Report of Investigation 2026-4

COASTAL FLOOD IMPACT ASSESSMENT FOR CHEFORNAK, ALASKA

Jessica E. Christian, Keith C. Horen, and Nora M. Nieminski

View of Chefornak, Alaska, taken with an Uncrewed Aerial Vehicle in 2022.

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Department of Natural Resources
Division of Geological & Geophysical Surveys

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COASTAL FLOOD IMPACT ASSESSMENT FOR CHEFORNAK, ALASKA

Jessica E. Christian[1], Keith C. Horen[2], and Nora M. Nieminski[2]

OVERVIEW

This Division of Geological & Geophysical Surveys (DGGS) report is an investigation of the historical flood record and provides an assessment of flood impacts for the community of Chefornak, Alaska. This community-specific report has three sections: data description, flood impact categorization, and historical flood record. Methods used to evaluate historical floods and delineate flood impact categories (minor, moderate, major) are defined by the National Weather Service (NWS) and described in detail by Horen, Poisson, and others (2024), an update from the methods described by Buzard and others (2021). Flood and infrastructure heights are relative to the local mean higher high water (MHHW) datum in feet (ft).

SUMMARY

The community of Chefornak is located about 16 miles (26 kilometers) from the coast on the south bank of the Kinia River, within the Clarence Rhode National Wildlife Refuge on the Yukon-Kuskokwim Delta. A United States Army Corps of Engineers (USACE) flood data sheet provided a note from September 1967, stating the community "is mostly located on a small solid rock outcropping… however, the surrounding area is extremely low and marshy and subject to frequent flooding" (USACE, 2017). However, a 2014 Hazard Mitigation Plan (HMP) indicated that flooding is a minimal hazard for the community since infrastructure is located on a bluff (City of Chefornak, 2014).

Four disaster declarations (2005, 2006, 2022, and 2025) have been reported for flooding in Chefornak (Federal Emergency Management Agency [FEMA], 2006; DHS&EM, 2018; SEOC, 2022, FEMA, 2025). Based on research done for this report, the community experienced at least 20 storm surge flood events between 1974 and 2025. Although the first-floor heights of many homes may now be higher than in the past, floods reaching the height of historical events would still cause similar impacts today. We estimated the peak still water height for two of these flood events, categorizing one as moderate and one as major. The highest recorded flood occurred on October 12, 2025, reaching a still water height of 6.0 ft (1.82 m) MHHW.

DATA

We used geospatial data to assess infrastructure impacts and estimate flood heights from various sources of evidence (e.g., personal accounts, photographs, official reports, etc.). We used Esri's ArcGIS Pro version 3.5.3 to map and process these geospatial data.

Digital Elevation Models and Orthoimagery

Accurate, high-resolution elevation models and orthoimagery are used to measure flood heights in the absence of high-water mark (HWM) data. Two digital elevation models (DEM; table 1) and three orthoimages (table 2) are available for Chefornak. Orthoimagery was collected in 2004 for a Community Profile Map (CMP; Alaska Division of Community & Regional Affairs [DCRA], 2004). Aerial imagery was collected in 2015 and 2022 and used to create digital surface models (DSM), and orthoimagery derived from photogrammetric structure from motion (SfM) processing (Overbeck and others, 2016; Horen,

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Table 1. Specifications of elevation models available for Chefornak, Alaska.

	2015 DSM	2022 DTM
Collection date	2016-MAY-07	2022-AUG-18
Elevation type	Photogrammetric SfM	Photogrammetric SfM
Vertical datum	NAVD88 (GEOID12B)	NAVD88 (GEOID12B)
Ground sample distance	0.7 ft (0.20 m)	0.2 ft (0.06 m)
Accuracy	0.2 ft (0.08 m)	0.3 ft (0.09 m)

Table 2. Summary of aerial imagery and orthoimagery available for Chefornak, Alaska

	2004 Aerial Imagery	2015 Orthoimagery	2022 Orthoimagery
Collection date	2004-OCT-02	2016-MAY-07	2022-AUG-18
Ground sample distance	2.0 ft (0.61 m)	0.3 ft (0.10 m)	0.1 ft (0.02 m)

Christian, and others, 2024).

Where first-floor height data were unavailable (e.g., unoccupied buildings, some facility-attached infrastructure, and private property), we extracted heights from the 2022 DSM if discernable from the 2022 SfM model, orthoimagery, or DSM (e.g., decking at entrances to buildings, visible platforms extending from building edges, etc.). All DEM and orthoimagery will be referenced in this report by the names assigned in tables 1 and 2.

First Floor Survey

CRW Engineering Group, LLC completed a field survey of the first-floor heights of occupied buildings in Chefornak in January 2024. These data were collected and reported in the North American Vertical Datum 1988 with GEOID12B applied (NAVD88 [GEOID12B]) in U.S. survey feet (usft) (app. A). The reported vertical accuracy of these data is ± 0.2 ft (0.07 m). DGGS spatially joined these first-floor heights to building footprints digitized from the 2022 orthoimagery, identifying 144 as occupied buildings (i.e., residential, public, or commercial structures in which people live or work), 122 of which are residential. This survey will be referenced in this report as the 2024 first-floor survey.

GNSS Survey

DGGS performed a global navigation satellite system (GNSS) survey on August 18, 2022, during a visit to Chefornak. The purpose of this survey was to collect community reports and HWM data related to historical flooding. These data were collected in the NAVD88 (GEOID12B) vertical datum in meters and reported in feet. The vertical accuracy of these data is ± 0.2 ft (0.07 m). This survey will be referenced in this report as the 2022 survey.

Vertical Datums

Local tidal datums (table 3) for Chefornak are described by National Oceanic and Atmospheric Administration Center for Operational Oceanographic Products (NOAA CO-OPS) tide station 946 6084 available from https://www.tidesandcurrents.noaa.gov/stationhome.html?id=9466084.

FLOOD IMPACT CATEGORIES

Flood impact categories are used by the NWS to define and communicate flood risk to the public. These categories are designated as major, moderate, and minor (NWS, 2016). Definitions for these categories in the NWS guidance specific to Alaska

Table 3. Tidal datum for Chefornak from NOAA CO-OPS tide station 946 6084.

Tidal Datum	Abbreviation	ft MHHW	m MHHW	ft NAVD88 (GEOID12B)	m NAVD88 (GEOID12B)
Mean Higher High Water	MHHW	0.0	0.00	6.8	2.08
Mean High Water	MHW	-0.9	-0.28	5.9	1.81
Mean Sea Level	MSL	-2.6	-0.80	4.2	1.28
Mean Tide Level	MTL	-2.7	-0.84	4.1	1.25
Mean Low Water	MLW	-4.6	-1.40	2.3	0.69
Mean Lower Low Water	MLLW	-5.1	-1.56	1.7	0.53
North American Vertical Datum 1988 (GEOID12B)	NAVD88 (GEOID12B)	-6.8	-2.08	0.0	0.00

are provided in the form of statements regarding flood impacts, some of which are more qualitative than quantitative (NWS, 2016). To ensure impact assessments are consistent and repeatable, DGGS developed a set of quantitative criteria for each category (Horen, Poisson, and others, 2024). A fourth category, extreme flooding, as defined by DGGS, is included in this report to delineate critical infrastructure situated at heights above the anticipated maximum based on the specifics of the local historical flood record, though flooding is still possible above this height (Horen, Poisson, and others, 2024; NWS, 2018).

Short definitions for each flood impact category are listed below and are explained in greater detail by Horen, Poisson, and others (2024). Table 4 provides a list of key infrastructure heights and the risk categories they fall within. Additional information about each piece of key infrastructure is detailed in the category blocks that follow table 4. Map sheets 1, 2, and 3 accompany this report and depict the potential inundation extents for each flood impact category.

Minor Flooding: "Minimal or no property damage, but possibly some public threat" (NWS, 2016).

Moderate Flooding: "Some inundation of structures and roads… Some evacuations of people and/or transfer of property to higher elevations may be necessary" (NWS, 2016).

Major Flooding: "Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations are necessary" (NWS, 2016).

Extreme Flooding: Flooding that reaches a height above the highest estimated flood height plus the confidence of that estimate. (Horen, Poisson, and others, 2024; NWS, 2018).

Table 4. Summary of infrastructure elevations and flood categories. Gray = extreme, purple = major, red = moderate, and yellow = minor. The extreme category represents infrastructure situated at elevations above the highest estimated flood height with uncertainty included. Categories are based on current infrastructure conditions.

Feature	Height (ft MHHW)	Vertical Uncertainty (ft)	Height (m MHHW)	Vertical Uncertainty (m)
Clinic (south)	45.0	± 0.2	13.72	± 0.07
Airstrip threatened	39.8	± 0.2	12.12	± 0.08
Church	32.4	± 0.2	9.87	± 0.07
School	30.8	± 0.2	9.40	± 0.07
Power plant	30.3	± 0.2	9.25	± 0.07
Store	29.2	± 0.2	8.89	± 0.07
Generator building	28.3	± 0.2	8.63	± 0.07
Washeteria and water tank	27.8	± 0.2	8.48	± 0.07
Tribal office	25.0	± 0.2	7.61	± 0.07
Access to airstrip threatened	19.4	± 0.3	5.90	± 0.09
Community center	19.3	± 0.2	5.89	± 0.07
Clinic (north)	18.6	± 0.2	5.68	± 0.07
Top of fuel containment wall	9.9	± 0.2	3.02	± 0.07
Water pumphouse	9.4	± 0.2	2.86	± 0.07
Head Start	8.9	± 0.2	2.71	± 0.07
Many buildings flooded	8.7	± 0.2	2.66	± 0.07
Avugiak Store and storage	8.6	± 0.2	2.61	± 0.07
Several buildings flooded	8.3	± 0.2	2.52	± 0.07
Lowest watering point	7.3	± 0.2	2.23	± 0.07
Fuel pump	6.6	± 0.2	2.01	± 0.07
Extreme	**6.4**		**1.96**	
Subsistence materials threatened	4.0	± 0.3	1.22	± 0.09
Wastewater lagoon	4.0	± 0.3	1.21	± 0.09
Low-lying roads threatened	3.7	± 0.3	1.14	± 0.09
Major	**3.7**		**1.12**	
Lowest residence flooded	3.5	± 0.2	1.06	± 0.07
Moderate	**3.5**		**1.05**	
Private property threatened	3.0	± 0.3	0.92	± 0.09
Minor	**2.7**		**0.83**	

Extreme Flooding: Greater than 6.4 ft (1.96 m) MHHW

Clinic (south): 45.0 ± 0.2 ft (13.72 ± 0.07 m) MHHW

The clinic is the local medical provider for the community. This is the first-floor height of the clinic building in the southern portion of the village.

Airstrip threatened: 39.8 ± 0.2 ft (12.12 ± 0.08 m) MHHW

Measured from the 2015 DSM, this is the height at which flood waters would reach but not overtop any portion of the airstrip.

Church: 32.4 ± 0.2 ft (9.87 ± 0.07 m) MHHW

This is the only church in the community.

School: 30.8 ± 0.2 ft (9.40 ± 0.07 m) MHHW

As the largest building, with one of the highest first-floor heights in the community, the school is the most suitable evacuation shelter.

Power plant: 30.3 ± 0.2 ft (9.25 ± 0.07 m) MHHW

The power plant provides electricity to the entire community.

Store: 29.2 ± 0.2 ft (8.89 ± 0.07 m) MHHW

This is one of two stores in the community.

Generator building: 28.3 ± 0.2 ft (8.63 ± 0.07 m) MHHW

The generator building houses a backup power generator to use in the event of power outages in the community.

Washeteria and water tank: 27.8 ± 0.2 ft (8.48 ± 0.07 m) MHHW

The washeteria provides laundry and shower services for the community.

Tribal office: 25.0 ± 0.2 ft (7.61 ± 0.07 m) MHHW

This is the first-floor height of the Tribal office.

Access to airstrip threatened: 19.4 ± 0.3 ft (5.90 ± 0.09 m) MHHW

Measured from the 2022 DSM, at this height access to the airstrip would become unsafe to traverse. The NWS (2023) assumes a depth of 1.0 ft (0.30 m) to be the maximum for reasonably safe travel on flooded roads.

Community center: 19.3 ± 0.2 ft (5.89 ± 0.07 m) MHHW

This is the first-floor height of the village's community center building.

Clinic (north): 18.6 ± 0.2 ft (5.68 ± 0.07 m) MHHW

The clinic is the local medical provider for the community. This is the first-floor height of the clinic building in the northern portion of the village near the school.

Top of fuel containment wall: 9.9 ± 0.2 ft (3.02 ± 0.07 m) MHHW

The fuel tank farm is surrounded by a protective containment wall. This height is the lowest point atop this wall.

Water pumphouse: 9.4 ± 0.2 ft (2.86 ± 0.07 m) MHHW

This is the first-floor height of the water pumphouse.

Head Start: 8.9 ± 0.2 ft (2.71 ± 0.07 m) MHHW

This facility provides early education services.

Many buildings flooded 1.0 ft (0.30 m) or more: 8.7 ± 0.2 ft (2.66 ± 0.07 m) MHHW

We consider "many" buildings to describe more than five occupied buildings (Horen, Poisson, and others, 2024). Occupied buildings are residential, public, or commercial structures in which people live or work.

Avugiak Store and storage: 8.6 ± 0.2 ft (2.61 ± 0.07 m) MHHW

This is one of two stores in the community.

Several buildings flooded less than 1.0 ft (0.30 m): 8.3 ± 0.2 ft (2.52 ± 0.07 m) MHHW

We consider "several" buildings to describe more than one but fewer than six occupied buildings (Horen, Poisson, and others, 2024).

Lowest watering point: 7.3 ± 0.2 ft (2.23 ± 0.07 m) MHHW

There are several watering points throughout the community that provide residents with fresh water. This is the height of the lowest watering point in the village.

Fuel pump: 6.6 ± 0.2 ft (2.01 ± 0.07 m) MHHW

The fuel pump is the primary source of fuel for the community.

Major Flooding: 3.7 to 6.4 ft (1.12 m to 1.96 m) MHHW

Subsistence materials threatened: 4.0 ± 0.3 ft (1.22 ± 0.09 m) MHHW

Measured from the 2022 DSM, this is the height at which flooding would cause significant damage to private property, including storage sheds, boats, fishing equipment, vehicles, and other property at ground level outside of occupied structures. From the 2022 orthoimagery, we identified 279 features meeting this description.

Wastewater lagoon: 4.0 ± 0.3 ft (1.21 ± 0.09 m) MHHW

Measured from the 2022 DSM, this is the height at which flood waters would overtop the lowest point of the earthen berm surrounding the wastewater lagoon. Accounting for uncertainty, this height forms the basis of the lower limit of the major flooding category.

Low-lying roads threatened: 3.7 ± 0.3 ft (1.14 ± 0.09 m) MHHW

Measured from the 2022 DSM, at this height the road to the Head Start facility would become difficult to traverse. The NWS (2023) assumes a depth of 1.0 ft (0.30 m) to be the maximum for reasonably safe travel on flooded roads. Accounting for uncertainty, this height forms the basis of the lower limit of the moderate flooding category.

Moderate Flooding: 3.5 to 3.7 ft (1.05 to 1.12 m) MHHW

Lowest residence flooded: 3.5 ± 0.2 ft (1.06 ± 0.07 m) MHHW

At this height, the lowest residence in the community would begin flooding.

Minor Flooding: -0.8 to 0.2 ft (-0.26 to 0.05 m) MHHW

Private property threatened: -0.7 ± 0.1 ft (-0.22 ± 0.04 m) MHHW

Measured from the 2022 DSM, flood waters would reach the lowest private property at this height. Private property may include storage sheds, boats, fishing equipment, vehicles, and other property at ground level outside of occupied structures. From the 2022 orthoimagery, we identified 279 features meeting this description. Accounting for uncertainty, this height forms the basis of the lower limit of the minor flooding category.

Historical Flood Record

The historical flood record for Chefornak is listed in chronological order below, with estimated floods identified by impact category. This record was compiled from information available to the public through open sources or upon request. It is possible that additional, undocumented flood events have impacted the community. Historical information was used in conjunction with the best available, temporally relevant geospatial data to estimate flood heights where possible.

All estimates and confidences were calculated following the methods developed by Horen, Poisson, and others (2024). As described by Horen, Poisson, and others (2024), each estimate is accompanied by two confidence metrics, an estimate confidence based on the combined known potential errors and a time-based confidence based on the temporal relevance of the data used to estimate a given event.

For each flood event, a list and summarization of sources is included, as well as an explanation of the data used and steps performed during estimation, where relevant. Each flood height estimate is classified into a single flood impact category but estimate confidences may span more than one category. Table 5 provides a complete list of the flood events found during our research, with estimated floods categorized and listed in order from highest to lowest, and floods not estimated listed in chronological order.

Table 5. Summary of historical floods. Flood categories are included for reference: purple = Major, red = Moderate, yellow = Minor.

Estimated Floods

	Flood Date	Type	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)
Major	2025-OCT-12	Storm	6.0	± 0.5	± 0.0	1.82	± 0.14	± 0.00
Moderate	2017-OCT-04	Storm	3.5	± 0.3	± 0.1	1.07	± 0.09	± 0.03

Floods Not Estimated

Date	Type
1974-NOV-11	Storm Surge
1979-NOV-09	Storm Surge
1982-SEP-20	Storm Surge
1987-OCT-14	Storm Surge
2000-NOV-13	Storm Surge
2001-SEP-05	Storm Surge
2003-DEC-09	Storm Surge
2004-SEP-09	Storm Surge
2004-OCT-19	Storm Surge
2004-NOV-19	Storm Surge
2005-SEP-24	Storm Surge
2006-SEP-07	Storm Surge
2006-OCT-15	Storm Surge
2011-NOV-09	Storm Surge
2012-OCT-05	Storm Surge
2013-OCT-07	Storm Surge
2022-SEP-17	Storm Surge
2024-AUG-18	Storm Surge

FLOOD EVENT SUMMARIES

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
1974-NOV-11	---	---	---	---	---	---	No flood height estimate

An NWS article in Weatherwise (Fathauer, 1975) featured a hand-drawn map of Alaska indicating "area[s] of coastal flooding" during "the great Bering Sea storms of 9–12 November 1974," which included the Yukon-Kuskokwim Delta coast.

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
1979-NOV-09	---	---	---	---	---	---	No flood height estimate

A 2018 State of Alaska (SOA) Department of Military and Veteran Affairs (DMVA) State Hazard Mitigation Plan (SHMP) appendix prepared by the Division of Homeland Security & Emergency Management (DHS&EM) listed a "major sea storm" impacted 14 villages along the west coast of Alaska. This storm led the State Governor to proclaim a "Disaster Emergency effective from [Nunum Iqua] to Togiak" (DHS&EM, 2018). This event is identified in the NOAA (1979) Storm Data archives with flooding "on the Kuskokwim Bay coast" between 8–10 November described as "the worst in the memory of long-time residents."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
1982-SEP-20	---	---	---	---	---	---	No flood height estimate

NOAA (1982) reported "an intense storm moved out of Bristol Bay and along the west coast of Alaska on the 19th and 20th… An oil rig platform under tow in the Bering Sea broke its tow and went aground off Nunivak Island," which is due west of Chefornak.

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
1987-OCT-14	---	---	---	---	---	---	No flood height estimate

NOAA (1987) reported "an intense Bering Sea storm brought winds… and minor flooding to the Yukon-Kuskokwim delta coast."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2000-NOV-13	---	---	---	---	---	---	No flood height estimate

NOAA (2000) reported storm surge that impacted the Kuskokwim Delta on November 13, 2000, noting "a prolonged south and southwest fetch brought high water to many coastal communities" and "the onset of this coastal flooding coincided with very high tides," causing "significant damage… to several locations."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2001-SEP-05	---	---	---	---	---	---	No flood height estimate

NOAA (2001) reported a strong low-pressure system impacted the Kuskokwim Delta with "gale force southwesterly winds… observed along the south side of the low." NOAA (2001) also noted "coastal flooding potential was highlighted during periods of high tide" when "water reached close to vegetation line along parts of the southwest Alaska Coast," characterizing damage from this event as "relatively minor."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2003-DEC-09	---	---	---	---	---	---	No flood height estimate

NOAA (2003) reported storm surge for the Kuskokwim Delta, noting "the strong long southwest fetch across the Bering Sea resulted in a coastal storm surge along the Yukon and Kuskokwim Delta and northern Bristol Bay."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2004-SEP-09	---	---	---	---	---	---	No flood height estimate

The National Centers for Environmental Information (NCEI) Storm Events Database notes "a strong storm in the Bering Sea created a long fetch with high wind" producing "a coastal storm surge resulting in minor coastal flooding along the Kuskokwim Delta" (NCEI, 2004a).

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2004-OCT-19	---	---	---	---	---	---	No flood height estimate

NCEI (2004b) reported "an intense" low-pressure system "moved into the northern Bering sea [sic] overnight Monday October 18th," and the "resultant long fetch of storm to hurricane force wind produced a storm surge" that "pushed into the Bering Sea coast along the Kuskokwim Delta Monday night and Tuesday. The surge coupled with high tides resulted in coastal flooding and beach erosion."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2004-NOV-19	---	---	---	---	---	---	No flood height estimate

NCEI (2004c) reported "a west to southwest fetch across the Bering Sea, combined with high astronomical tide, resulted in coastal flooding across the west coast of the state."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2005-SEP-24	---	---	---	---	---	---	No flood height estimate

DHS&EM (2018) reported "a powerful fall storm produced high winds combined with wind-driven tidal surges resulting in severe and widespread coastal flooding and a threat to life and property" along the west coast of Alaska between 22 and 26 September, 2005.

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2006-SEP-07	---	---	---	---	---	---	No flood height estimate

NCEI (2006a) reported coastal flooding along the Kuskokwim Delta, noting "the Remnants of super typhoon Ioke… produced strong west wind across the Bering Sea that produced seas in excess of 30 feet" and "coincided with very high astronomical tides along the Bristol Bay coast and the coast of the Kuskokwim Delta" with "the combination of the storm surge and the very high tides" producing "minor coastal flooding."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2006-OCT-15	---	---	---	---	---	---	No flood height estimate

NCEI (2006b) reported coastal flooding from "an intense storm" that "moved into the central Bering Sea," noting "the strong south to southwest wind associated with this storm produce[d] a surge along the coast of the Kuskokwim Delta."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2011-NOV-09	---	---	---	---	---	---	No flood height estimate

NCEI (2011) reported "strong wind and long fetch resulted in a coast storm surge that produced minor coastal flooding in the Kuskokwim Delta region."

An Alaska Department of Environmental Conservation (ADEC) Coastal Impact Assessment Program (CIAP) Waste Erosion Assessment and Report (WEAR) noted at the Avugiak Store's old fuel tank site "two large bulk fuel tanks were eroded away and washed upstream during a storm event in 2011" (ADEC, 2012).

A flood height could not be estimated for this event because we were unable to locate the indicated bulk fuel tanks from the information available.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2012-OCT-05	---	---	---	---	---	---	No flood height estimate

DHS&EM (2018) reported "on October 5, 2012, a strong Fall storm moved north into the Bering Sea and produced severe winds, heavy rain, and storm surges up to 4 feet above mean tide levels in the Kuskokwim Delta."

ADEC (2012) reported the "Consolidated Tank Farm… stayed dry during the major flood event of October 2012."

A flood height could not be estimated for this event because the actual water height could be any height lower than the minimum height at the tank farm, 3.9 ft (1.19 m) MHHW from the 2024 first-floor survey.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2013-OCT-07	---	---	---	---	---	---	No flood height estimate

NCEI (2013) reported "an intense and large storm in the Bering Sea produced a long fetch of strong wind across the Bering Sea aligned with the Kuskokwim Delta coast November 6th through the 9th. This produced a surge of up to 5 feet along the Kuskokwim Delta Coast."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2017-OCT-04	3.5	± 0.3	± 0.1	1.07	± 0.09	± 0.03	Moderate

A report by PND Engineers, Inc. (2018) notes "in early October… a strong gale force wind event struck the eastern Bering Sea" with "flooding extended over a 3-day period during and immediately following the storm." Two photographs of flooding were included in the PND (2018) report (fig. 1 and 2).

Figure 1. Flooding at Head Start utility building on October 5, 2017, in Chefornak, Alaska (PND, 2018).

Figure 2. Flooding on access road to Head Start building on October 5, 2017, in Chefornak, Alaska (PDN, 2018).

To estimate this flood, we identified the buildings and infrastructure in the photographs, located these within the 2015 orthoimagery, and overlayed this orthoimagery with a simple bathtub model applied to the 2015 DSM to approximate the water heights depicted. We found that the water heights shown in the photographs corresponded to 3.3 ft (1.02 m) MHHW (fig. 1) and 3.7 ft (1.12 m) MHHW (fig. 2). We calculated an average of these two heights to estimate a flood height of 3.5 ft (1.07 m) MHHW.

Although this flood estimate is categorized as moderate based on the average, the estimate confidence range could also potentially place this flood event within the minor or major impact categories.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2022-SEP-17	---	---	---	---	---	---	No flood height estimate

NCEI (2022) reported "a myriad of impacts were noted across the West Alaska Coastline" as the remnants of Typhoon Merbok reached the Kuskokwim Delta coast in the early evening of September 16, 2022, indicating that "impacts, including damaging wind gusts and storm surge, were observed from the Kuskokwim Delta to the Yukon Delta…"

FEMA (2022) Housing Inspectors traveled to Chefornak in early October 2022 "to help survivors register for FEMA assistance and perform housing inspections for applicants who experienced damage from the Sept. 15 – 20 severe storms, flooding and landslides."

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2024-AUG-18	---	---	---	---	---	---	No flood height estimate

NCEI (2024) reported "two Bering Sea low pressure systems tracked into Western Alaska from August 15 through 18th bringing a period of nearly-persistent southerly winds which led to storm surge and coastal flooding along the Kuskokwim Delta coast" with flooding "most severe on August 18…"

A flood height could not be estimated for this event because no specific impacts to Chefornak were provided.

Flood Date	Height (ft MHHW)	Estimate Confidence (ft)	Temporal Confidence (ft)	Height (m MHHW)	Estimate Confidence (m)	Temporal Confidence (m)	Category
2025-OCT-12	6.0	± 0.5	± 0.0	1.82	± 0.14	± 0.00	Major

NWS (2025) reported the remnants of Typhoon Halong "reached the Yukon–Kuskokwim Delta coast early on Sunday morning, October 12, bringing "a record-breaking storm surge," with "the villages of Kongiganak, Kwigillingok, Kipnuk, Nightmute, and Chefornak all report[ing] varying degrees of inundation."

In response to the "catastrophic flooding and destruction" (NWS, 2025) DGGS contracted JOA Surveys, LLC, to collect survey data in multiple communities following this event, including 17 HWM in Chefornak (app. B).

To estimate this flood, we first assessed the quality of the HWM data, discarding five as outliers: points 100, 112, 113, 114, and 116 (app. B). An average of the remaining 12 HWM was calculated to estimate a flood height of 6.0 ft (1.82 m) MHHW.

ACKNOWLEDGMENTS

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REFERENCES

Alaska Department of Environmental Conservation (ADEC), 2012, Coastal impact assistance program (CIAP) waste erosion assessment and review (WEAR) trip report—Chefornak, 4 p.

Alaska Division of Community & Regional Affairs (DCRA), 2004, Community profile map, Chefornak: Department of Commerce, Community, and Economic Development. https://experience.arcgis.com/experience/3c4d6f91cd0d49cbb99041885671277c#data_s=id%3AdataSource_1-Community_Profiles_189%3A16

Alaska Division of Homeland Security & Emergency Management (DHS&EM), 2018, State of Alaska Hazard Mitigation Plan (SHMP): Department of Military and Veteran Affairs, Appendices, 378 p.

Buzard, R.M., Overbeck, J.R., Chriest, Jonathan, Endres, K.L., and Plumb, E.W., 2021, Coastal flood impact assessments for Alaska communities: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2021-1, 16 p. https://doi.org/10.14509/30573

City of Chefornak, 2014, City of Chefornak Hazard Mitigation Plan, 162 p.

Fathauer, T.F., 1975, The great Bering Sea storms of 9–12 November 1974: Weatherwise, v. 28, p. 76-83.

Federal Emergency Management Agency (FEMA), 2006, Alaska Disaster Declaration as of 08/04/2006: FEMA-1657-DR. https://gis.fema.gov/maps/dec_1657.pdf

———2022, FEMA Housing Inspectors in Chefornak, Stebbins, Golovin, [Press Release] https://ready.alaska.gov/Documents/Storms/PressReleases/ADV_002_FEMA_Specialists_Traveling_to_Stebbin_Golovin_Chefornak.pdf

———2025, Alaska Severe Storms, Flooding, and Remnants of Typhoon Halong: DR-4893-AK. https://www.fema.gov/disaster/4893

Horen, K.C., Christian, J.E., Doiron, N.M., Poisson, A.C., and Siemsen, Z.J., 2024, Photogrammetry-derived orthoimagery and elevation data for Chefornak, Alaska, collected August 18, 2022: Alaska Division of Geological & Geophysical Surveys Raw Data File 2024-26, 6 p. https://doi.org/10.14509/31294

Horen, K.C., Poisson, A.C., Christian, J.E., and Nieminski, N.M., 2024, Methods for evaluating coastal flood impacts in Alaska communities: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 177, 13 p. https://doi.org/10.14509/31279

National Centers for Environmental Information (NCEI), 2004a, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=5425095

———2004b, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=5425096

———2004c, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=5426902

———2006a, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=5533225

———2006b, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=2387

———2011, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=347158

———2013, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=483054

———2022, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=1060589

———2024, Storm events database: National Oceanic and Atmospheric Administration, 1 p. https://www.ncei.noaa.gov/stormevents/eventdetails.jsp?id=1207885

National Oceanic and Atmospheric Administration (NOAA), 1979, Storm data—November 1979: U.S. Department of Commerce, v. 21, no. 11, 10 p.

———1982, Storm data—September 1982: U.S. Department of Commerce, v. 24, no. 09, 24 p.

———1987, Storm data—October 1987: U.S. Department of Commerce, v. 29, no. 10, 30 p.

———2000, Storm data—November 2000: U.S. Department of Commerce, v. 42, no. 11, 106 p.

———2001, Storm data—September 2001: U.S. Department of Commerce, v. 43, no. 09, 174 p.

———2003, Storm data—December 2003: U.S. Department of Commerce, v. 45, no. 12, 144 p.

National Weather Service (NWS), 2016, High water level terminology. [Accessed May 8, 2024] https://www.weather.gov/aprfc/terminology

———2018, Coastal flood categories: National Weather Service Eastern Region supplement 01-2018, 9 p. https://www.weather.gov/media/directives/010_pdfs/pd01001003a012018curr.pdf

———2023, Flood safety: During a flood. [Accessed May 8, 2024] https://www.weather.gov/safety/ flood-during

———2025, West coast Alaska storm—Ex-Typhoon Halong: National Oceanic and Atmospheric Administration, 13 p.

Overbeck, J.R., Hendricks, M.D., and Kinsman, N.E.M., 2016, Photogrammetric digital surface models and orthoimagery for 26 coastal communities of western Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2016-1, 3 p. https://doi.org/10.14509/29548

PND Engineers Inc. (PND), 2018, City of Chefornak Site Observation Report, 20 p. PND Head Start Report w appendix.pdf

State Emergency Operations Center (SEOC), 2022, 2022 September Winter Storm Incident Situation Report, 12 p., https://ready.alaska.gov/Documents/Sitrep/Archive/2022/9.26.2022%20September%20West%20Coast%20Storm%20SitRep%20(1).pdf

United States Army Corps of Engineers (USACE), 2017, Chefornak flood data: USACE Alaska District, 2 p.

APPENDIX A: CHEFORNAK, ALASKA, FIRST-FLOOR HEIGHT SURVEY

ALASKA NATIVE TRIBAL HEALTH CONSORTIUM
Environmental Health & Engineering

January 12, 2024

Chefornak, Alaska Finish Floor Elevation Study
ANTHC Project No. 10-0189-01-01

The data provided is from a field survey completed by ANTHC on January 9, 2024. Project elevations are NAVD88 Orthometric heights (U.S. Feet), computed using GEOID12B, and were measured utilizing Trimble R10 GPS Receivers using RTK GPS.

BASIS OF HORIZONTAL CONTROL:
The Basis of Horizontal Control is ANTHC Point 401, a 6" spike set in a grassy area north of the Chefornak School. The position for this point was derived through a static GPS session using a Trimble R10 GPS Receiver post processed using the National Geodetic Survey (NGS) Online Positioning User Service (OPUS). Said point has the following coordinates:

NAD83(2011)(EPOCH2010.00) Geodetic Coordinates:
Latitude = 60° 09' 28.28052" N
Longitude = 164° 16' 55.43483" W

NAD83(2011)(EPOCH2010.00) Alaska State Plane Zone 8, U.S. Feet:
Northing = 2,253,657.02'
Easting = 1,953,365.41'

BASIS OF VERTICAL CONTROL:
The Basis of Vertical Control is ANTHC Point 551, NOAA tidal benchmark 6084 B 2021, NOAA station designation 9466084 B, a chiseled square on top of the corner of a steel cap on an arctic thermopile supporting the north corner of the Chefornak school. Said point has a NAVD88 Orthometric height of 10.557m/34.64'.

Sincerely,

Paul Russell, PLS
Survey Manager

Enclosures:
- Chefornak-FF_AKSPZ8.csv
- Chefornak-FF_NAD83(2011).csv
- OPUS Report_Pt-401_20240109.pdf
- Published Bench Mark Sheet for 9466084 CHEFORNAK AK.pdf

Alaska Native Tribal Health Consortium//Division of Environmental Health & Engineering
4500 Diplomacy Drive, Suite 454, Anchorage, Alaska 99508//Main: (907) 729-3600 //Fax: (907) 729-4090//anthc.org

FILE: 98960091.24o OP1704993998868

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information:
https://urldefense.com/v3/__https://www.ngs.noaa.gov/OPUS/about.jsp*accuracy__;Iw!!PD8KOL_GOQI!wG_ntDXKNqfGRDY749jbp8b6sL-bSOUgD2gYA_piRpKjo9iJ674IpBeneAlBceLPZUJy7xlLM6O335-d$

USER: ajbrennan@anthc.org DATE: January 11, 2024
RINEX FILE: 9896009r.24o TIME: 17:27:41 UTC

SOFTWARE: page5 2008.25 master279.pl 160321 START: 2024/01/09 17:52:00
EPHEMERIS: igu22962.eph [ultra-rapid] STOP: 2024/01/10 02:02:00
NAV FILE: brdc0090.24n OBS USED: 21486 / 23702 : 91%
ANT NAME: TRMR10 NONE # FIXED AMB: 123 / 147 : 84%
ARP HEIGHT: 1.6219 OVERALL RMS: 0.015(m)

REF FRAME:	NAD_83(2011)(EPOCH:2010.0000)		ITRF2014 (EPOCH:2024.0244)	
X:	-3062891.208(m)	0.014(m)	-3062892.456(m)	0.014(m)
Y:	-861974.481(m)	0.018(m)	-861973.475(m)	0.018(m)
Z:	5509266.262(m)	0.025(m)	5509266.524(m)	0.025(m)
LAT:	60 9 28.28052	0.005(m)	60 9 28.25870	0.005(m)
E LON:	195 43 4.56517	0.019(m)	195 43 4.48046	0.019(m)
W LON:	164 16 55.43483	0.019(m)	164 16 55.51954	0.019(m)
EL HGT:	19.003(m)	0.027(m)	19.692(m)	0.027(m)
ORTHO HGT:	8.880(m)	0.355(m)	[NAVD88 (Computed using GEOID12B)]	

	UTM COORDINATES UTM (Zone 03)	STATE PLANE COORDINATES SPC (5008 AK 8)
Northing (Y) [meters]	6669208.014	686916.034
Easting (X) [meters]	539853.286	595386.968
Convergence [degrees]	0.62274444	1.49024722
Point Scale	0.99961946	1.00001147
Combined Factor	0.99961649	1.00000850

US NATIONAL GRID DESIGNATOR: 3VWG3985369208(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL6431	AB17 UNALAKLEETAK2008 CORS GRP	N635310.903	W1604140.939	455747.9
DK4091	BET1 BETHEL WAAS CORS ARP	N604716.508	W1615030.124	151458.6
DI2154	AB15 NYAC_GOLD_AK2006 CORS GRP	N610223.117	W1595242.014	260445.8

NEAREST NGS PUBLISHED CONTROL POINT

DQ2641	CFK B		N600900.910 W1641709.616	874.9

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

FF = Finish Floor

GS = Ground Shot

401	2253657.02	1953365.41	29.17	SPIKE
551	2253664.31	1953264.45	34.64	6084 B 2021
4000	2251520.08	1954395.66	33.14	FF HOME
4001	2251493.82	1954472.62	30.61	FF HOME
4002	2251589.08	1954467.65	28.79	FF HOME
4003	2251643.61	1954349.80	29.06	FF HOME
4004	2251606.23	1954271.98	37.12	FF HOME
4005	2251635.11	1954200.62	36.21	FF HOME
4006	2251721.21	1954095.48	35.24	FF HOME
4007	2251588.28	1954143.61	35.86	FF HOME
4008	2251643.88	1954024.16	37.10	FF HOME
4009	2251676.32	1953945.57	38.55	FF HOME
4010	2251697.73	1953869.71	38.82	FF HOME
4011	2251762.49	1953926.18	39.43	FF HOME
4012	2251770.55	1953898.73	38.99	FF HOME
4013	2251725.73	1953787.18	40.33	FF HOME
4014	2251812.53	1953789.88	38.71	FF HOME
4015	2251838.10	1953746.52	38.21	FF HOME
4016	2251747.19	1953711.99	39.48	FF HOME
4017	2251777.72	1953617.36	40.94	FF HOME
4018	2251855.30	1953643.14	38.33	FF HOME
4019	2251884.83	1953587.90	38.53	FF HOME
4020	2251793.64	1953535.68	40.78	FF HOME
4021	2251816.76	1953452.16	43.45	FF HOME
4022	2251790.03	1953355.82	44.99	FF HOME
4023	2251884.13	1953347.60	43.10	FF HOME
4024	2251938.75	1953327.79	43.82	FF HOME
4025	2251949.16	1953434.81	40.07	FF HOME
4026	2251863.70	1953539.05	41.48	FF SHED
4027	2251923.10	1953294.13	47.44	FF SHED
4028	2251950.81	1953280.49	48.89	FF SHED
4029	2252124.75	1953327.29	51.83	FF CLINIC
4030	2252045.14	1953449.40	41.87	FF SHED
4031	2252119.32	1953422.40	39.95	FF HOME
4032	2252167.72	1953451.33	38.43	FF HOME
4033	2252267.08	1953570.31	37.79	FF HOME
4034	2252337.26	1953587.41	37.58	FF HOME
4035	2252212.85	1953644.39	36.52	FF HOME
4036	2252132.85	1953657.06	36.15	FF HOME
4037	2252126.82	1953727.77	36.11	FF HOME
4038	2252211.37	1953739.22	35.77	FF HOME
4039	2252381.64	1953677.12	31.82	FF HOME

4040	2252459.04	1953654.61	31.00	FF HOME
4041	2252533.01	1953639.06	33.50	FF HOME
4042	2252484.55	1953545.02	36.68	FF HOME
4043	2252457.42	1953536.28	36.94	FF HOME
4044	2251661.34	1954080.75	29.56	FF WATERING POINT
4045	2251791.57	1953672.44	34.21	FF WATERING POINT
4046	2251896.06	1953366.82	38.60	FF WATERING POINT
4047	2252589.53	1953547.43	30.64	FF WATERING POINT
4048	2252624.79	1953531.18	36.17	FF HOME
4049	2252609.68	1953615.80	33.84	FF HOME
4050	2252687.60	1953594.91	29.57	FF HOME
4051	2252729.08	1953514.58	31.67	FF HOME/SHED
4052	2252703.58	1953485.92	32.91	FF HOME
4053	2252725.54	1953488.10	35.42	FF HOME
4054	2252722.16	1953446.91	35.41	FF HOME
4055	2252587.42	1953329.52	39.00	FF HOME
4056	2252648.38	1953319.50	39.93	FF HOME
4057	2252727.42	1953275.45	38.89	FF HOME
4058	2252756.17	1953237.35	37.63	FF HOME
4059	2252803.23	1953309.02	37.45	FF HOME
4060	2252868.85	1953316.56	37.23	FF HOME
4061	2252839.15	1953446.60	36.01	FF HOME
4062	2252813.98	1953486.05	33.84	FF HOME
4063	2252789.15	1953590.43	25.24	FF HOME
4064	2252832.88	1953497.42	29.04	FF WATERING POINT
4065	2252908.36	1953420.23	33.69	FF HOME
4066	2253152.19	1953201.11	37.65	FF HOME
4067	2253104.61	1953190.45	39.21	FF CHURCH
4068	2253152.02	1953303.29	35.94	FF STORAGE
4069	2253134.44	1953337.38	35.50	FF HOME
4070	2253158.80	1953345.53	34.20	FF HOME
4071	2253245.10	1953343.45	32.41	FF HOME
4072	2253244.01	1953219.73	35.13	FF GENERATOR BUILDING
4073	2253459.07	1953278.81	36.35	FF TEACHER HOUSING
4074	2253479.35	1953229.91	35.25	FF TEACHER HOUSING
4075	2253645.86	1953029.91	27.50	FF GARAGE
4076	2253531.49	1953150.88	28.00	FF GARAGE
4077	2253849.96	1953145.59	24.35	FF GARAGE
4078	2253910.07	1953168.66	27.88	FF COMM BUILDING
4079	2253957.35	1953248.52	26.05	FF HOME
4080	2253973.39	1953309.03	31.57	FF HOME
4081	2253806.73	1953331.48	34.67	FF WASHETERIA
4082	2253729.46	1953301.55	37.17	FF POWER PLANT
4083	2253738.94	1953253.84	35.66	FF BUILDING

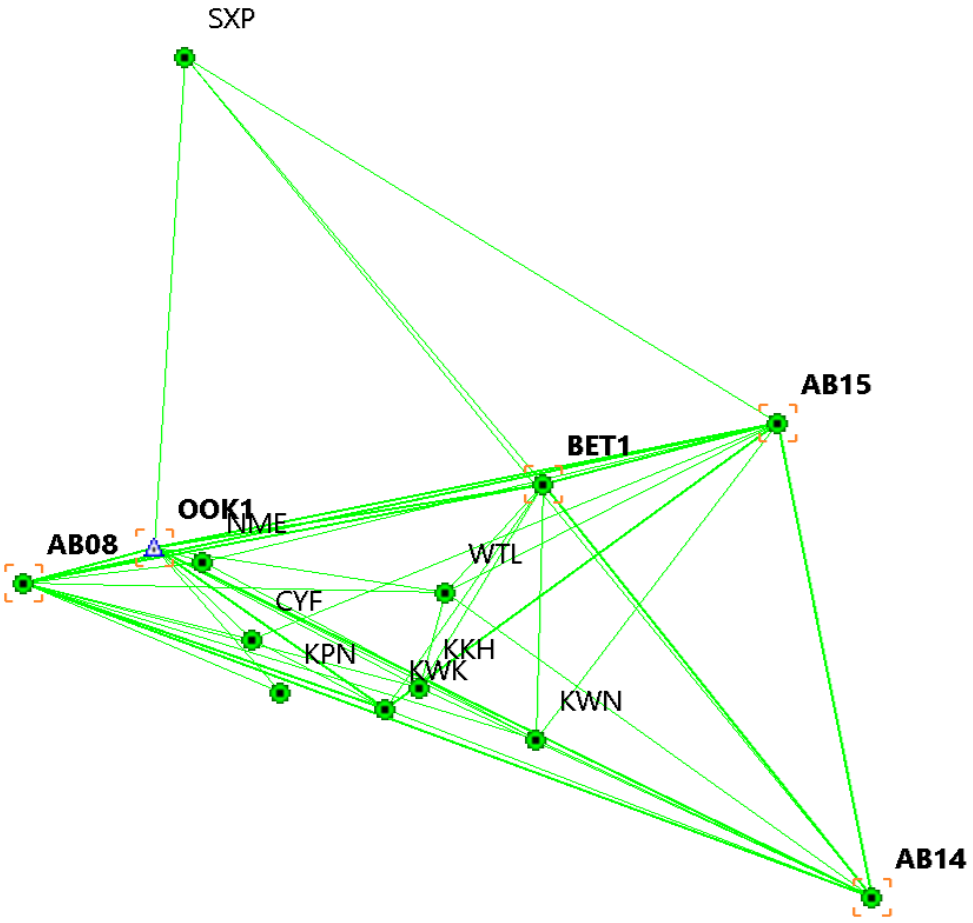
4084	2253753.66	1953436.95	33.08	FF HOME
4087	2253943.63	1953405.25	33.46	FF HOME
4088	2254040.85	1953206.70	22.43	FF SHED
4089	2254098.23	1953268.77	23.37	FF HOME
4090	2254134.16	1953259.36	21.27	FF HOME
4091	2254170.88	1953294.46	25.53	FF HOME
4092	2254186.69	1953286.78	21.54	FF SHED
4093	2254211.91	1953291.00	20.35	FF SHED
4094	2254102.48	1953386.60	27.18	FF SHED
4095	2254115.26	1953403.48	26.98	FF WATERING POINT
4096	2254249.76	1953192.81	15.03	FF CONTSRUCTION HOUSING
4097	2254117.96	1953372.24	26.83	FF HOME
4098	2254103.04	1953369.64	28.55	FF HOME
4099	2253640.44	1953177.88	37.50	FF SCHOOL BUILDING
4100	2253518.40	1953199.20	37.53	FF SCHOOL BUILDING
5001	2246500.92	1953442.16	53.68	FF DOT BUILDING
5002	2246448.23	1953450.24	53.27	FF DOT BUILDING
5003	2246395.62	1953454.41	51.53	FF DOT BUILDING
5004	2246455.57	1953644.70	50.32	GS APRON
5005	2246517.57	1954052.31	50.22	GS RUNWAY
5006	2245811.08	1954132.68	53.41	GS RUNWAY
5007	2246922.71	1954033.04	48.50	GS RUNWAY
5008	2254548.68	1953272.71	7.53	GS BARGE LANDING
5009	2254476.63	1953242.10	10.92	GS BARGE LANDING
5010	2254397.50	1953185.70	13.44	FF FUEL PUMP
5011	2254458.56	1952483.27	16.73	FF TOP FUEL CONTAINMENT
5012	2254423.19	1952495.17	10.73	FF BOTTOM FUEL CONTAINMENT
5014	2253556.30	1955016.96	13.27	FF SHED
5016	2254131.42	1955852.86	16.61	FF CVRF BUILDING
5017	2254210.83	1955475.41	15.72	FF HEADSTART/TEACHER HOUSING
5018	2254103.55	1955367.71	14.06	FF OLD BIA SCHOOL - LKSD SCHOOL STORAGE
5019	2254197.03	1955336.27	13.10	FF TEACHER HOUSING
5020	2254282.02	1955362.28	13.09	FF OLD BIA GENERATOR/STORAGE
5021	2254221.05	1955307.98	14.57	FF TEACHER HOUSING
5022	2254009.60	1955161.99	15.06	FF W & S PROJECT CONNEX BUILDING
5023	2253777.43	1955223.67	14.56	FF HOME
5024	2253771.67	1955029.82	10.30	FF HOME
5025	2253719.16	1954968.13	12.74	FF HOME
5026	2253906.09	1954914.73	12.41	FF HOME
5027	2254045.84	1954979.80	14.11	FF ALASKA NATIONAL GUARD BUILDING
5028	2254128.29	1954871.04	10.65	FF SHED
5029	2254101.36	1954860.93	16.23	FF W & S PUMPHOUSE
5030	2254093.55	1954658.04	15.30	FF HOME
5031	2254067.08	1954606.48	14.14	FF WATERING POINT

5032	2254044.47	1954542.26	14.05	FF	SHED
5033	2254095.72	1954485.20	19.44	FF	HOME
5034	2254085.74	1954458.13	19.65	FF	HOME
5035	2254034.85	1954370.35	15.39	FF	AVUGIAK'S STORE & STORAGE
5036	2254095.03	1954344.62	19.65	FF	HOME
5037	2254066.69	1954307.38	20.88	FF	WATERING POINT
5038	2254087.16	1954305.37	21.87	FF	HOME
5039	2254030.21	1954295.01	17.65	FF	HOME
5040	2254000.08	1954322.27	14.86	FF	HOME
5041	2254076.75	1954225.70	21.38	FF	HOME
5042	2254055.75	1954195.47	22.70	FF	HOME
5043	2254000.37	1954169.72	24.47	FF	HOME
5044	2254011.76	1954230.76	20.25	FF	HOME
5045	2253954.20	1954067.59	15.73	FF	HOME
5046	2253960.88	1954046.95	22.12	FF	HOME
5047	2254047.85	1954040.97	26.17	FF	TC OFFICE/CVRF OFFICE/COMMUNITY CENTER
5048	2254064.92	1954064.75	24.48	FF	PARISH BUILDING
5049	2254100.39	1954148.44	22.40	FF	HOME
5050	2254086.74	1954012.12	24.02	FF	HOME
5051	2254072.79	1953963.17	24.21	FF	WATERING POINT
5052	2254020.14	1953931.95	25.04	FF	HOME
5053	2253972.43	1953942.38	22.75	FF	HOME
5054	2253958.27	1953934.39	24.95	FF	HOME
5055	2253917.72	1953957.24	18.34	FF	HOME
5056	2253715.42	1954093.73	15.13	FF	HOME
5057	2254103.34	1953851.16	25.14	FF	HOME
5058	2253995.20	1953873.03	24.77	FF	HOME
5059	2253925.55	1953823.44	22.63	FF	SHED
5060	2253927.92	1953842.03	23.31	FF	HOME
5061	2253882.60	1953855.76	17.84	FF	HOME
5062	2253909.47	1953774.35	24.02	FF	HOME
5063	2254065.32	1953780.03	25.87	FF	HOME
5064	2253994.15	1953784.78	26.88	FF	HOME
5065	2254056.74	1953704.43	28.87	FF	HOME
5066	2254098.56	1953691.54	27.82	FF	HOME
5067	2254148.65	1953678.87	23.48	FF	HOME
5068	2254210.21	1953667.36	19.69	FF	HOME
5069	2254249.51	1953650.21	19.91	FF	HOME
5070	2254242.06	1953595.81	19.64	FF	HOME
5071	2254203.06	1953592.20	25.00	FF	HOME
5072	2254164.33	1953634.00	26.71	FF	HOME
5073	2254065.94	1953650.18	27.96	FF	HOME
5074	2254021.42	1953680.88	29.62	FF	WATERING POINT
5075	2254030.36	1953638.33	29.74	FF	HOME

5076	2254090.65	1953619.50	28.96	FF	HOME
5077	2254145.80	1953496.97	28.22	FF	HOME
5078	2254140.40	1953456.56	28.01	FF	HOME
5079	2253931.13	1953588.72	31.40	FF	VSPO RESIDENCE
5080	2253896.84	1953625.90	31.80	FF	TRIBAL OFFICE
5081	2253851.99	1953697.55	22.14	FF	HOME
5082	2253743.74	1953677.83	20.87	FF	HOME
5083	2253740.88	1953610.85	25.47	FF	CLINIC
5084	2253839.64	1953587.12	36.00	FF	STORE
5086	2253867.91	1953492.46	34.40	FF	HOME
5089	2253624.66	1953450.85	37.68	FF	SCHOOL
5090	2253930.67	1953702.34	25.36	FF	HOME
5091	2254116.80	1955051.30	14.73	FF	ALASKA NATIONAL GUARD ARMORY

APPENDIX B: ACCURACY REPORT WITH OPUS SOLUTIONS

2025 Typhoon Halong High-Water Mark Accuracy Assessment



Survey Results– The field response was conducted during the Federal Government shutdown and the NGS OPUS positioning service was unavailable. To obtain final coordinates a least squares adjustment of a regiomal network including the RTK base in each surveyed village and six nearby CORS sites, holding the ACORN site OOK1 at Toksook Bay fixed was performed. The results of the adjustment (Table 3) show standard errors of +/- 0.01 m horizontal and +/- 0.02-0.03 m vertical. As a check on the least squares adjustment OPUS solutions were obtained. Tables 1 and 2 summarize the OPUS results. The RMSE of the solution differences is +/- 0.022 m horizontal and +/- 0.025 m vertical.

Given short baseline lengths and fixed RTK solutions, rover positioning accuracy is expected to be comparable to the network RMSE values. Accordingly, RTK survey accuracy is conservatively quoted as ±0.03 m horizontal and ±0.05 m vertical.

Table 1

2025 Halong High Water Mark Survey Village Base Statio Coordinate Checks

	Field Solution Topcon Magnet							OPUS Check									
Village	Latitude			Longitude			Ellip. Ht.(m)	Latitude			Longitude			Ellip. Ht.(m)	dN(m)	dE(m)	dHt.(m)
BET2	60	47	28.63987	-161	45	20.35263	15.968	60	47	28.64126	-161	45	20.35248	15.966	-0.043	0.002	0.002
CYF	60	9	27.53819	-164	17	4.61717	20.890	60	9	27.53809	-164	17	4.61699	20.882	0.003	0.003	0.008
KKH	59	57	37.49944	-162	53	1.63527	20.564	59	57	37.49825	-162	53	1.63093	20.603	0.037	0.067	-0.039
KPN	59	56	34.91689	-164	2	31.04466	13.178	59	56	34.91657	-164	2	31.04394	13.124	0.010	0.011	0.054
KWK	59	52	32.33283	-163	9	58.13696	14.602	59	52	32.33262	-163	9	58.13618	14.566	0.007	0.012	0.036
KWN	59	45	6.67084	-161	53	54.77391	18.350	59	45	6.67170	-161	53	54.77363	18.351	-0.027	0.004	-0.001
NME	60	28	24.74153	-164	42	2.68863	17.580	60	28	24.74177	-164	42	2.68895	17.574	-0.007	-0.005	0.006
SXP	62	31	29.38853	-164	50	43.67362	11.319	62	31	29.38861	-164	50	43.67544	11.255	-0.003	-0.028	0.064
WTL	60	21	1.76695	-162	39	33.76335	20.069	60	21	1.76717	-162	39	33.76379	20.054	-0.007	-0.007	0.015
														RMSE	**0.022**	**0.025**	**0.034**
AB08	60	23	5.40615	-166	12	3.00222	25.797	CORS									
AB14	59	6	29.40381	-159	5	29.43297	657.062	CORS									
AB15	61	2	23.11692	-159	52	42.01403	559.737	CORS									
BET1	60	47	16.50771	-161	50	30.12395	51.078	CORS									
NGMT	60	28	31.56528	-164	43	24.94228	19.596	CORS									
OOK1	**60**	**31**	**43.14590**	**-165**	**6**	**27.81555**	**16.416**	**Fixed Position in the Adjustment (CORS)**									

Table 2

OPUS Solution Quality Metrics

Site	Duration	RMS	%Obs.	%Amb.	P2P Lat/Lon/Hgt.
BET	02h 21m	0.01	95%	**58%**	0.015 / 0.026 / 0.011
CYF	03h 42m	0.02	97%	86%	0.011 / 0.023 / 0.017
KKH	02h 56m	0.02	96%	91%	0.007 / 0.022 / 0.030
KPN	04h 18m	0.02	98%	91%	0.014 / 0.027 / 0.008
KWK	03h 46m	0.01	97%	94%	0.011 / 0.010 / 0.014
KWN	03h 15m	0.01	98%	89%	0.019 / 0.006 / 0.013
NME	03h 21m	0.02	99%	93%	0.011 / 0.015 / 0.023
WTL	06h 06m	0.01	98%	96%	0.010 / 0.024 / 0.023

Table 3

Topcon Magnet Processing - Least Squares Adjustment Results

Name	Latitude (°)	Longitude (°)	Ell.Height (m)	Elevation (m)	Hz Stdev,(m)	Hgt, Stdev. (m)	Geoid 12B
BET2	60°47'28.63987"N	161°45'20.35263"W	15.968	5.334	0.006	0.009	10.634
CYF	60°09'27.53819"N	164°17'04.61717"W	20.89	10.767	0.009	0.016	10.123
KKH	59°57'37.49944"N	162°53'01.63527"W	20.564	9.204	0.011	0.018	11.36
KPN	59°56'34.91689"N	164°02'31.04466"W	13.178	2.791	0.013	0.023	10.388
KWK	59°52'32.33283"N	163°09'58.13696"W	14.602	3.291	0.009	0.015	11.311
KWN	59°45'06.67084"N	161°53'54.77391"W	18.35	6.384	0.012	0.020	11.965
NME	60°28'24.74153"N	164°42'02.68863"W	17.58	7.565	0.003	0.004	10.015
SXP	62°31'29.38853"N	164°50'43.67362"W	11.319	11.319	0.019	0.025	0
WTL	60°21'01.76695"N	162°39'33.76335"W	20.069	9.333	0.010	0.017	10.735
AB08	60°23'05.40615"N	166°12'03.00222"W	25.797	16.018	0.004	0.007	9.78
AB14	59°06'29.40381"N	159°05'29.43297"W	657.062	643.575	0.008	0.011	13.487
AB15	61°02'23.11692"N	159°52'42.01403"W	559.737	559.737	0.006	0.009	0
BET1	60°47'16.50771"N	161°50'30.12394"W	51.078	40.468	0.005	0.009	10.61
NGMT	60°28'31.56528"N	164°43'24.94228"W	19.596	9.569	0.002	0.004	10.027
OOK1*	**60°31'44.54055"N**	**165°06'26.05568"W**	**25.001**	**14.977**			**10.024**

*** Fixed point in Adjustment**

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : bet22920.25o OP1768175359882

1 message

opus <opus@ngs.noaa.gov> Sun, Jan 11, 2026 at 2:50 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: bet22920.25o OP1768175359882

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: January 11, 2026
RINEX FILE: bet2292v.25o TIME: 23:50:09 UTC

SOFTWARE: page5 2008.25 master255.pl 160321 START: 2025/10/19 21:24:00
EPHEMERIS: igs23890.eph [precise] STOP: 2025/10/19 23:45:00
NAV FILE: brdc2920.25n OBS USED: 6909 / 7262 : 95%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 28 / 48 : 58%
ARP HEIGHT: 2.000 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.7998)

X:	-2963592.253(m)	0.014(m)	-2963593.570(m)	0.014(m)
Y:	-976921.959(m)	0.025(m)	-976920.983(m)	0.025(m)
Z:	5544044.745(m)	0.012(m)	5544044.951(m)	0.012(m)

LAT:	60 47 28.64126	0.015(m)	60 47 28.61783	0.015(m)
E LON:	198 14 39.64754	0.026(m)	198 14 39.55902	0.026(m)
W LON:	161 45 20.35246	0.026(m)	161 45 20.44098	0.026(m)
EL HGT:	15.966(m)	0.011(m)	16.607(m)	0.011(m)
ORTHO HGT:	5.332(m)	0.356(m) [NAVD88 (Computed using GEOID12B)]		

	UTM COORDINATES (UTM (Zone 04))	STATE PLANE COORDINATES (SPC (5007 AK 7))
Northing (Y) [meters]	6742689.702	756270.561
Easting (X) [meters]	350011.578	513306.279
Convergence [degrees]	-2.40571111	0.21327778
Point Scale	0.99987565	0.99990217
Combined Factor	0.99987315	0.99989967

US NATIONAL GRID DESIGNATOR: 4VCN5001142689(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL7658	AC24 KINGSALMONAK2006 CORS GRP	N584053.668	W1563909.837	370736.3
DL6422	AB08 MEKORYUK_AK2008 CORS GRP	N602305.408	W1661203.007	247733.9
DR5470	AT01 STMICHAEL_AK2018 CORS GRP	N632902.581	W1620022.945	300359.4

NEAREST NGS PUBLISHED CONTROL POINT

DR6569	946 6477 B	N604728.640	W1614520.351	0.0

This position and the above vector components were computed without any

knowledge by the National Geodetic Survey regarding the equipment or
field operating procedures used.
8002 Was this collected on a published mark? Please help update
8002 NGS records by sharing https://geodesy.noaa.gov/marks/sharing/ or
8002 updating descriptions https://geodesy.noaa.gov/marks/recovery/

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : cyf_2960.25o OP1768171333024

1 message

opus <opus@ngs.noaa.gov> Sun, Jan 11, 2026 at 1:44 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: cyf_2960.25o OP1768171333024

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: January 11, 2026
RINEX FILE: cyf_296t.25o TIME: 22:43:44 UTC

SOFTWARE: page5 2008.25 master293.pl 160321 START: 2025/10/23 19:56:00
EPHEMERIS: igs23894.eph [precise] STOP: 2025/10/23 23:38:00
NAV FILE: brdc2960.25n OBS USED: 12058 / 12474 : 97%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 57 / 66 : 86%
ARP HEIGHT: 0.0001 OVERALL RMS: 0.015(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.8107)

X:	-3062949.662(m) 0.020(m)	-3062950.945(m) 0.020(m)
Y:	-861843.783(m) 0.019(m)	-861842.778(m) 0.019(m)
Z:	5509256.459(m) 0.013(m)	5509256.700(m) 0.013(m)

LAT:	60 9 27.53809 0.011(m)	60 9 27.51498 0.011(m)
E LON:	195 42 55.38301 0.023(m)	195 42 55.29776 0.023(m)
W LON:	164 17 4.61699 0.023(m)	164 17 4.70224 0.023(m)
EL HGT:	20.882(m) 0.017(m)	21.571(m) 0.017(m)
ORTHO HGT:	10.759(m) 0.355(m) [NAVD88 (Computed using GEOID12B)]	

	UTM COORDINATES (UTM (Zone 03))	STATE PLANE COORDINATES (SPC (5008 AK 8))
Northing (Y) [meters]	6669183.511	686889.383
Easting (X) [meters]	539711.952	595245.966
Convergence [degrees]	0.62053056	1.48803056
Point Scale	0.99961933	1.00001114
Combined Factor	0.99961606	1.00000787

US NATIONAL GRID DESIGNATOR: 3VWG3971169183(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DK4091	BET1 BETHEL WAAS CORS ARP	N604716.507	W1615030.123	151593.9
DI2154	AB15 NYAC_GOLD_AK2006 CORS GRP	N610223.117	W1595242.014	260584.5
DR5470	AT01 STMICHAEL_AK2018 CORS GRP	N632902.581	W1620022.945	389543.9

NEAREST NGS PUBLISHED CONTROL POINT

DQ2641	CFK B	N600900.910	W1641709.616	827.7

This position and the above vector components were computed without any

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : kkh12940.25o OP1768175422396

1 message

opus <opus@ngs.noaa.gov> Sun, Jan 11, 2026 at 2:52 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: kkh12940.25o OP1768175422396

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: January 11, 2026
RINEX FILE: kkh1294u.25o TIME: 23:51:53 UTC

SOFTWARE: page5 2008.25 master243.pl 160321 START: 2025/10/21 20:55:00
EPHEMERIS: igs23892.eph [precise] STOP: 2025/10/21 23:51:30
NAV FILE: brdc2940.25n OBS USED: 8864 / 9276 : 96%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 48 / 53 : 91%
ARP HEIGHT: 2.000 OVERALL RMS: 0.017(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.8053)

X:	-3059163.325(m)	0.025(m)	-3059164.606(m)	0.025(m)
Y:	-942069.223(m)	0.019(m)	-942068.215(m)	0.019(m)
Z:	5498288.595(m)	0.022(m)	5498288.824(m)	0.022(m)

LAT:	59 57 37.49825	0.007(m)	59 57 37.47604	0.007(m)
E LON:	197 6 58.36907	0.022(m)	197 6 58.28267	0.022(m)
W LON:	162 53 1.63093	0.022(m)	162 53 1.71733	0.022(m)
EL HGT:	20.603(m)	0.030(m)	21.265(m)	0.030(m)
ORTHO HGT:	9.243(m)	0.357(m)	[NAVD88 (Computed using GEOID12B)]	

	UTM COORDINATES (UTM (Zone 03))	STATE PLANE COORDINATES (SPC (5007 AK 7))
Northing (Y) [meters]	6648892.259	664009.925
Easting (X) [meters]	618165.074	450631.732
Convergence [degrees]	1.83217222	-0.76509167
Point Scale	0.99977112	0.99992986
Combined Factor	0.99976790	0.99992664

US NATIONAL GRID DESIGNATOR: 3VXG1816548892(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL7658	AC24 KINGSALMONAK2006 CORS GRP	N584053.668	W1563909.837	382086.5
DI2154	AB15 NYAC_GOLD_AK2006 CORS GRP	N610223.117	W1595242.014	204279.3
DL6422	AB08 MEKORYUK_AK2008 CORS GRP	N602305.408	W1661203.007	190072.0

NEAREST NGS PUBLISHED CONTROL POINT

UV7883	ILKEVIK	N595702.991	W1625005.665	2932.5

This position and the above vector components were computed without any

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : kpn12950.25o OP1768175469303

1 message

opus <opus@ngs.noaa.gov> Sun, Jan 11, 2026 at 2:53 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: kpn12950.25o OP1768175469303

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: January 11, 2026
RINEX FILE: kpn1295t.25o TIME: 23:52:50 UTC

SOFTWARE: page5 2008.25 master241.pl 160321 START: 2025/10/22 19:46:00
EPHEMERIS: igs23893.eph [precise] STOP: 2025/10/23 00:04:00
NAV FILE: brdc2950.25n OBS USED: 13994 / 14339 : 98%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 98 / 108 : 91%
ARP HEIGHT: 2.00 OVERALL RMS: 0.017(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.8080)

X:	-3079188.200(m)	0.011(m)	-3079189.482(m)	0.011(m)
Y:	-880503.288(m)	0.028(m)	-880502.278(m)	0.028(m)
Z:	5497312.328(m)	0.001(m)	5497312.566(m)	0.001(m)

LAT:	59 56 34.91657	0.014(m)	59 56 34.89371	0.014(m)
E LON:	195 57 28.95606	0.027(m)	195 57 28.87081	0.027(m)
W LON:	164 2 31.04394	0.027(m)	164 2 31.12919	0.027(m)
EL HGT:	13.124(m)	0.008(m)	13.808(m)	0.008(m)
ORTHO HGT:	2.736(m)	0.355(m)	[NAVD88 (Computed using GEOID12B)]	

	UTM COORDINATES (UTM (Zone 03))	STATE PLANE COORDINATES (SPC (5008 AK 8))
Northing (Y) [meters]	6645454.220	663362.313
Easting (X) [meters]	553528.040	609425.056
Convergence [degrees]	0.82923333	1.69490833
Point Scale	0.99963511	1.00004670
Combined Factor	0.99963306	1.00004465

US NATIONAL GRID DESIGNATOR: 3VWG5352845454(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL6422	AB08 MEKORYUK_AK2008 CORS GRP	N602305.408	W1661203.007	129572.5
DK4091	BET1 BETHEL WAAS CORS ARP	N604716.507	W1615030.123	153619.0
DR5470	AT01 STMICHAEL_AK2018 CORS GRP	N632902.581	W1620022.945	408915.0

NEAREST NGS PUBLISHED CONTROL POINT

UV7899	KIPNUK ASTRO USAF 1949	N595618.405	W1640232.529	511.5

This position and the above vector components were computed without any

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : kwk12960.25o OP1768183582051

1 message

opus <opus@ngs.noaa.gov> Sun, Jan 11, 2026 at 5:08 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: kwk12960.25o OP1768183582051

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: January 12, 2026
RINEX FILE: kwk1296v.25o TIME: 02:07:56 UTC

SOFTWARE: page5 2008.25 master290.pl 160321 START: 2025/10/23 21:15:00
EPHEMERIS: igs23894.eph [precise] STOP: 2025/10/24 01:01:00
NAV FILE: brdc2960.25n OBS USED: 11823 / 12151 : 97%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 50 / 53 : 94%
ARP HEIGHT: 2.000 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.8109)

X:	-3071587.833(m)	0.006(m)	-3071589.114(m)	0.006(m)
Y:	-929347.549(m)	0.012(m)	-929346.538(m)	0.012(m)
Z:	5493549.610(m)	0.015(m)	5493549.841(m)	0.015(m)

LAT:	59 52 32.33262	0.011(m)	59 52 32.31026	0.011(m)
E LON:	196 50 1.86382	0.010(m)	196 50 1.77778	0.010(m)
W LON:	163 9 58.13618	0.010(m)	163 9 58.22222	0.010(m)
EL HGT:	14.566(m)	0.014(m)	15.234(m)	0.014(m)
ORTHO HGT:	3.255(m)	0.355(m)	[NAVD88 (Computed using GEOID12B)]	

	UTM COORDINATES (UTM (Zone 03))	STATE PLANE COORDINATES (SPC (5007 AK 7))
Northing (Y) [meters]	6638983.752	654812.010
Easting (X) [meters]	602662.892	434693.609
Convergence [degrees]	1.58630556	-1.00868333
Point Scale	0.99972917	0.99995225
Combined Factor	0.99972689	0.99994997

US NATIONAL GRID DESIGNATOR: 3VXG0266238983(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DK4091	BET1 BETHEL WAAS CORS ARP	N604716.507	W1615030.123	125229.8
DI2154	AB15 NYAC_GOLD_AK2006 CORS GRP	N610223.117	W1595242.014	222568.2
DL6422	AB08 MEKORYUK_AK2008 CORS GRP	N602305.408	W1661203.007	177929.8

NEAREST NGS PUBLISHED CONTROL POINT

UV7885	GILL	N595135.116	W1630709.893	3160.7

This position and the above vector components were computed without any

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : kwn12970.25o OP1768183423428

1 message

opus <opus@ngs.noaa.gov> Sun, Jan 11, 2026 at 5:05 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: kwn12970.25o OP1768183423428

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: January 12, 2026
RINEX FILE: kwn1297s.25o TIME: 02:05:26 UTC

SOFTWARE: page5 2008.25 master295.pl 160321 START: 2025/10/24 18:03:00
EPHEMERIS: igs23895.eph [precise] STOP: 2025/10/24 21:18:00
NAV FILE: brdc2970.25n OBS USED: 9495 / 9661 : 98%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 49 / 55 : 89%
ARP HEIGHT: 2.000 OVERALL RMS: 0.012(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.8132)

X:	-3061610.551(m)	0.013(m)	-3061611.855(m)	0.013(m)
Y:	-1000774.441(m)	0.010(m)	-1000773.452(m)	0.010(m)
Z:	5486618.147(m)	0.014(m)	5486618.349(m)	0.014(m)

LAT:	59 45 6.67170	0.019(m)	59 45 6.64898	0.019(m)
E LON:	198 6 5.22637	0.006(m)	198 6 5.14022	0.006(m)
W LON:	161 53 54.77363	0.006(m)	161 53 54.85978	0.006(m)
EL HGT:	18.351(m)	0.013(m)	18.995(m)	0.013(m)
ORTHO HGT:	6.386(m)	0.355(m) [NAVD88 (Computed using GEOID12B)]		

	UTM COORDINATES (UTM (Zone 04))	STATE PLANE COORDINATES (SPC (5007 AK 7))
Northing (Y) [meters]	6627335.708	640451.029
Easting (X) [meters]	337150.693	505702.778
Convergence [degrees]	-2.50446111	0.08763889
Point Scale	0.99992502	0.99990040
Combined Factor	0.99992215	0.99989753

US NATIONAL GRID DESIGNATOR: 4VCM3715027335(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL6422	AB08 MEKORYUK_AK2008 CORS GRP	N602305.408	W1661203.007	249669.1
DI2154	AB15 NYAC_GOLD_AK2006 CORS GRP	N610223.117	W1595242.014	181634.7
DL7658	AC24 KINGSALMONAK2006 CORS GRP	N584053.668	W1563909.837	322316.9

NEAREST NGS PUBLISHED CONTROL POINT

UV7874	EC 10717	N594517.415	W1615305.781	834.2

This position and the above vector components were computed without any

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : nme12970.25o OP1768183459395

1 message

opus <opus@ngs.noaa.gov> Sun, Jan 11, 2026 at 5:06 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: nme12970.25o OP1768183459395

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: January 12, 2026
RINEX FILE: nme1297t.25o TIME: 02:05:42 UTC

SOFTWARE: page5 2008.25 master271.pl 160321 START: 2025/10/24 19:09:00
EPHEMERIS: igs23895.eph [precise] STOP: 2025/10/24 22:30:00
NAV FILE: brdc2970.25n OBS USED: 10754 / 10831 : 99%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 51 / 55 : 93%
ARP HEIGHT: 0.0001 OVERALL RMS: 0.016(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.8133)

X:	-3039633.413(m)	0.021(m)	-3039634.697(m)	0.021(m)
Y:	-831507.013(m)	0.012(m)	-831506.015(m)	0.012(m)
Z:	5526683.310(m)	0.016(m)	5526683.556(m)	0.016(m)

LAT:	60 28 24.74177	0.011(m)	60 28 24.71826	0.011(m)
E LON:	195 17 57.31105	0.015(m)	195 17 57.22588	0.015(m)
W LON:	164 42 2.68895	0.015(m)	164 42 2.77412	0.015(m)
EL HGT:	17.574(m)	0.023(m)	18.268(m)	0.023(m)
ORTHO HGT:	7.558(m)	0.356(m)	[NAVD88 (Computed using GEOID12B)]	

	UTM COORDINATES (UTM (Zone 03))	STATE PLANE COORDINATES (SPC (5008 AK 8))
Northing (Y) [meters]	6704187.477	721549.643
Easting (X) [meters]	516452.489	571449.458
Convergence [degrees]	0.26038889	1.13056389
Point Scale	0.99960332	0.99996254
Combined Factor	0.99960057	0.99995979

US NATIONAL GRID DESIGNATOR: 3VWH1645204187(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DR5470	AT01 STMICHAEL_AK2018 CORS GRP	N632902.581	W1620022.945	363913.5
DL6671	AB04 SAVOONGA__AK2007 CORS GRP	N633924.727	W1703402.710	468524.8
DK4091	BET1 BETHEL WAAS CORS ARP	N604716.507	W1615030.123	160343.5

NEAREST NGS PUBLISHED CONTROL POINT

UV8243	TOOKSOOK	N602928.869	W1644349.167	2566.0

This position and the above vector components were computed without any

JOA Surveys

Jim Mitchell <jim@joasurveys.com>

OPUS solution : wtl12940.25o OP1764038209313

1 message

opus <opus@ngs.noaa.gov> Mon, Nov 24, 2025 at 5:37 PM
Reply-To: ngs.opus@noaa.gov
To: jim@joasurveys.com

FILE: wtl12940.25o OP1764038209313

1008 NOTE: You provided a zero or negative antenna height.
1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
1008

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: jim@joasurveys.com DATE: November 25, 2025
RINEX FILE: wtl1294s.25o TIME: 02:37:29 UTC

SOFTWARE: page5 2008.25 master262.pl 160321 START: 2025/10/21 18:11:00
EPHEMERIS: igs23892.eph [precise] STOP: 2025/10/22 00:17:30
NAV FILE: brdc2940.25n OBS USED: 19635 / 20087 : 98%
ANT NAME: TPSHIPER_HR NONE # FIXED AMB: 76 / 79 : 96%
ARP HEIGHT: 0.000 OVERALL RMS: 0.012(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2020 (EPOCH:2025.8052)

X:	-3019466.714(m)	0.010(m)	-3019467.997(m)	0.010(m)
Y:	-942808.067(m)	0.022(m)	-942807.073(m)	0.022(m)
Z:	5519916.019(m)	0.025(m)	5519916.247(m)	0.025(m)

LAT:	60 21 1.76717	0.010(m)	60 21 1.74474	0.010(m)
E LON:	197 20 26.23621	0.024(m)	197 20 26.14942	0.024(m)
W LON:	162 39 33.76379	0.024(m)	162 39 33.85058	0.024(m)
EL HGT:	20.054(m)	0.023(m)	20.712(m)	0.023(m)
ORTHO HGT:	9.319(m)	0.355(m)	[NAVD88 (Computed using GEOID12B)]	

	UTM COORDINATES (UTM (Zone 03))	STATE PLANE COORDINATES (SPC (5007 AK 7))
Northing (Y) [meters]	6692738.717	707318.130
Easting (X) [meters]	629152.678	463600.588
Convergence [degrees]	2.03443611	-0.57305000
Point Scale	0.99980440	0.99991623
Combined Factor	0.99980126	0.99991309

US NATIONAL GRID DESIGNATOR: 3VXG2915292738(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DK4091	BET1 BETHEL WAAS CORS ARP	N604716.507	W1615030.123	66227.2
DR5470	AT01 STMICHAEL_AK2018 CORS GRP	N632902.581	W1620022.945	350850.0
DI2154	AB15 NYAC_GOLD_AK2006 CORS GRP	N610223.117	W1595242.014	170209.8

NEAREST NGS PUBLISHED CONTROL POINT

UV8191	KINAK	N602150.144 W1623344.911	5554.4

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

Datum NAD83(2011)(2010.00) NAVD88 (Geoid12b) UTM Zone 3N

community	point	north (m)	east (m)	elev (m)	Measure Up	HWM Elev.
CYF	100	6669334.07	540227.78	3.69	0.00	3.69
CYF	101	6669289.93	540482.84	2.91	1.05	3.96
CYF	102	6669295.63	540544.25	2.99	0.97	3.96
CYF	103	6669261.17	540589.06	3.83	0.00	3.83
CYF	104	6669348.10	540289.64	3.85	0.00	3.85
CYF	105	6669317.36	540274.04	3.76	0.00	3.76
CYF	106	6669323.97	540252.98	3.86	0.00	3.86
CYF	107	6669309.18	540160.95	3.80	0.00	3.80
CYF	108	6669288.60	540075.44	4.02	0.00	4.02
CYF	109	6669225.16	539957.60	3.82	0.00	3.82
CYF	110	6669429.74	539799.58	3.94	0.00	3.94
CYF	111	6669431.00	539651.70	3.43	0.53	3.96
CYF	112	6669456.13	539590.03	4.14	0.00	4.14
CYF	113	6669308.20	539771.06	4.24	0.00	4.24
CYF	114	6669016.74	539924.74	3.68	0.00	3.68
CYF	115	6668780.06	540050.89	4.02	0.00	4.02
CYF	116	6669074.12	539629.25	3.45	0.20	3.65