MEMORANDUM

State of Alaska

Department of Transportation & Public Facilities
Design and Engineering Services - Southcoast Region
Materials Section

TO: File

DATE: March 1, 2024

FROM: Travis Eckhoff, P.E. 3/1/24
Mitch McDonald
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SUBJECT: SDRER0561– WRG Zimovia Highway Milepost 11.2 Landslide; 11/2023-02/2024 Monitoring Summary

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1.0 Introduction

This memo summarizes the Alaska Department of Transportation & Public Facilities' (DOT&PF) monitoring efforts at the Zimovia Highway Milepost 11.2 Landslide in Wrangell, Alaska for the monitoring period 11/20/2023 through 2/29/2024. Subsequent memos will be completed monthly.

2.0 Background

A catastrophic landslide occurred near Zimovia Highway Milepost 11.2 on November 20, 2023. At the request of the State Emergency Operations Center DOT&PF responded to the landslide to support search and rescue operations, debris removal, road reconstruction and utility reconnections. The landslide resulted in six fatalities and cut off road access to approximately 75 residences for six days. The landslide path is approximately 4,250 feet long from the head scarp to the toe. The head scarp is located at an elevation of 1,490 feet and the toe is located below the high tide line. The Alaska Division of Geological and Geophysical Survey (DGGS) estimated 2.8 million cubic feet of material was released or eroded by the landslide and 1.7 million cubic feet of material was deposited (DGGS, 2024).

Since the initial emergency response DOT&PF has continued periodic monitoring of the landslide to understand the geomorphology of the landslide path and the resulting impacts to Zimovia Highway. Monitoring activities include the evaluation of precipitation data and temporal change detection using digital surface models derived from Unmanned Aerial Systems (UAS). Monitoring efforts are primarily intended to inform decision making related to road reconstruction, maintenance, and operations.

3.0 Monitoring Equipment

DOT&PF installed a remote UAS docking station and weather station at the landslide site on December 20, 2023. The monitoring equipment is located near the southern flank of the landslide toe at Latitude 56.337137, Longitude -132.339077. The location of the monitoring equipment is shown in attached Figure 1. Photographs of the monitoring equipment installation are provided in Appendix A. The remote UAS dock and associated aircraft was deemed fully operational on January 11, 2024 and the weather station was fully functional on January 15, 2024.

Table 1 provides a list of the equipment and instruments installed at the site. The UAS includes a drone, docking station, and avionics necessary for safety in remote operations. The weather station includes instruments for monitoring air temperature, relative humidity, wind speed, wind direction, and precipitation. The monitoring equipment is powered by a Wrangell Municipal Light and Power service connection and connected to the internet with a Starlink terminal.

Table 1 - Wrangell Zimovia MP 11.2 Landslide Monitoring Equipment

System	Component	Equipment/Instrument
UAS	Drone Dock	DJI M30 Dock
		DJI M30T Aircraft
	Avionics	ICOM A120 VHF Radio
		ICOM VE-PG4 ROIP Gateway
		uAvionix pingStation
		Starlink Terminal
Weather Station (WEMA2)	Data Logger	Campbell Scientific CR1000x
	Precipitation Gauge	Noalynx 12" Heated Tipping Bucket (0.25mm/tip)
	Air Temperature/Relative Humidity	Campbell Scientific HygroVue 10
	Anemometer	RM Young 05108-45 Alpine Wind Monitor

3.1 Drone Operations

The UAS is remotely accessible 24 hours a day through DJI's FlightHub2 web interface, but drone flight operations are weather dependent. The drone is used to perform live observation flights and periodic orthoimagery mapping missions. Live observation flights are streamed through DJI's FlightHub2 interface. Imagery collected during mapping missions is store on DJI's Amazon Web Service and locally on a hard drive at DOT&PF's Southcoast Region Headquarters. The imagery is processed using DJI's Terra software to create an orthomosaic and digital surface model for each mapping mission.

Table 2 lists orthoimagery mapping missions of the full landslide path successfully completed to date. Mapping missions were attempted on a weekly basis after the drone dock was installed but several missions in January 2024 were unsuccessful due to weather. Based on observations to date, the scheduled flight frequency will be reduced to one mapping mission per month or as needed based on precipitation events. Figure 2 shows the orthoimagery dataset collected on 11/22/2023. Figure 3 shows the latest orthoimagery dataset collected on 2/20/2024.

Table 2 - Summary of DOT&PF Drone Mapping Missions

Date	Notes
11/22/2023	Collected during initial response. Baseline for change detection analysis.
12/06/2023	Collected during initial response. First dataset with debris removed from highway.
01/11/2024	First dataset collected with remote drone dock. Landslide path obscured by snow.
02/01/2024	Snow melted from landslide path. First dataset after End of January Storm Event.
02/07/2024	Landslide path partially obscured by snow.
02/15/2024	Landslide path partially obscured by snow.
02/20/2024	Landslide path partially obscured by snow.

4.0 Weather Observations

Weather data from the Wrangell Airport Automated Weather Observing System (AWOS, Station ID PAWG) was used during the initial landslide response to inform slope stability assessments. DOT&PF also installed two simple rain gauges at the onsite incident command post. The onsite rain gauges generally collected twice as much precipitation as was reported at the PAWG station. After the initial landslide response DOT&PF continued to monitor precipitation data from the PAWG station. Weather data was accessed through the National Weather Service's website and the National Centers for Environmental Information (NCEI). The PAWG station stopped reporting precipitation data at the end of December 2023, likely due to issues with the heated tipping bucket.

DOT&PF's on-site weather station (Station ID WEMA2) was deemed fully operational on January 15, 2024. WEMA2 transmits weather observations every hour to Snowbound Solutions, LLC's web-based service SnowObs. The weather data is archived on SnowObs and then served publicly via a web-based API. The WEMA2 weather station data will be publicly available online soon through MesoWest (mesowest.utah.edu). DOT&PF will install a second weather station on the ridge above the landslide in the Spring of 2024.

The precipitation data from PAWG and WEMA2 for the subject monitoring period are provided graphically in Appendix B. Each figure provides 3-hour, 6-hour, and 24-hour total precipitation amounts. These precipitation totals are monitored because debris flow type landslide initiation is typically a function of soil saturation due to cumulative rainfall and rainfall intensity immediately before initiation. Table 3 below summarizes precipitation events with a 3-hour total precipitation amount greater than 0.3 inches. Field observations during the initial landslide response and subsequent monitoring indicate that at least 0.3 inches of precipitation over a three-hour period is required for material mobilized in the landslide path to collect in the highway ditch.

Table 3 – Precipitation Events with 3-hour Total Precipitation >0.3 in., 11/17/2023 - 2/29/2024

Date	24-Hour Total Precipitation (in.)	Maximum 3-hour Total Precipitation (in.)	Maximum 6-hour Total Precipitation (in.)
11/17/2023	1.96	0.64	1.01
11/18/2023	0.64	0.36	0.89
11/20/2023 (Landslide)	2.65	0.61	1.15
12/5/2023	0.42	0.36	0.44
12/9/2023	0.83	0.41	0.59
12/12/2023	2.11	0.51	0.97
12/15/2023	0.59	0.41	0.58
12/28/2023	0.56	0.30	0.47
1/28/2024	1.18	0.54	0.88
1/29/2024	1.51	0.68	1.22
2/1/2024	0.74	0.31	0.51
2/9/2024	0.82	0.33	0.54
2/22/2024	1.16	0.74	1.11
2/23/2024	0.57	0.56	1.22

Three significant weather events have occurred since the landslide. The first significant weather event occurred on December 12, 2023 with 2.11 inches of rain in 24 hours recorded at PAWG. This storm occurred while repairs were underway on Zimovia Highway. On site construction activities were suspended during the storm. Erosion caused by the storm filled three large sediment ponds constructed in the uphill ditch to prevent the temporary cross culvert from plugging.

The second significant storm event started on January 26, 2024 and ended on February 2, 2024. This region wide eight-day storm event produced 6.0 inches of precipitation observed at WEMA2. The storm peaked on January 29, 2024 with 1.51 inches of precipitation in 24 hours. Multiple small landslides occurred throughout the region and in Wrangell on January 29, 2024. This storm resulted in significant erosion within the landslide path and downed trees along the MP 11.2 landslide margin.

The third significant storm event started rapidly on the evening of February 22, 2024 and ended 14 hours later on the morning of February 23, 2024 with 1.65 inches of precipitation observed at WEMA2. A maximum hourly rainfall rate of 0.31 inches was recorded at 2100H on February 22, 2024. Precipitation resumed on the evening of February 23, 2024. Drone observations of the impacts from this storm have not been possible due to continued poor weather as of the writing of this memo.

5.0 Change Detection Analysis

Temporal change detection analysis is being performed to evaluate the effects of precipitation on the geomorphology of the landslide. To facilitate the change detection analysis, a digital surface model (DSM) is derived from the drone imagery captured during each mapping mission. The DSM is created by assigning an elevation value to each georeferenced pixel in the drone collected imagery. A raster of elevation change over time data is created by subtracting a previous DSM from the most recently acquired DSM. This raster allows the change in elevation over time to be displayed graphically.

Several sources of noise, or false results, are filtered from the raster data during the change detection analysis. Typical sources of noise include vegetation, snow cover, differences in GPS signal quality, lighting, and imagery resolution. There are limitations to data collection efforts due to the type of sensors used to collect the orthoimagery and resulting DSM. Dense vegetation on the landslide margins limits the ability for the drone camera to capture the underlying topography. Vegetation movement due to wind causes significant noise so vegetated areas outside of the landslide margins are masked to reduce noise in the resulting datasets. Areas adjacent to vegetation may also produce noise because of the ground surface being obscured from some camera angles. Snow accumulation within the landslide path causes temporary elevation changes that are not representative of the landslide geomorphology. The raster data is also filtered to remove elevation differences less than ± three feet to further reduce noise.

Results of the change detection analysis between the 11/22/2023 baseline dataset and most recent 02/20/2024 dataset are provided graphically in Figure 4 and Figure 5. Warmer red colors represent greater elevation loss or material erosion, and cooler blue colors represent elevation gain or material deposition. No significant movements were detected in the change detection results. The largest area of change is located near Zimovia Highway and is due to debris removal from the roadway and property within the slide path. These areas show an elevation decrease of about three to 15 feet. The accumulation of material on the downhill side of the road is due to construction of the temporary traffic bypass.

Stream channels within the landslide path show change due to erosion caused by multiple precipitation events after the landslide. The most significant erosion occurred in an area of the lower slope 225 feet upslope of the highway surface during the End of January storm event. This area is shown in detail in Figure 5. In this area, a waterfall feature in the stream eroded to establish a continuous gradient. Other areas of the stream have also eroded including an area along the logging road where the bank is eroding on the uphill side.

The island of standing trees within the landslide path causes significant noise in the data. This area is outlined in Figure 4. Most other areas showing elevation changes are due to vegetation, woody debris, and the camera's inability to photograph the ground surface through dense vegetation. Areas of movement on the margin of the slide path are mostly due to noise caused by vegetation blocking the camera's view of the ground from various angles. Some areas are showing deposition along the upper margins of the landslide due to post landslide tree fall.

Attachments:

Figure 1 – Site Map
Figure 2 – November 22, 2023 Orthoimagery
Figure 3 – February 20, 2024 Orthoimagery
Figure 4 – 11/22/2023 vs. 02/20/2024 Change Detection
Figure 5 – 02/20/2024 Change Detection Detail
Appendix A – Monitoring Equipment Photographs
Appendix B – Graphical Weather Data

Legend

- 100' Contours Post-Landslide
- 20' Contours Post-Landslide
- Wrangell Zimovia Hwy 11.2 Mile Landslide Boundary (Interpreted)
- Drone Dock and Weather Station

N

1,000 500 0 1,000 Feet

HILLSHADE BASE MAP AND CONTOURS DERIVED FROM ALASKA DGGS RDF 2024-1

SITE MAP

Wrangell Zimovia Highway
MP 11.2 Landslide

State of Alaska
Department of Transportation and Public Facilities
Southcoast Region

FIGURE 1

Legend

- 100' Contours Post-Landslide
- 20' Contours Post-Landslide
- Wrangell Zimovia Hwy 11.2 Mile Landslide Boundary (Interpreted)
- Drone Dock and Weather Station

N

1,000 500 0 1,000 Feet

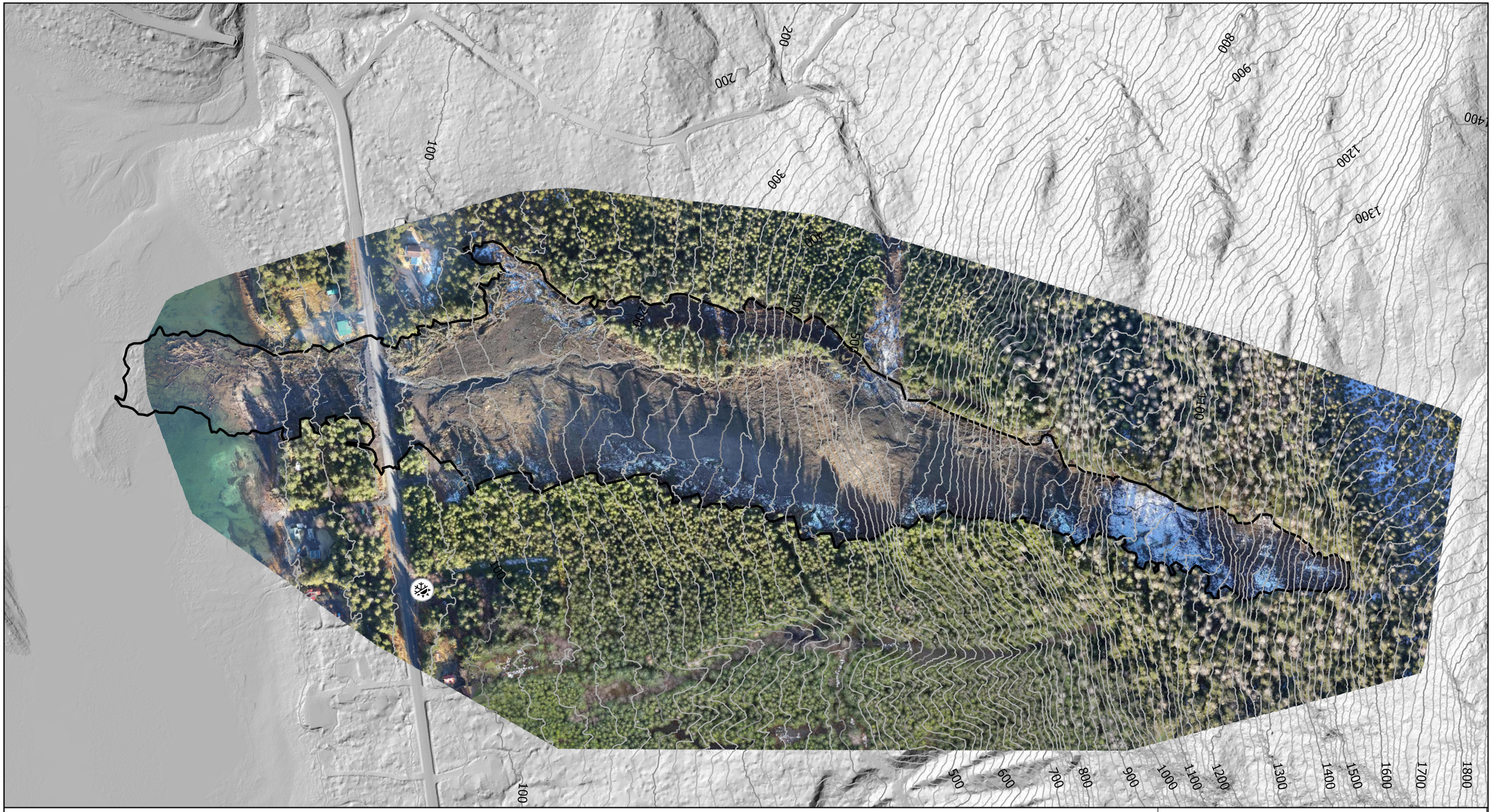
HILLSHADE BASE MAP AND CONTOURS DERIVED FROM ALASKA DGGS RDF 2024-1

NOVEMBER 22, 2023 ORTHOIMAGERY

Wrangell Zimovia Highway
MP 11.2 Landslide

State of Alaska
Department of Transportation and Public Facilities
Southcoast Region

FIGURE 2



Legend

- 100' Contours Post-Landslide
- 20' Contours Post-Landslide
- Wrangell Zimovia Hwy 11.2 Mile Landslide Boundary (Interpreted)
- Drone Dock and Weather Station

N

1,000 500 0 1,000 Feet

HILLSHADE BASE MAP AND CONTOURS DERIVED FROM ALASKA DGGS RDF 2024-1

FEBRUARY 20, 2024 ORTHOIMAGERY

Wrangell Zimovia Highway
MP 11.2 Landslide

State of Alaska
Department of Transportation and Public Facilities
Southcoast Region

FIGURE 3

CHANGE DUE TO DEBRIS REMOVAL

SEE FIGURE 5

NOISE DUE TO VEGETATION, TYPICAL.

Elevation Change (Feet)

Value

- <-5'
- <-4.5'
- <-4.0'
- <-3.5'
- <-3.0'
- <3.0'
- <3.5'
- <4.0'
- <4.5'
- <5.0'

Legend

- 100' Contours Post-Landslide
- 20' Contours Post-Landslide
- Wrangell Zimovia Hwy 11.2 Mile Landslide Boundary (Interpreted)
- Drone Dock and Weather Station

N

1,000 500 0 1,000 Feet

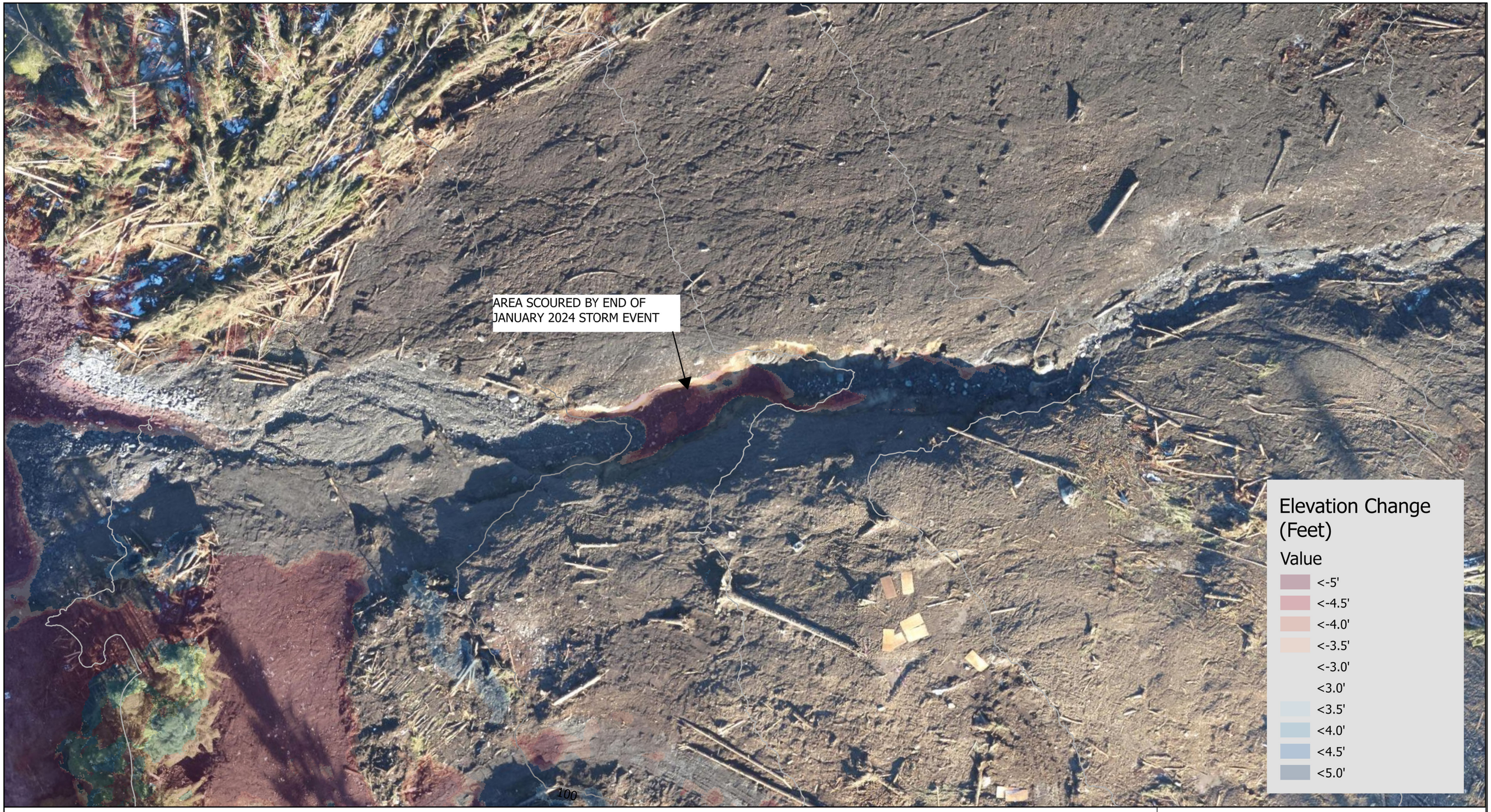
HILLSHADE BASE MAP AND CONTOURS DERIVED FROM ALASKA DGGS RDF 2024-1

11/22/2023 vs. 02/20/2024 CHANGE DETECTION

Wrangell Zimovia Highway
MP 11.2 Landslide

State of Alaska
Department of Transportation and Public Facilities
Southcoast Region

FIGURE 4



Legend

100' Contours Post-Landslide

20' Contours Post-Landslide

N

110 55 0 110 Feet

HILLSHADE BASE MAP AND CONTOURS DERIVED FROM ALASKA DGGS RDF 2024-1

02/20/2024 CHANGE DETECTION DETAIL

Wrangell Zimovia Highway
MP 11.2 Landslide

State of Alaska
Department of Transportation and Public Facilities
Southcoast Region

FIGURE 5

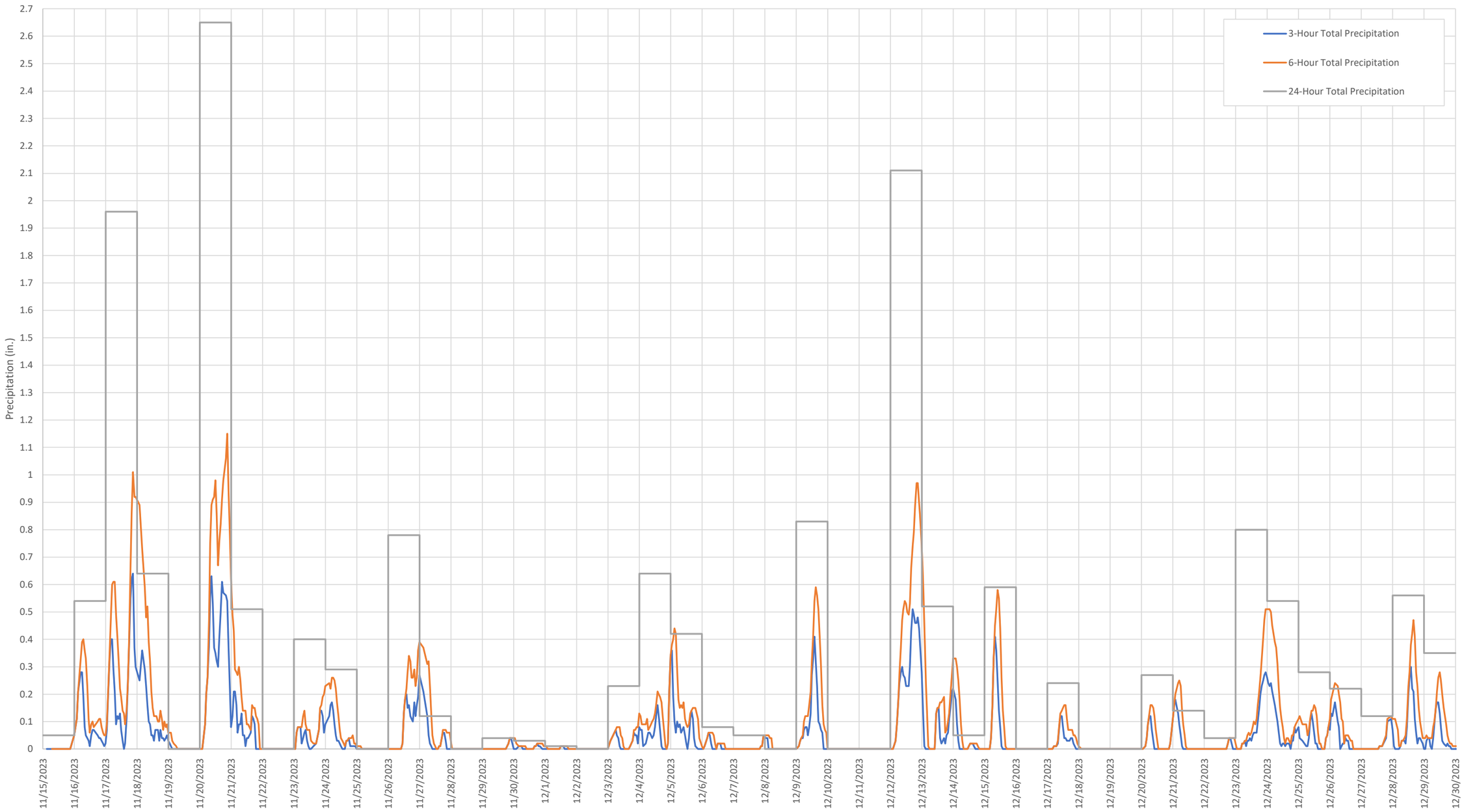
APPENDIX A – MONITORING EQUIPMENT PHOTOGRAPHS

Figure 1 - Avionics Cabinet and Weather Station WEMA2

Figure 2 - Drone Dock

APPENDIX B – GRAPHICAL WEATHER DATA FOR PAWG AND WEMA2

Wrangell Zimovia Hwy MP 11.2 Landslide - Airport Weather Station (PAWG) Precipitation Data 11/15/2023 - 12/31/2023



Wrangell Zimovia Hwy MP 11.2 Landslide - Drone Dock Weather Station (WEMA2) Precipitation Data 01/15/2024 - 02/29/2024