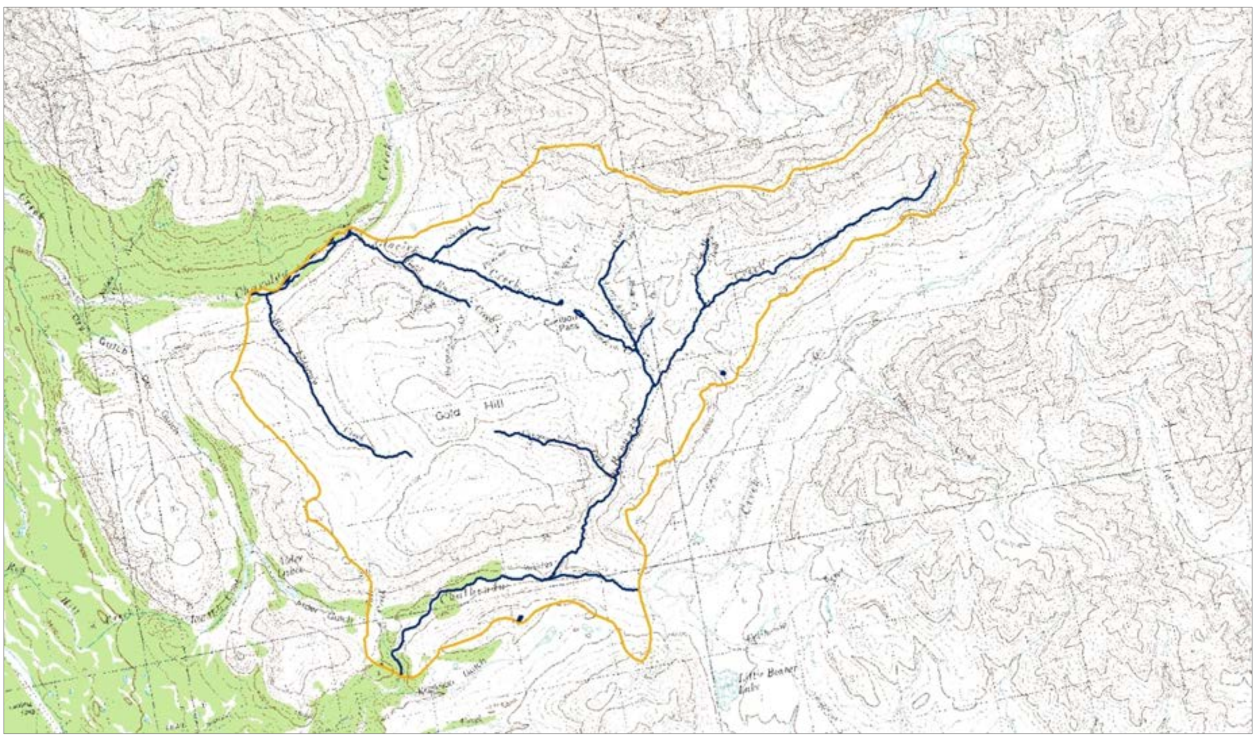

Figure 28. Permanently Flooded Streams and Ponds.

Study Block Wetland Summary

Results of mapping for the expanded study area outside of the Gold Hill mining district by and large mirror those within the district in terms of wetland classifications. The additional area was included to portray the district within the context of the Chavolda and Cathenda watersheds.

A significant difference within the expanded Study Block is that of landform geomorphology. Saturated wetland (PEM1/SS1B) was consistently found to occupy abandoned channels within the Chisana River floodplain. One other wetland classification was found to occur in the expanded area that is absent from the mining district. These wetlands were small Semipermanently Flooded basins dominated by sedges and classified as PEM1F; Palustrine (P), Emergent (EM), Persistent (1), Semipermanently Flooded (F). In addition four beaver ponds (b) were mapped west of the Village of Chisana near the Chisana River. There were classified as PUBHb.

In total wetlands in the expanded Study Block occupy more than 10 percent of the surface area in the entire study block (Figure 29).

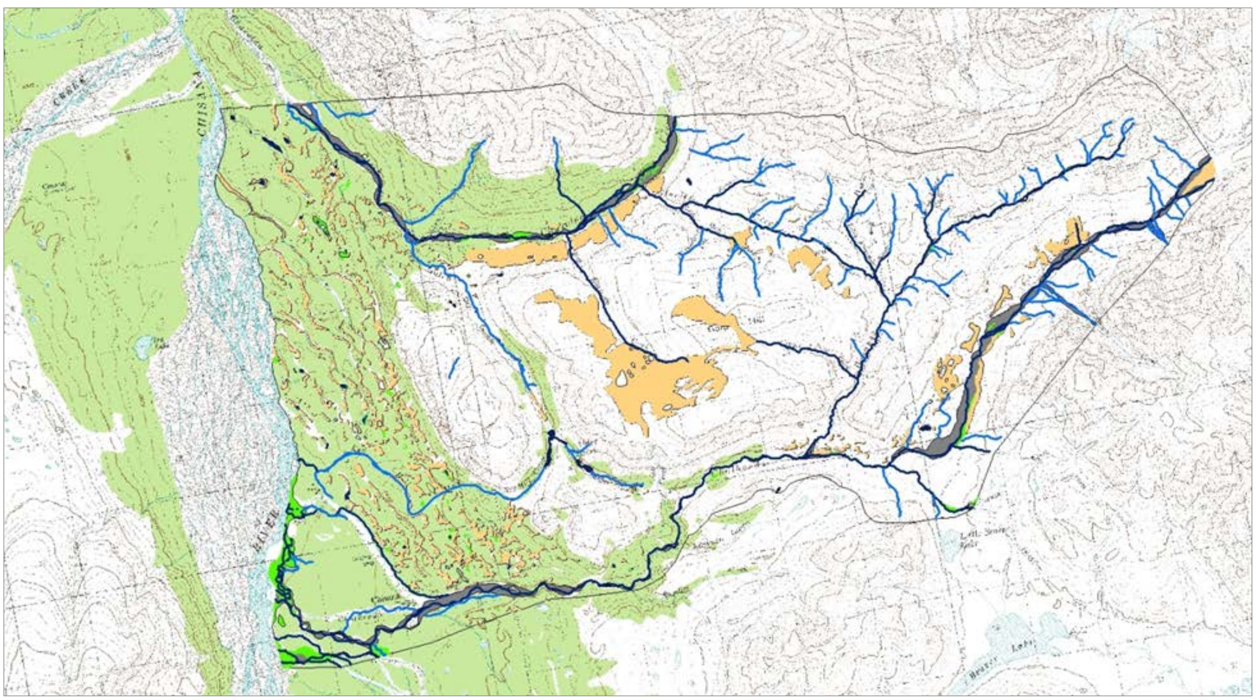

Figure 29**.** Wetlands, streams and rivers total to 10.36% of the land surface area in the study block.

Conclusions and Recommendations

Important contributions were made to the project during both phases but especially through the completion of ground-truthing and field verification efforts of Phase 2. Wetlands that were not visible on any of available imagery or collateral data sources were located and mapped when seen directly in the field. Some wetland areas exhibited marginal signatures that, pre-trip, were flagged as potential wetlands. Many of these were subsequently found to be upland. For other wetland areas represented in the imagery with distinctive signature keys the accuracy of the classification was improved as a result of field verification. The statistics below (Table 2, Table 3) show differences between datasets, for the entire study block of 40,365 acres, developed with and without the benefit of ground-truthing. The area of wetland captured in the first phase of this project (prior to field reconnaissance) totaled 1,453.14 acres or 3.59 % of the study block (Figure 30) shown below. This contrasted significantly to the 4,183.14 acres or 10.36% of wetland areas mapped in the entire surface area after the benefit of field investigation (Figure 31).

Table 2. Pre-Ground Truthing Wetland Summary

NWI Classification Code	Acres
PEM1C	161.19
PEM1F	1.17
PRBH	1.17
PSS1C	38.00
PSS3/EM1B	4.11
PUBH	68.26
PUBHb	1.61
PUSC	14.92
R3US1C	1,162.70
Total Wetland Acreage	**1,453.14**
Total Upland Acreage	**38,911.36**

Table 3. Post-Ground Truthing Wetland Summary

NWI Classification Code	Acres
PEM1/SS1B	2,298.69
PEM1/SS1C	156.10
PEM1C	53.74
PEM1F	.31
PSS1/EM1B	196.93
PSS1/EM1C	1.26
PSS1/FO4B	104.54
PSS1B	6.39
PSS1C	100.92
PSS3/EM1B	4.11
PUBF	2.05
PUBH	62.86
PUBHb	2.60
R3USC	117.45
R5USC	1,075.19
Total Wetland Acreage	**4,183.14**
Total Upland Acreage	**36,184.92**

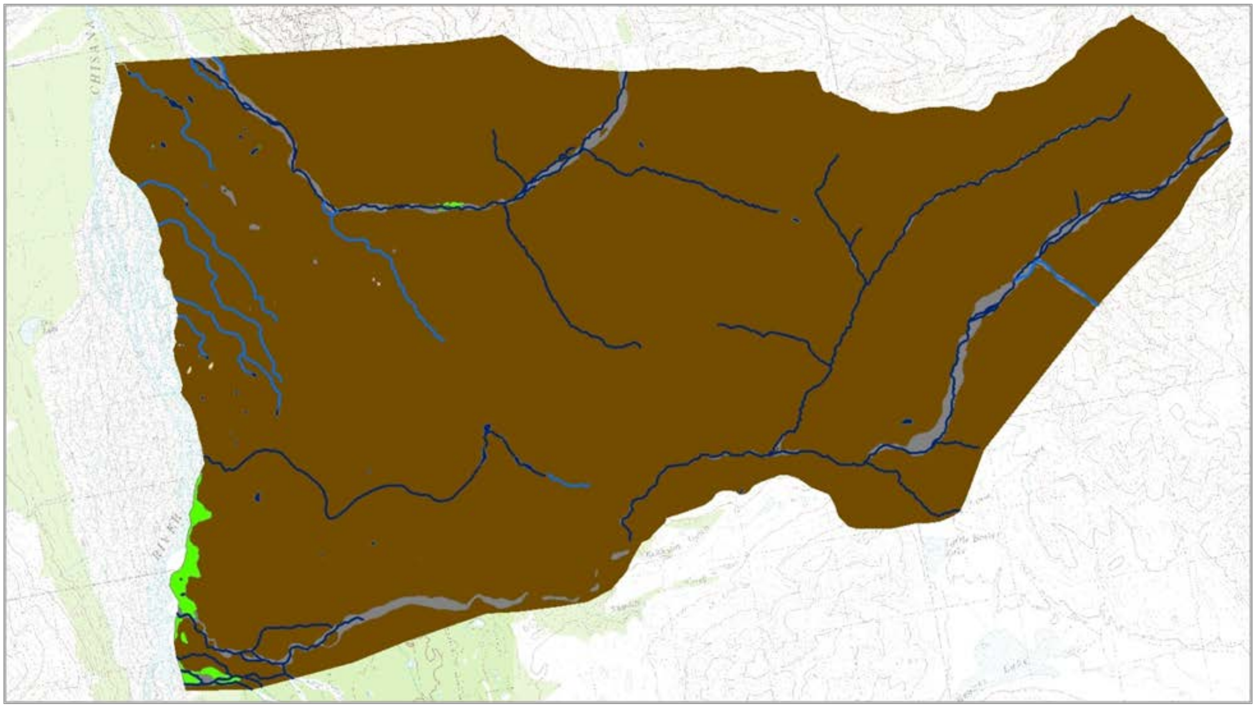

Figure 30. 3.59% of the study block was mapped as wetland in April, 2014 without field verification.

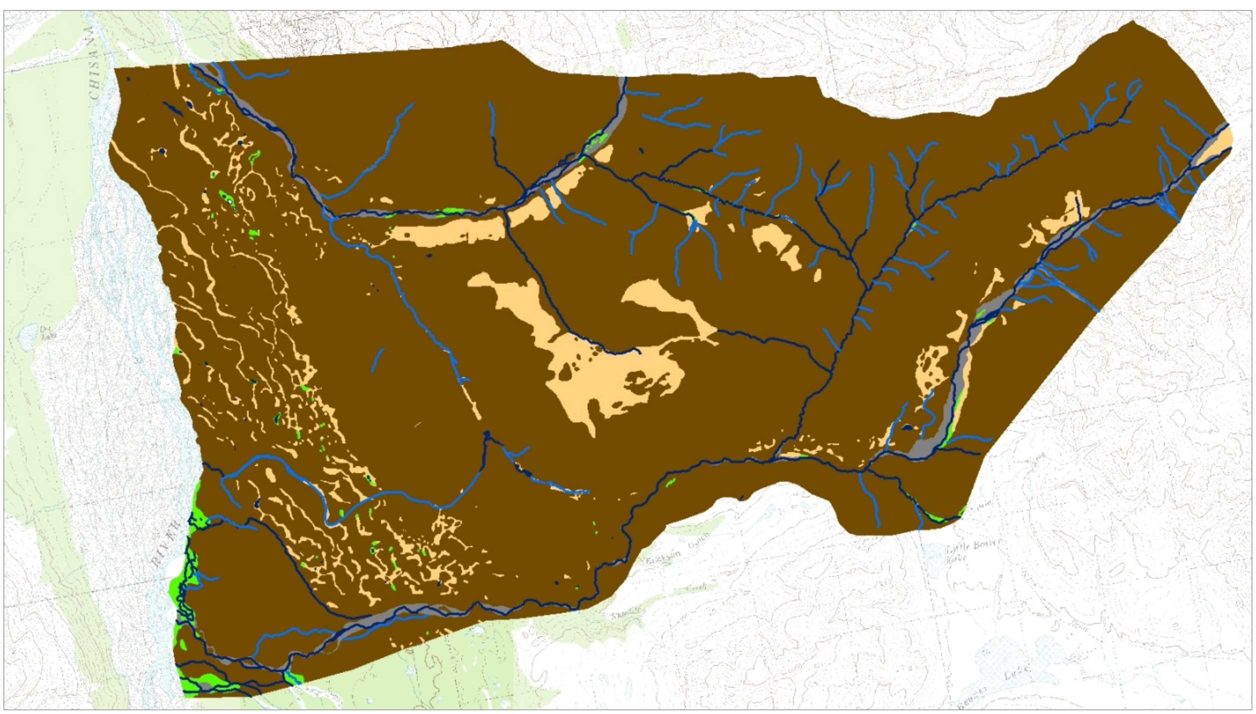

Figure 31. 10.36% of the study block was mapped as wetlands in August, 2014 after field verification.

The relatively small project area, large area format CIR aerial photography, and previous experience of the analysis team resulted in suitable spatial data of wetland and deepwater habitat in the Gold Hill Study Block. Recommendations for similar scale projects include the requirement for ground-truthing and the application of AHAP imagery (where available and suited) as a collateral if not primary imagery source.

The use of the AHAP imagery worked well in this project. The large coverage area made it easy to use both in the field and in flight. The nine by nine inch frames allowed the analyst to see areas that required investigation from a distance and allowed the pilot to adjust the flight path easily. The project was covered by portions of only three AHAP frames, making it simple to move between them while concentrating on the landscape and imagery. The film-based imagery also helped the interpreters to enhance their understanding and recognition of surface hydrology features.

Because the Gold Hill Mining district is subjected to intensive land use, high resolution photography was vital. The AHAP imagery is film based and allowed the photo interpreter to recognize subtle signature keys in the field and during the entire API process. Digital photographs do not have film grain but are limited by the individual elements of the image sensor (e.g. CCD cell), the pixels. Just as small-grain film has better resolution than large-grain film, an image sensor with more elements results in an image with better resolution. However, unlike pixels, film grain does not represent the limit of resolution. Film grains are randomly distributed and have size variation while image sensor cells are of same size and are arranged in a grid. For these reasons, direct comparison of film and digital resolutions is not straightforward. In general, as the pixels from a digital image sensor are set in straight lines they may irritate the eye of the viewer more than the randomly arranged film grains. Most people will reject an enlargement that shows pixels, whereas a grained film enlargement with lower resolution will be acceptable and even perceived as “sharper.”

The extensive Alaska field experience by the SMUMN analysts was foundational to the project’s successful field work and accurate data development. SMUMN personnel have worked with helicopter pilots and crews understood their roles as passengers. The weather conditions for flying and field work were ideal. The experienced crew and weather conditions helped to exceed the number of field verification visits that were originally anticipated.

AHAP imagery printed at a large scale on smaller sheets of paper did not work well for this project. The printing resulted in too many images to be handled efficiently in the field. Each frame was printed at a large scale (1:5000) encompassing a small area so that it was more challenging to extrapolate wetland signatures across larger portions of the landscape. These prints were essentially discarded for these reasons and also because GPS waypoints were not able to be downloaded into the helicopter navigation system.

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Appendix A: Field Data Form

Field Form ID: ____________________

Site Code: ________________________

State: _________________________ County: ____________________________

USGS Quad: ________________________

TWP/R: _____________ Lat/Long (dms):________________________________

Datum: ____

Reported by: __________________________________ Date: ______________________
(Name and affiliation) (dd/mm/yyyy)

Other Participants: ____

Accessed Via: ____
(Boat /road /helicopter /air boat/etc.)

Wetland type: ____

Cowardin Classification: ____
(Lake, fen, pothole, etc.)

Video: _____________________ Photograph(s): quantity: ___________________

Direction and view angle: ____

Source Imagery: ____

Type of Imagery Used:

Photograph: _____ DOQQ: _____ Satellite Image: _____ Other: _____

Date of Imagery: ____

Imagery source: ________________ Type: __________ Scale: ________

Discussion of Imagery: ____

____

____

____

____

Wildlife Observations:____

____

____

____

____

Tide Stage: High: _____ Low: _____ Slack: _____

Water Depth at the time of field visit: ______________________________________
(Feet or inches)

Indicators:

Standing water_____ Water Marks_____

Buttressed Trunks_____ Water Stained Leaves_____

Water Carried Debris_____ Saturated Soils_____

Floating Mat_____ Shallow Roots_____

Bare Areas_____ Oxidized Rhizospheres_____

Other Indicators of Hydrology____

Surrounding Land Use: ____
(Farmland, residential, mining, etc.)

Hydrogeomorphic classification:____

Plant Community

Dominance Type: ____

Abundance - Cover Dense (high) 70 - 100% _____________________________________

Common (medium) 30 - 69% ______________________________________

Occasional < 30% ____

Common Plant Spp: ____

____

____

Less Common Plant Spp.:____

____

____

Rare or Unique Plant Spp.:______________________________________

____

____

Soils/Substrate

Substrate type: Silt______ Sand______ Clay ______ Loam _____ Peat ______

Rubble ___ Rock _____ Other ____

Soil Map Unit Name:____

Taxonomy: ____

Drainage Class: _________________________ Hydric List (National) __________

Other____

Soil Survey Publication Date: ______________

Munsell: hue value chroma

_______________________depth________ (inches)

_______________________depth________ (inches)

_______________________depth________ (inches)

_______________________depth________ (inches)

Hydric Soil Indicators

Histosol_____ Concretions_____ Histic Epipedon _____

High Organic Content____ Sulfidic Odor_____ Organic Streaking______

Aquic Moisture Regime____ Reducing Conditions____ Gleyed_____

Other Remarks____

Disturbance

Fill ____ Waste ____ Dredging ____ Fire ____

Channels/ditches ____ Farming ____ Industrial ____ Residential____

Commercial ____ Timber Harvesting ____ Roads ____ Drainage ____

Impoundment ____ Other ____

Land Ownership

Federal_____ State_____ County_____ Private_____

Appendix B: Example of Photointerpretation (PI) Conventions: Bristol Bay

- PI Conventions were developed using a selective key composed of descriptions of typical and atypical photosignatures within the project area.

- Common terms used to describe photosignatures in this project area are:

  1) Color (red, orange, blue etc.);

  2) Tone (bright/dark);

  3) Texture (roughness or smoothness);

  4) Pattern (stippled, diffuse, irregular, dendritic);

  5) Association (relative position to, landscape position); and,

  6) Size (> 5acres, >20 acres).

- Signature terms are based on "Signature Development Assessment Summary" developed by National Wetlands Research Center, U.S. Geological Survey, Lafayette Louisiana.

- In order to ensure consistency in photosignature recognition and, minimize the possibility for errors of omission and commission, the general order in which signatures will be delineated and classified is as follows:

  1) Open water (Marine, Estuarine, Lacustrine, Palustrine) habitat, if greater than five acres in area);

  2) Seasonal wetlands; and,

  3) Remaining wetland habitats.

- Wetland delineation and classification shall be conducted "Heads-Up" using ArcGIS version 10.1.

- Linears on 1:250k quad shall not be delineated

- As the NWI (Cowardin et *al*.,) System provides for numerous alpha-numeric combinations to accurately describe a wide variety of surficial hydrology landscapes, the classifications listed below, and their associated image visual signatures are not all-inclusive of those that will be present in the finalized database, but they do represent common wetland types and signatures found within project area.

Upland

Upland/wetland breaks are very subtle in areas where there is little topographical relief. Upland dominated by lichens and herbaceous species are generally represented by a smooth appearing photographic texture and tan color or gray tone. Upland plant communities that are partially composed of grasses, forbs, and shrubs have light magenta color. They are located in higher landscape positions that may be differentiated with DRG overlays. The 1:63,360 scale DRG's have a contour interval of 50 feet.

Upland areas dominated by shrubs were found to be in landscape positions similar to those areas dominated by lichens. Upland forested areas include bright magenta areas that have a rough texture (aspen) mixed with dark tone, rough texture signature (white spruce). Upland/wetland breaks in mountainous areas, in areas of steep relief. These are outcrop areas that appear gray and vegetated, and that appear as a lighter shade of magenta and have a rough texture adjacent to the rock outcrops. Upland areas, located on moderate slopes, have a rough, texture, dark tone, and magenta color, and are dominated by shrubs.

Checksite #: 5,8,14,19,21,26,31,36,38,49,56,60,67,69,77,85,96,127,129,145,147,148,149,156, 157,159,160,166,167,168,170,176,179,184,185,199,200,201,203,209,210,211,213,214,215,216,219, 220,221,222,228,230,236,237,240,243,250,251,253,255

Marine Classification and Signature

M1UBL (Marine, Subtidal, Unconsolidated Bottom, Subtidal) – The texture is flat and the color is dark blue. Open ocean associated with a high-energy coastline.

M2USN (Marine, Intertidal, Unconsolidated Shore, Regularly Flooded) – dark tone, smooth texture, adjacent to open ocean.

Checksite #: 130

Estuarine Classifications and Signatures

E1UBL (Estuarine, Subtidal, Unconsolidated Bottom, Subtidal) – Brackish open water which is not exposed with tidal flux. The DRG will be used for separating Estuarine mudflats from Estuarine subtidal channels throughout the project area. This signature has a flat texture, dark blue color, and is connected to the open ocean (M1UBL).

Checksite #: 137

E2USN (Estuarine, Intertidal, Unconsolidated Shore, Regularly Flooded) - Mudflats along the coastline and tributaries should be delineated using digital collateral data and NOT through photo interpretation as the signature is not consistently present. Use best judgment as to extent of coastal mudflats where digital collateral data is not available. (Use 1950's DRG's) Most intertidal mudflats are classified as E2USN when not vegetated. Signatures are gray with a dark tone, smooth texture, irregular shape, and they are associated with channels and flats located within Estuaries.

E2US/EM1N (Estuarine, Intertidal, Unconsolidated Shore/Emergent, Persistent, Regularly Flooded) - These intertidal areas are at least 30% vegetated. Signatures are gray mixed with light pink. These are associated with channels and flats located adjacent to E1UBL areas.

E2EM1P (Estuarine, Intertidal, Emergent, Persistent, Irregularly Flooded) - These intertidal vegetated areas have a smooth texture bright tone, and light magenta. These are associated open water estuarine areas.

Checksite #: 116, 142

Riverine Classifications and Signatures

E1/R1 boundary – The Estuarine, Subtidal/Riverine, Tidal break will be delineated near the mouth of rivers.

R1/R2 or R5 boundary – The Riverine, Tidal/Riverine Lower Perennial break will be delineated at locations at or near confluence of R2 and R5 tributaries.

Down-river habitat is classified as R1UBV (Riverine, Tidal, Unconsolidated Bottom, and Permanent-Tidal). This is the freshwater-tidal zone. Riverine habitat up-river from freshwater tidal areas are classified as R2UBH (Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded) where gradients are low, water velocity is slow, there is no tidal influence, and water flows throughout the year.

Checksite #: 155

Riverine habitat that consists of a broad floodplain with fast moving water will be classified as R5UBH (Riverine, Unknown, Unconsolidated Bottom, and Permanently Flooded).

R3UBH (Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded) these are river channels that have high gradients, fast moving water, with little floodplain development. Linears with rock bottoms will be classified as R3UBH (Riverine, Upper Perennial, Rock Bottom, and Permanently Flooded).

R1USC (Riverine, Tidal, Unconsolidated Shore, Seasonally Flooded)

Checksite #: 100

R2USC (Riverine, Lower Perennial, Unconsolidated Shore, Seasonally Flooded), R3USC (Riverine, Upper Perennial, Unconsolidated Shore, Seasonally Flooded), and R5USC (Riverine, Unknown, Unconsolidated Shore, Seasonally Flooded. These areas have a smooth texture, dark gray tones, and associated with rivers in lower areas of scoured flats.

R2USA (Riverine, Lower Perennial, Unconsolidated Shore, Temporarily Flooded), R3USA (Riverine, Upper Perennial, Unconsolidated Shore, Temporarily Flooded), and R5USA (Riverine, Unknown, Unconsolidated Shore, Temporarily Flooded – These areas have a smooth texture, white tones, and associated with rivers. These are located on higher areas of scoured riverine flats.

* Linears and narrow rivers will be lumped into adjacent larger wetland habitats (e.g. PEM1/SS1B or PEM1/SS1C complexes).

Lacustrine Classification and Signatures

Lacustrine systems are open water systems with areas greater than 20 acres in size.

L1UBH (Lacustrine, Limnetic, Unconsolidated Bottom, Permanently Flooded), L2UBH (Lacustrine, Littoral, Unconsolidated Bottom, Permanently Flooded), and L2AB3H (Lacustrine, Littoral, Aquatic Bed, Rooted Vascular, Permanently Flooded) - All enclosed bodies of water outside of the Estuarine system that are 20 acres in area or larger. Lacustrine deepwater habitat will be delineated whenever possible. Lacustrine bodies of water will be assigned the Aquatic Bed “AB” Class only where vegetation signatures, including those that appear feint, are present within open water areas.

Checksite #: 54, 71

L2UBV (Palustrine, Littoral, Unconsolidated Bottom, Permanent-Tidal) - The primary keys are open water polygons larger than 20 acres and are located in freshwater-tidal areas.

Checksite #: 92,140

L2USC (Lacustrine, Littoral, Unconsolidated Shore, Seasonally Flooded) - These areas have a smooth texture, dark gray tones, adjacent to open water lacustrine areas.

Checksite #: 39

Palustrine Classification and Signatures

Palustrine wetlands include moist tundra, drained lakes, open water ponds that are less than 20 acres in size, seasonally flooded marshlands, saturated bogs, vegetated drainages, and freshwater tidal meadows.

PEM1/SS1B (Palustrine, Emergent, Persistent, Scrub/Shrub, Broad-Leaved, Deciduous, Saturated) - The signature for PEM1/SS1B is light tan or cream-colored. A very subtle gray tone is visible in extensive areas. This classification is often associated with scattered Seasonally and Semi-permanently flooded wetland areas. Tundra also is located in topographically higher areas and is frequently dissected by seasonally flooded streams, sloughs and drainage areas.

- Tundra vegetation is dominated by Caribou Moss (*Sphagnum sp*.), Sedge (*Carex sp.*), Labrador Tea (*Ledum decumbens*), Black Crowberry (*Vaccinium oxycoccos*), Tundra Dwarf Birch (*Betula nana*), Blueberry (*Vaccinium sp*.), Currant (*Ribes sp.*),

- Seasonally flooded drainage-ways in Tundra will be lumped in with larger PEM1/SS1B polygons where they are too narrow to delineate separately

Checksite #: 1,7,9,32,33,50,53,55,61,76,79,86,88,95,112,139,143,151,158,160,162,163, 173,177,178,190,192,198,202,203,204,205,206,207,208,224,231,248,252

PEM1B (Palustrine, Emergent, Persistent, Saturated) – Light pink color, smooth texture, located adjacent to stream channels. Atypical signatures, as seen on a few SPOT images include smooth textured, light tone, peach colored areas in basins adjacent to open water. Emergent vegetation typically consists of *Calamagrostis canadensis*, and Carex spp.

Checksite #: 25, 28,121,138,196

PSS1B (Palustrine, Scrub/Shrub, Persistent, Saturated) – Medium to darker tone, red/rust color, with a rough carpet-like texture. Often found in drainage patterns and near lower slope areas. Shrub vegetation is mainly Salix sp.

Checksite #: 43,105,106,107

PSS1/EM1B (Palustrine, Scrub/Shrub, Broad-leaved Deciduous, Emergent, Persistent, Saturated)

Checksite #: 3, 12, 42,175,238

PEM1C (Palustrine, Emergent, Persistent, Seasonally Flooded) _ These signatures have a light tone, grey color, and area associated with wetland drainage patterns.

Checksite #: 2,6,30,45,51,87,102,115,114,118,146,152,136,180,193,204,217,232,249

PEM1/SS1C (Palustrine, Emergent, Persistent, Scrub/Shrub, Broad-Leaved Deciduous, Seasonally Flooded) **–** Gray color, light to medium tone, rougher texture, in drainage pattern (e.g. sloughs). This signature will be delineated if greater than 5 acres in area and does not make over-all delineation of any area too complex. Frequently associated with Marsh Symbols on DRG's.

PEM1F (Palustrine, Emergent, Persistent, Semi-Permanently Flooded) - Wetlands exhibit a medium gray to black tone due to the significant amount of standing water in these areas. The signature is often a smooth texture and in drainage patterns (e.g. sloughs). Frequently associated with Marsh Symbols on DRG's.

Checksite #: 34,37,44,57,63,70,80,94,97,98,111,164,165,171,182,183,189,197,201,212,227, 244,246,254,256

PEM1/SS1F (Palustrine, Emergent, Persistent, Scrub Shrub, Semi-Permanently Flooded) - Wetlands exhibit a dark gray to black signature, and appear dark due to the significant amount of standing water in these areas. The signature is often a somewhat rough texture and in drainage patterns (e.g. sloughs). These are delineated if greater than 5 acres in area and will not make over-all delineation of area too complex. Frequently associated with Marsh Symbols on DRG's.

Checksite #: 16, 17,113,239

PEM1/UBF (Palustrine, Emergent, Persistent, Unconsolidated Bottom, Semipermanently Flooded) **–** These areas have a dark tone, smooth texture, basin configuration that is evenly mixed with open water polygons.

Checksite #: 64, 78

PEM1R (Palustrine, Emergent, Persistent, Seasonal-Tidal) - Generally located between Estuaries and Tundra landscapes. These Freshwater-Tidal areas are zones of transition between Estuarine habitat and Freshwater habitat. These are freshwater wetlands where water tables are influenced by the highest tides of the year. Delineating the breaks between Freshwater-Tidal,

Freshwater (e.g. PEM1/SS1B), and Estuarine (e.g. E2EM1P) will be accomplished through heads-up interpretation whenever possible. The primary key in identification is a consistently even magenta signature. Frequently associated with Marsh Symbols on DRG's.

Checksite #: 93, 117, 119,123, 124,126, 135

PUBV (Palustrine, Unconsolidated Bottom, Permanent-Tidal) - The primary keys are open water polygons that are located in freshwater-tidal emergent areas. Individual polygons will only be delineated when they are larger than 5 acres, are isolated, and when their inclusion will not add to database complexity.

Checksite #: 120

PEM1/UBT (Palustrine, Emergent, Persistent, Unconsolidated Bottom, Semi-Permanent-Tidal) - The primary keys are open water polygons that are located in freshwater-tidal emergent areas. The signature is a darker tone than that of adjacent emergent estuarine wetlands and contrasts in color with the emergent wetlands of the interior Tundra and upland. Emergent signature dominates at least 70% of delineated polygons. Frequently associated with Marsh Symbols on DRG's.

PUB/EM1T (Palustrine, Unconsolidated Bottom, Emergent Persistent, Semi-Permanent-Tidal) - The primary keys are open water polygons that are located in freshwater-tidal emergent areas. The signature is a darker tone than that of adjacent emergent estuarine wetlands and contrasts in color with the emergent wetlands of the interior Tundra and upland. Open water signature dominates at least 70% of delineated polygons. Frequently associated with Marsh Symbols on DRG's.

PEM1T (Palustrine, Emergent, Persistent, Semipermanent-Tidal) – Dark tone, smooth texture areas in freshwater tidal zone.

Checksite #: 125

PUBH (Palustrine, Unconsolidated Bottom, Permanently Flooded) – Bodies of water less than 20 acres in the Tundra Plateau where aquatic vegetation is absent. Palustrine wetlands that are larger than 5 acres but smaller than 20 acres will be delineated separately, except when this will make an area overly complex. Most ponds dominated by open water were found during field work in the Bristol Bay area.

Checksite #: 10, 18,144

PAB3H (Palustrine, Aquatic Bed, Rooted Vascular, Permanently Flooded) – Bodies of water less than 20 acres in the Tundra Plateau that have a predominance of aquatic vegetation and therefore will include the "AB" class in their labels. Palustrine wetlands that are larger than 5 acres but smaller than 20 acres will be delineated separately, except when this will make an area overly complex. Few ponds dominated by aquatic vegetation were found during field work in the Bristol Bay area. These areas also were found to have very feint signatures as seen on SPOT imagery.

• Drained lakes are common in this region of Alaska and will be classified using one or more of the following codes: PEM1B, PEM1C, PEM1/SS1C, PEM1F, PUBH, and PAB3H. Signatures are similar to those listed above for non-tidal classifications,

• Palustrine emergent wetlands along Lacustrine shorelines will not be delineated unless areas are large and do not make work area too complex

• Palustrine emergent areas on lake shorelines will be delineated if are large polygons.

• Delineating split-class polygons in Tundra areas that are evenly mixed with ponds:

PEM/UBF and PEM/AB3F <50% emergent
PUB/EM1H and PAB3/EM1H >50% open water

Checksite #: 47

PSS1B (Palustrine, Scrub Shrub Broad-Leaved Deciduous, Saturated) - The primary keys for identification are these areas have a rough photographic texture, which is red or orange in color, has a bright tone, and are located on saturated slopes and moist tundra.

PSS1/EM1B (Palustrine, Scrub Shrub/Emergent, Broad-Leaved Deciduous, Saturated) - The primary keys for identification are these areas have a rough photographic texture, that is dark magenta in color. These wetlands are along Riverine floodplains and are dominated by *Salix*, *Alnus,* and *Calamagrostis*.

PEM1/SS1C (Palustrine, Emergent, Scrub/Shrub Broad-Leaved Deciduous, Seasonally Flooded) - The primary keys for identification are these areas have a rough photographic texture, that is red or orange in color, has a bright tone, is evenly mixed with a magenta colored emergent signature. These wetlands are located throughout the project area along Riverine floodplains, within drained lakes, and throughout all the expansive marshlands for this region. Frequently associated with Marsh Symbols on DRG's.

Checksite #: 11,13,22,24,40,41,48,65,66,84,89,90,99,104,123,150,156,169,174,195

PSS1/EM1C (Palustrine, Scrub Shrub/Emergent, Broad-Leaved Deciduous, Seasonally Flooded) - The primary keys for identification are these areas have a rough photographic texture, that is dark magenta in color. These wetlands are along Riverine floodplains and are dominated by *Salix, Alnus,* and *Calamagrostis.* Frequently associated with Marsh Symbols on DRG's.

Checksite #: 35, 72

PSS1C (Palustrine, Scrub Shrub, Broad-Leaved Deciduous, Seasonally Flooded) – Rough texture, magenta, associated with stream and river channels. Dominated by *Salix sp*. or *Alnus sp.*

Checksite #: 161,223

PSS1R (Palustrine, Scrub Shrub, Broad-Leaved Deciduous, Seasonal-Tidal) **–** Located in tidal zone. Dark tone, rough texture, magenta. Frequently associated with Marsh Symbols on DRG's.

Appendix C: Wetlands Field Data Form

Field Form ID: ____________________ **SITE NUMBER**: ________________

State: _Alaska________________________ **County**: ___U.S.A.______________

USGS Quad: _Nabesna A-2 or Nabesna A-3 *(circle one)* **TWP/R**: ________________________

Lat/Long (dms):____

Datum: ____

Reported by: ____John Anderson__(St. Mary's University of Minnesota –GeoSpatial Services)________

Date: ____(*dd/mm/yyyy*)________

Other Participants: _____Kevin Stark (SMUMN GSS)____________________________________

Accessed Via: ____(*Boat /road /helicopter /air boat/etc.*)___

Wetland type: ____

Water Depth at the time of field visit: ______________________(*Feet or inches*)__

Wetland Indicators (x):

____Standing water ____Water Marks ____Buttressed Trunks

____Water Stained Leaves ____Water Carried Debris ____Saturated Soils

____Floating Mat ____Shallow Roots ____Bare Areas

____Oxidized Rhizospheres Other Indicators of Hydrology_________________________________

Surrounding Land Use: ____(*Farmland, residential, mining, etc.*)_

Hydrogeomorphic classification:____

Plant Community

Dominance Type: ____

Abundance - Cover Dense (high) 70 - 100% ____

Common (medium) 30 - 69% ____

Occasional < 30% ____

Common Plant Spp: ____
____
____

Less Common Plant Spp.:____
____
____

Rare or Unique Plant Spp.:____

Soils/Substrate

Substrate type: ____Silt, ____Sand, ____Clay, ____Loam, ____Peat, ____Rubble, ____Rock

Other ____

Soil Map Unit Name:____

Taxonomy: ____

Drainage Class: _______________________ Hydric List (National) _______________

Other____

Soil Survey Publication Date: _____________

Munsell: hue value chroma: _______________________depth_______ (inches)

_______________________depth_______ (inches)

_______________________depth_______ (inches)

Hydric Soil Indicators

____Histosol ____Concretions ____Histic Epipedon

____High Organic Content ____Sulfidic Odor ____Organic Streaking

____Aquic Moisture Regime ____Reducing Conditions ____Gleyed

Other Remarks____

Disturbance

____Fill ____Waste ____Dredging ____Fire

____Channels/ditches ____Farming ____Industrial ____Residential

____Commercial ____Timber harvesting ____Roads ____Drainage

____Impoundment ____Other ____

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

____Federal _____Private

Source Imagery: ____

Type of Imagery Used (x): Photograph: ____DOQQ, _____Satellite Image, ____Other

Date of Imagery: ________________ **Imagery source**: ___________ **Scale**: _____________________

Discussion of Imagery: ____

Wildlife Observations:____

Photograph(s): Name Direction (N, SE) View angle (uphill)

______________________________ ____________ _______________

______________________________ ____________ _______________

Cowardin Classification:____

Appendix D: Completed Wetlands Field Data Forms

7/21/14

Field Data Form

Field Form ID: 1 **SITE NUMBER:** 20 - Pre-Trip Pt

State: Alaska **County:** U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* **TWP/R:**

Lat/Long (dms): Get from point file

Datum:

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: *(Boat /road /helicopter /air boat/etc.)*

Wetland type: PSS1B

Water Depth at the time of field visit: *(Feet or inches)*

Wetland Indicators (x):

___Standing water ___Water Marks ___Buttressed Trunks

___Water Stained Leaves ___Water Carried Debris ___Saturated Soils

___Floating Mat ___Shallow Roots ___Bare Areas

___Oxidized Rhizospheres Other Indicators of Hydrology Wetland Drainage Pattern

Surrounding Land Use: National Park *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification:

Plant Community

Dominance Type: Salix sp.

Abundance - Cover Dense (high) 70 - 100%

Common (medium) 30 - 69%

Occasional < 30%

Common Plant Spp: Salix sp ~~Potentilla~~ (yellow flower) Drasphora tomentosum FDG

Less Common Plant Spp.: Carex sp.

Rare or Unique Plant Spp.:

Soils/Substrate

Substrate type: X Silt, X Sand, ___Clay, ___Loam, ___Peat, ___Rubble, ___Rock

#1 site 20

Other ______

Soil Map Unit Name: ______

Taxonomy: ______

Drainage Class: ______ Hydric List (National) ______

Other ______

Soil Survey Publication Date: ______

Munsell: hue value chroma: 10YR 3/2 | 7.5YR 4/4 1% faint depth 0-4 (inches)

10YR 3/2 | 7.5YR 4/4 depth 4-10 (inches)

2.5Y 3/2 | 7.5YR 4/6 depth 10-18 (inches)

______ depth ______ (inches)

30% prominant

40% distinct

Hydric Soil Indicators

____Histosol ____Concretions ____Histic Epipedon

____High Organic Content ____Sulfidic Odor ____Organic Streaking

____Aquic Moisture Regime ____Reducing Conditions ____Gleyed

Other Remarks 1% faint mottles (0-4)

Disturbance

____Fill ____Waste ____Dredging ____Fire

____Channels/ditches ____Farming ____Industrial ____Residential

____Commercial ____Timber Harvesting ____Roads ____Drainage

____Impoundment ____Other ______

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal ____Private

Source Imagery: AHAP

Type of Imagery Used (x): Photograph: X DOQQ, ____Satellite Image, ____Other

Date of Imagery: ? **Imagery source:** ______ **Scale:** ______

Discussion of Imagery: Medium magenta rougher texture, flat associated with River floodplain

Wildlife Observations: ______

Photograph(s):: Name	Direction (N, SE)	View angle (uphill)
2221	soil plug	down
2222		west
2223		North
2224		East
2225		South

Cowardin Classification:

#2

~~fol~~ 5/21/14

Field Data Form

Field Form ID: ____________

SITE NUMBER: 21 pre-tube

State: Alaska

County: U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)*

TWP/R: ____________

Lat/Long (dms): Get from points layer

Datum: ____________

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____________ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: Helicopter *(Boat /road /helicopter /air boat/etc.)*

Wetland type: R3USC

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

____Standing water ✓ Water Marks ____Buttressed Trunks

____Water Stained Leaves ✓ Water Carried Debris ____Saturated Soils

____Floating Mat ____Shallow Roots ✓ Bare Areas

____Oxidized Rhizospheres Other Indicators of Hydrology Stream bed

Surrounding Land Use: ____________ *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____________

Plant Community

Dominance Type: N/A – barren

Abundance - Cover Dense (high) 70 - 100% ____________

Common (medium) 30 - 69% ____________

Occasional < 30% ____________

Common Plant Spp: ____________

Less Common Plant Spp.: scattered Salix

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: ____Silt, ____Sand, ____Clay, ____Loam, ____Peat, ____Rubble, ____Rock

#2 Pre-trip point #21

Other ____________

Soil Map Unit Name: Not Sample - Non-Soil

Taxonomy: ____________

Drainage Class: ____________ Hydric List (National) ____________

Other ____________

Soil Survey Publication Date: ____________

Munsell: hue value chroma: ____________ depth ____ (inches)

____________ depth ____ (inches)

____________ depth ____ (inches)

____________ depth ____ (inches)

Hydric Soil Indicators

____Histosol ____Concretions ____Histic Epipedon

____High Organic Content ____Sulfidic Odor ____Organic Streaking

____Aquic Moisture Regime ____Reducing Conditions ____Gleyed

Other Remarks ____________

Disturbance

____Fill ____Waste ____Dredging ____Fire

____Channels/ditches ____Farming ____Industrial ____Residential

____Commercial ____Timber Harvesting ____Roads ____Drainage

____Impoundment ____Other ____________

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

____Federal ____Private

Source Imagery: AHAP

Type of Imagery Used (x): Photograph: X DOQQ, ____Satellite Image, ____Other

Date of Imagery: 1964 (?) **Imagery source:** ____ **Scale:** ____

Discussion of Imagery: Smooth grey tone in floodplain

Wildlife Observations: Light blue / Kreads

Photograph(s):: Name	Direction (N, SE)	View angle (uphill)
2226		West
2227		North
" 28		E.
" 29		S.

Cowardin Classification:

Field Data Form

Field Form ID: ____________________ **SITE NUMBER:** ~~004~~ 003

State: Alaska **County:** U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* **TWP/R:** ____________

Lat/Long (dms): N 62.12021 W 141.88783

Datum: ____________

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____________ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____________ *(Boat /road /helicopter /air boat/etc.)*

Wetland type: PEM1B

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

X Standing water ____Water Marks ____Buttressed Trunks

____Water Stained Leaves ____Water Carried Debris ____Saturated Soils

____Floating Mat ____Shallow Roots ____Bare Areas

____Oxidized Rhizospheres Other Indicators of Hydrology____________

Surrounding Land Use: ____________ *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____________

Plant Community

Dominance Type: Carex ~~sp~~ aquatilis 100%

Abundance - Cover Dense (high) 70 - 100% ____________

Common (medium) 30 - 69% ____________

Occasional < 30% ____________

Common Plant Spp: ____________

Less Common Plant Spp.: ____________

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: ____Silt, ____Sand, ____Clay, ____Loam, X Peat, ____Rubble, ____Rock

~~004~~ 003

Other ______

Soil Map Unit Name: ______

Taxonomy: ______

Drainage Class: Very Poor Hydric List (National) ______

Other ______

Soil Survey Publication Date: ______

Munsell: hue value chroma: 10YR2/1 depth 0-16 (inches)

______ depth ______ (inches)

______ depth ______ (inches)

______ depth ______ (inches)

Hydric Soil Indicators

X Histosol ____Concretions X Histic Epipedon

X High Organic Content ____Sulfidic Odor ____Organic Streaking

X Aquic Moisture Regime ____Reducing Conditions ____Gleyed

Other Remarks ______

Disturbance

____Fill ____Waste ____Dredging ____Fire

____Channels/ditches ____Farming ____Industrial ____Residential

____Commercial ____Timber Harvesting ____Roads ____Drainage

____Impoundment ____Other ______

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal ____Private

Source Imagery: ______

Type of Imagery Used (x): Photograph: ____DOQQ, ____Satellite Image, ____Other

Date of Imagery: ______ **Imagery source**: ______ **Scale**: ______

Discussion of Imagery: Smooth, tdnt white in mountain saddle

Wildlife Observations: ______

Photograph(s):: Name / Direction (N, SE) / View angle (uphill)

Name	Direction (N, SE)	View angle (uphill)
2256	Soil	
1157		N
" 58		E
" 59		S
		W

Cowardin Classification:

Field Data Form

Field Form ID: ____________ **SITE NUMBER:** ~~005~~ 004

State: Alaska **County:** U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* **TWP/R:** ____________

Lat/Long (dms): N 62.10559 W 141.89767

Datum: WGS 84

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: 7/21/2014 *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____________ *(Boat /road/helicopter/air boat/etc.)* [helicopter circled]

Wetland type: PEM1B

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

- X Standing water
- ___ Water Marks
- ___ Buttressed Trunks
- ___ Water Stained Leaves
- ___ Water Carried Debris
- X Saturated Soils
- ___ Floating Mat
- ___ Shallow Roots
- ___ Bare Areas
- ___ Oxidized Rhizospheres
- Other Indicators of Hydrology ____________

Surrounding Land Use: ____________ *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: sloped

Plant Community

Dominance Type: Sedge

Abundance - Cover Dense (high) 70 - 100% ____________

Common (medium) 30 - 69% ____________

Occasional < 30% ____________

Common Plant Spp: ____________

Less Common Plant Spp.: Polyginum ~~spp~~ bistorta (new name checked)

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: ___ Silt, ___ Sand, ___ Clay, ___ Loam, ___ Peat, ___ Rubble, ___ Rock

~~005~~ 004

Other ______________________________

Soil Map Unit Name: ______________________________

Taxonomy: ______________________________

Drainage Class: ______________ Hydric List (National) ______________

Other ______________________________

Soil Survey Publication Date: ______________

Munsell: hue value chroma: 10 YR 2/1 fibric depth 0-6 (inches)

10 YR 6/4 depth 6-18 (inches)

______________ depth ______ (inches)

______________ depth ______ (inches)

Hydric Soil Indicators

X Histosol
X High Organic Content
___ Aquic Moisture Regime
___ Concretions
___ Sulfidic Odor
___ Reducing Conditions
X Histic Epipedon
___ Organic Streaking
___ Gleyed

Other Remarks ______________________________

Disturbance

___ Fill
___ Channels/ditches
___ Commercial
___ Impoundment
___ Waste
___ Farming
___ Timber Harvesting
___ Other ______________
___ Dredging
___ Industrial
___ Roads
___ Fire
___ Residential
___ Drainage

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal
___ Private

Source Imagery: ______________________________

Type of Imagery Used (x): Photograph: ___ DOQQ, ___ Satellite Image, ___ Other

Date of Imagery: ______________ **Imagery source:** ______________ **Scale:** ______________

Discussion of Imagery: Creamy ~~wgt~~ white, Flat / slope landscape

Wildlife Observations: ______________________________

Photograph(s):: Name | Direction (N, SE) | View angle (uphill)

Name	Direction (N, SE)	View angle (uphill)
2264	~~[illegible]~~ plug	
65		N
66		E
67		S
68	~~Pit~~	W
69	pit	

Cowardin Classification:

~~006~~ 005

Field Data Form

Field Form ID: ____________ **SITE NUMBER**: ____________

State: Alaska **County**: U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* **TWP/R**: ____________

Lat/Long (dms): N 62.10594 / W 141.95178

Datum: ____________

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____________ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____________ *(Boat /road /helicopter /air boat/etc.)* [helicopter circled]

Wetland type: PEM1B

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

- ____Standing water
- ____Water Marks
- ____Buttressed Trunks
- ____Water Stained Leaves
- ____Water Carried Debris
- __X__Saturated Soils
- ____Floating Mat
- ____Shallow Roots
- ____Bare Areas
- ____Oxidized Rhizospheres Other Indicators of Hydrology ____________

Surrounding Land Use: ____________ *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____________

Plant Community

Dominance Type: Carex aquatilis SP 80%

Abundance - Cover Dense (high) 70 - 100% ____________

Common (medium) 30 - 69% ~~Leatherleaf~~ Rhododendron tomentosum

Occasional < 30% ↑FACW

Common Plant Spp: Salix sp

Less Common Plant Spp.: ____________

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: ____Silt, ____Sand, ____Clay, ____Loam, __X__Peat, ____Rubble, ____Rock

~~006~~ 005

Other ____

Soil Map Unit Name: ____

Taxonomy: ____

Drainage Class: ____________________ Hydric List (National) ______________

Other ____

Soil Survey Publication Date: ______________

Munsell: hue value chroma: ____________________ depth________ (inches)

____________________ depth________ (inches)

____________________ depth________ (inches)

____________________ depth________ (inches)

Hydric Soil Indicators

X Histosol | ____Concretions | X Histic Epipedon

____High Organic Content | ____Sulfidic Odor | ____Organic Streaking

____Aquic Moisture Regime | ____Reducing Conditions | ____Gleyed

Other Remarks ____

Disturbance

____Fill | ____Waste | ____Dredging | ____Fire

____Channels/ditches | ____Farming | ____Industrial | ____Residential

____Commercial | ____Timber Harvesting | ____Roads | ____Drainage

____Impoundment | ____Other ______________________________

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal ____Private

Source Imagery: AHAP

Type of Imagery Used (x): Photograph: X DOQQ, ____Satellite Image, ____Other

Date of Imagery: ______________ **Imagery source**: __________ **Scale**: __________

Discussion of Imagery: Smooth orange/altitude outflow

Wildlife Observations: Pdw on drainage way

Photograph(s): Name | Direction (N, SE) | View angle (uphill)

Name	Direction (N, SE)	View angle (uphill)
2272		N
73		W
74		S
75		E
76		pit & plug

Cowardin Classification: PEM1B

Field Data Form

~~GA~~1006

Field Form ID: ____________ **SITE NUMBER:** ____________

State: Alaska **County:** U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* **TWP/R:** ____________

Lat/Long (dms): ~~007~~

Datum: N 62.12564 / W 141.77914

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____________ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____________ *(Boat /road /helicopter /air boat/etc.)*

Wetland type: PEM/SS1B

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

- ____Standing water
- ____Water Marks
- ____Buttressed Trunks
- ____Water Stained Leaves
- ____Water Carried Debris
- X Saturated Soils
- ____Floating Mat
- ____Shallow Roots
- ____Bare Areas
- ____Oxidized Rhizospheres Other Indicators of Hydrology ____________

Surrounding Land Use: National Park *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____________

Plant Community

Dominance Type: ~~Aq~~ aquatils Carex 50 Betula Nana 50

Abundance - Cover Dense (high) 70 - 100% ____________

Common (medium) 30 - 69% ____________

Occasional < 30% ____________

Common Plant Spp: ~~Cott~~ Cottonus Fao

~~O;~~ Equisetum arvense

Less Common Plant Spp.: ____________

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: ____Silt, ____Sand, ✓____Clay, ____Loam, ____Peat, ____Rubble, ____Rock

x Perma frost

Other ______________ ~~007~~ 006

Soil Map Unit Name: ______________

Taxonomy: ______________

Drainage Class: ______________ Hydric List (National) ______________

Other ______________

Soil Survey Publication Date: ______________

Munsell: hue value chroma: ~~7D~~ 7.5YR5/6 depth 4 (inches)

10YR2/1 depth ~~10~~ 6 (inches)

______________ depth ______ (inches)

______________ depth ______ (inches)

Hydric Soil Indicators

X Histosol	____Concretions	X Histic Epipedon
____High Organic Content	____Sulfidic Odor	____Organic Streaking
____Aquic Moisture Regime	____Reducing Conditions	____Gleyed

Other Remarks perma frost @ 6''

Disturbance

____Fill	____Waste	____Dredging	____Fire
____Channels/ditches	____Farming	____Industrial	____Residential
____Commercial	____Timber Harvesting	____Roads	____Drainage
____Impoundment	____Other ______________		

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal ____Private

Source Imagery: ______________

Type of Imagery Used (x): Photograph: ____DOQQ, ____Satellite Image, ____Other

Date of Imagery: ______________ **Imagery source:** ______________ **Scale:** ______________

Discussion of Imagery: Light Grey / Medium magenta on flat

Wildlife Observations: a bird

Photograph(s):: Name

Name	Direction (N, SE)	View angle (uphill)
2284		N
85		E
86		S
87		W
46		pit plug

Cowardin Classification:

Field Data Form

Field Form ID: ____________ SITE NUMBER: ~~008~~ 007

State: Alaska County: U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* TWP/R: ____________

Lat/Long (dms): 62.11919 / 142.00565 4200 ft

Datum: ____________

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____________ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____________ *(Boat /road /helicopter /air boat/etc.)*

Wetland type: PEM1B

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

___Standing water ___Water Marks ___Buttressed Trunks

___Water Stained Leaves ___Water Carried Debris X Saturated Soils

___Floating Mat ___Shallow Roots ___Bare Areas

___Oxidized Rhizospheres , Other Indicators of Hydrology ____________

Surrounding Land Use: National Park *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____________

Plant Community

Dominance Type: Carex ~~sp~~ aquatilis

Abundance - Cover Dense (high) 70 - 100% ____________

Common (medium) 30 - 69% ____________

Occasional < 30% ____________

Common Plant Spp: Betula nana

Less Common Plant Spp.: Sphagnum

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: ___Silt, ___Sand, ___Clay, ___Loam, ___Peat, ___Rubble, ___Rock

perma frost

007

Other ________________________________

Soil Map Unit Name: ________________________________

Taxonomy: ________________________________

Drainage Class: ______________ Hydric List (National) ______________

Other ________________________________

Soil Survey Publication Date: ______________

Munsell: hue value chroma: 0-8 5YR 2.5/2 depth 0-8 (inches) Fibric

______________ depth ______ (inches)

______________ depth ______ (inches)

______________ depth ______ (inches)

Hydric Soil Indicators

X Histosol ____ Concretions ____ Histic Epipedon

____ High Organic Content ____ Sulfidic Odor ____ Organic Streaking

____ Aquic Moisture Regime ____ Reducing Conditions ____ Gleyed

Other Remarks Perma frost @ 8"

Disturbance

____ Fill ____ Waste ____ Dredging ____ Fire

____ Channels/ditches ____ Farming ____ Industrial ____ Residential

____ Commercial ____ Timber Harvesting ____ Roads ____ Drainage

____ Impoundment ____ Other ______________

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal ____ Private

Source Imagery: ______________

Type of Imagery Used (x): Photograph: X DOQQ, ____ Satellite Image, ____ Other

Date of Imagery: 1984 **Imagery source:** AHAP **Scale:** 1:58K

Discussion of Imagery: CSK Smooth white in saddle

Wildlife Observations: ______________

Photograph(s): Name	Direction (N, SE)	View angle (uphill)
2298		Pit/plan
99		E N
2300		S E
2301		W S
2302		W

Cowardin Classification:

Field Data Form

Field Form ID: ____________

SITE NUMBER: ~~009~~ 008

State: Alaska

County: U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)*

TWP/R: ____________

Lat/Long (dms): N 62.13144 W 142.04773

Datum: ____________

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____________ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____________ *(Boat /road /helicopter /air boat/etc.)* (helicopter circled)

Wetland type: PEM1/SS1B

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

____Standing water ____Water Marks ____Buttressed Trunks

____Water Stained Leaves ____Water Carried Debris ____Saturated Soils

____Floating Mat ____Shallow Roots ____Bare Areas

_X_Oxidized Rhizospheres Other Indicators of Hydrology____________

Surrounding Land Use: ____________ *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____________

Plant Community

Dominance Type: Carex

Abundance - Cover Dense (high) 70 - 100% Carex

Common (medium) 30 - 69% Betula nana

Occasional < 30% ____________

Common Plant Spp: ____________

Less Common Plant Spp.: ____________

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: _X_Silt, ____Sand, ____Clay, ____Loam, ____Peat, ____Rubble, ____Rock

008

Other ______

Soil Map Unit Name: ______

Taxonomy: ______

Drainage Class: ______ Hydric List (National) ______

Other ______

Soil Survey Publication Date: ______ prominent mottles @ 10% glistening

Munsell: hue value chroma: 10 YR 3/3 depth 0-1 (inches)

silty 2.5 7/1 | 7.5 5/6 depth 1-18 (inches)

______ depth ______ (inches)

______ depth ______ (inches)

Hydric Soil Indicators

___ Histosol
___ High Organic Content
X Aquic Moisture Regime
X Concretions
___ Sulfidic Odor
X Reducing Conditions
___ Histic Epipedon
___ Organic Streaking
___ Gleyed

Other Remarks ______

Disturbance

___ Fill
___ Channels/ditches
___ Commercial
___ Impoundment
___ Waste
___ Farming
___ Timber Harvesting
___ Other ______
___ Dredging
___ Industrial
___ Roads
___ Fire
___ Residential
___ Drainage

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal ___ Private

Source Imagery: ______

Type of Imagery Used (x): Photograph: ___ DOQQ, ___ Satellite Image, ___ Other

Date of Imagery: ______ **Imagery source:** ______ **Scale:** ______

Discussion of Imagery: ______

Wildlife Observations: ______

Photograph(s):: Name	Direction (N, SE)	View angle (uphill)
2302	SOIL PIT	DOWN
2303	N	
2304	E	
2305	S	
2306	W	

Cowardin Classification: PEM1/SS1B micro-hummocks

slight depression

Field Data Form

Field Form ID: associated w/ point # SITE NUMBER: ~~0~~89

State: Alaska County: U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* TWP/R: ____

Lat/Long (dms): N 62.10507 W 142.03540

Datum: WGS 84

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____ *(Boat /road /helicopter /air boat/etc.)*

Wetland type: PSS1B

Water Depth at the time of field visit: ____ *(Feet or inches)*

Wetland Indicators (x):

____Standing water ____Water Marks ____Buttressed Trunks

____Water Stained Leaves ____Water Carried Debris ____Saturated Soils

____Floating Mat ____Shallow Roots ____Bare Areas

____Oxidized Rhizospheres Other Indicators of Hydrology____

Surrounding Land Use: ____ *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____

Plant Community

Dominance Type: ____

Abundance - Cover Dense (high) 70 - 100% ____

Common (medium) 30 - 69% ____

Occasional < 30% ____

Common Plant Spp: ____

Less Common Plant Spp.: ____

Rare or Unique Plant Spp.: ____

Soils/Substrate

Substrate type: ____Silt, ____Sand, ____Clay, ____Loam, ____Peat, ____Rubble, ____Rock

009

Other ______

Soil Map Unit Name: ______

Taxonomy: ______

Drainage Class: ______ Hydric List (National) ______

Other ______

Soil Survey Publication Date: ______

Munsell: hue value chroma: 5 YR 3/3 fibric depth 0-5 (inches)

5 YR 2.5/1 fibric depth 5-10 (inches)

______ depth ______ (inches)

______ depth ______ (inches)

Hydric Soil Indicators

X Histosol
____ High Organic Content
____ Aquic Moisture Regime
____ Concretions
____ Sulfidic Odor
____ Reducing Conditions
____ Histic Epipedon
____ Organic Streaking
____ Gleyed

Other Remarks gently sloping small pockets of PEMC

Disturbance

____ Fill
____ Channels/ditches
____ Commercial
____ Impoundment
____ Waste
____ Farming
____ Timber Harvesting
____ Other ______
____ Dredging
____ Industrial
____ Roads
____ Fire
____ Residential
____ Drainage

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

X Federal ____ Private

Source Imagery: ______

Type of Imagery Used (x): Photograph: ____ DOQQ, ____ Satellite Image, ____ Other

Date of Imagery: ______ **Imagery source:** ______ **Scale:** ______

Discussion of Imagery: ______

Wildlife Observations: ______

Photograph(s):: Name	Direction (N, SE)	View angle (uphill)
2308	Soil PLG	Down
2309	N	
2310	E	
2311	S	
2312	W	

Cowardin Classification:

Field Data Form

Field Form ID: ____________ SITE NUMBER: ~~011~~ 010

State: Alaska County: U.S.A.

USGS Quad: Nabesna A-2 or Nabesna A-3 *(circle one)* TWP/R: ____________

Lat/Long (dms): N 62.08020 W 142.08690

Datum: ____________

Reported by: John Anderson (St. Mary's University of Minnesota –GeoSpatial Services)

Date: ____________ *(dd/mm/yyyy)*

Other Participants: Kevin Stark (SMUMN GSS)

Accessed Via: ____________ *(Boat /road /helicopter /air boat/etc.)* [helicopter circled]

Wetland type: PSS1 ~~B~~

Water Depth at the time of field visit: ____________ *(Feet or inches)*

Wetland Indicators (x):

___Standing water	X Water Marks	___Buttressed Trunks
___Water Stained Leaves	___Water Carried Debris	___Saturated Soils
___Floating Mat	___Shallow Roots	X Bare Areas

___Oxidized Rhizospheres Other Indicators of Hydrology: scattered debris

Surrounding Land Use: ____________ *(Farmland, residential, mining, etc.)*

Hydrogeomorphic classification: ____________

Plant Community

Dominance Type: ____________

Abundance - Cover Dense (high) 70 - 100% ____________

Common (medium) 30 - 69% ____________

Occasional < 30% ____________

Common Plant Spp: ____________

Less Common Plant Spp.: ____________

Rare or Unique Plant Spp.: ____________

Soils/Substrate

Substrate type: ___Silt, ___Sand, ___Clay, ___Loam, ___Peat, ___Rubble, ___Rock

010

Other ____

Soil Map Unit Name: ____

Taxonomy: ____

Drainage Class: ____ Hydric List (National) ____

Other ____

Soil Survey Publication Date: ____

Munsell: hue value chroma: ____ depth ____ (inches)

____ depth ____ (inches)

____ depth ____ (inches)

____ depth ____ (inches)

Hydric Soil Indicators

___ Histosol	___ Concretions	___ Histic Epipedon
___ High Organic Content	___ Sulfidic Odor	___ Organic Streaking
___ Aquic Moisture Regime	___ Reducing Conditions	___ Gleyed

Other Remarks ____

Disturbance

___ Fill	___ Waste	___ Dredging	___ Fire
___ Channels/ditches	___ Farming	___ Industrial	___ Residential
___ Commercial	___ Timber Harvesting	___ Roads	___ Drainage
___ Impoundment	___ Other ____		

Land Ownership *(field points with the following FIDs are on private lands: 0-6, 14, 97-99, 105, 106, 108-115)*

___ Federal ___ Private

Source Imagery: ____

Type of Imagery Used (x): Photograph: ___ DOQQ, ___ Satellite Image, ___ Other

Date of Imagery: ____ **Imagery source:** ____ **Scale:** ____

Discussion of Imagery: ____

Wildlife Observations: ____

Photograph(s):: Name	Direction (N, SE)	View angle (uphill)
2315	N	
2316	E	
2317	S	
2318	W	

Cowardin Classification: PSS1A to West PEM1C to East

Appendix E: Photo Interpretation Notes

The interpreter noted that the AHAP orthos did not always line up exactly. The shift between images required the photo interpreter to go with one or the other. This determination was done based on where the features were located and also which AHAP was used for the majority of the wetlands.

With aerial photography the best and most accurate area is towards the center of the photo. As one goes towards the edges there is increased distortion. When determining which AHAP to use this is taken into consideration.

Brief List of Conventions – Gold Hill

PSS1B – rougher texture, frequently ~~dotty~~ Salix, Dasiphora, Carex
adjacent to floodplain
PEM1B – smooth white on sloped flats,
saddles, sometimes faint green tones.
– carex
PEM1/SS1B – light/grey (magenta), slopes, drainage patterns
carex/salix/Betula nana
R5USC – grey, riverchannel, smooth

~~PSS1A~~

PSS1/FO4B – magenta speckled grey

PEM1C - basin-shape, bright white

PUBF – dark, basin med blue?

PUBH – Dark blue, basin

* some B wetlands on slopes
mixed w/ upland in Gold Hill

NPS 190/127652, January 2015

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
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