

# Innovative Unmanned Aerial Survey to Assess Impacts to a Shoreline Landfill

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## BACKGROUND/OBJECTIVES

### A Shoreline Landfill Impacted by Lake Level Rise

The work described was performed on behalf of NAVFAC BRAC Program Management Office, around the shores of Andrew Lake on Adak Island, Alaska in the Aleutian Island chain (Figure 1). It assessed the potential inundation of the landfill located at Solid Waste Management Unit (SWMU) 4 if the Navy discontinues management of the water level in Andrew Lake.



Figure 1. Andrew Lake on Adak Island, AK

Andrew Lake has a surface area of approximately 2,100 acres and receives water from short, steep creeks draining the mountains to the east and west (U.S. Navy, 1997a). Outflow from the lake occurs through the permeable, natural causeway, and a narrow spillway at the northwest corner of the lake. Without intervention by the Navy, the spillway becomes progressively blocked with coarse material deposited by the Bering Sea (Figure 2).

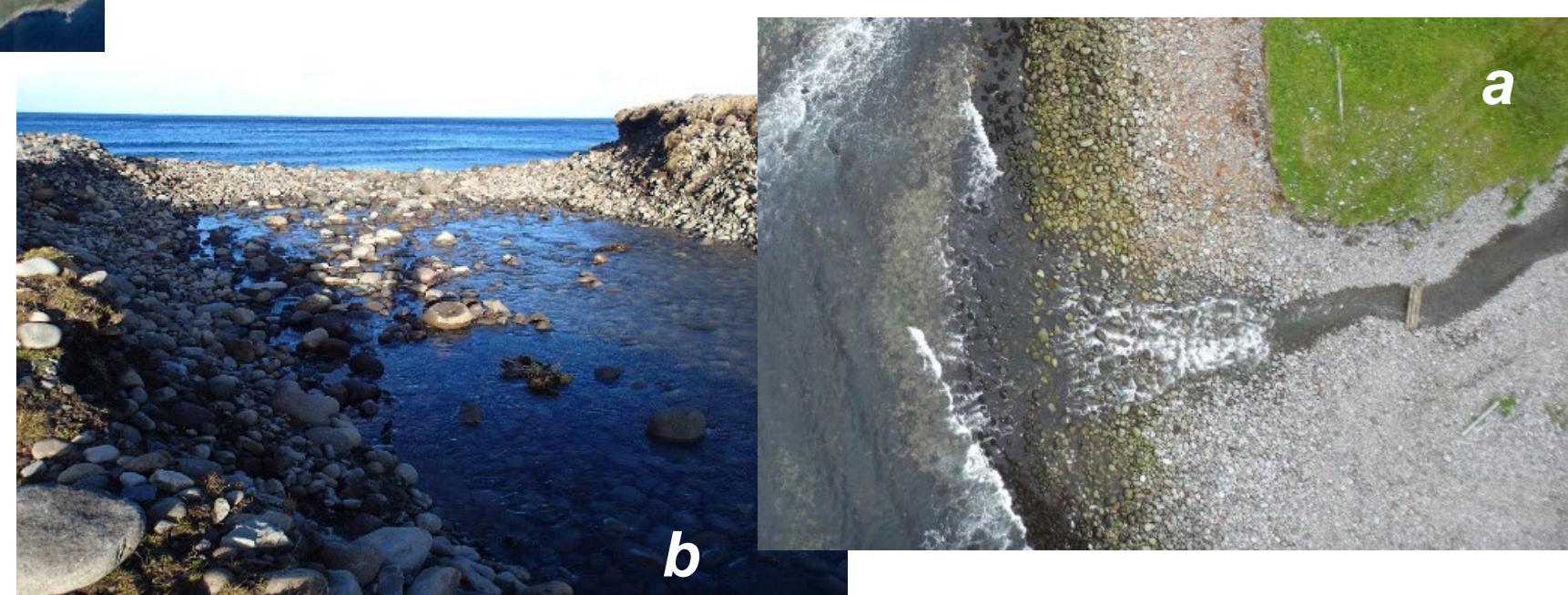


Figure 2. Free flowing spillway (a) and blocked spillway (b)

### SWMU 4 – A Lakeshore Landfill



Figure 3. Views of the SWMU 4 Landfill

The SMUW 4 landfill encompasses between 3.0 and 4.1 acres and operated during the 1940s (Figure 3). The landfill waste body is approximately 6 ½ feet thick and believed to consist of solid wastes generated from the construction and subsequent demolition of Albert Mitchell Airfield (U.S. Navy, 1997a). The remedy consists of a surface cap, two armored drainages crossing the cap, and no shore armoring (U.S. Navy 1997b). The landfill cover placement was terminated several feet from the shoreline to prevent sediment contamination of Andrew Lake during construction.

The surface of the landfill is only a few feet above the current lake level and the Navy has observed several feet of lake level rise with just a year of spillway blockage. The most recent five-year review noted that the Navy may soon no longer need to maintain the lake level and that further study was needed to determine the effect of lake level rise on the integrity of the landfill remedy at SWMU 4.

## APPROACH – UAS SURVEY AND MODELING

### Generating a High-Resolution Digital Elevation Model

Meeting the study objectives required assessment of the affects on topography of lake level rise of only a few feet, necessitating a topographic model of the lake accurate to 1-foot increments. The model generally available was sufficient to generate 20-foot contours, but because all of the impacts would occur within a 20-foot elevation change, more detail was needed. An unmanned aerial system (UAS) was used to perform a photogrammetric survey of the perimeter of Andrew Lake in July 2018.

In the field existing benchmarks were first located and verified. Survey control points were set, consisting of 77 photo-identifiable primary control points and 342 secondary check points. A survey grade Trimble R10 real-time kinematic (RTK) global positioning system (GPS) was used to establish control points and calibrate to the local site control system. A two-person UAS crew and a SenseFly eBee+ unmanned survey aircraft equipped with an RTK antennae collected high-resolution, comprehensive data over the Andrew Lake area (Figure 4). Nineteen flights were performed, ranging from 30 to 45 minutes each and generating 4,438 photos. Flight imagery provided 1.0-inch ground sample distance (GSD) orthoimagery and a DEM supporting a 1-foot contour interval. Agisoft Photoscan Professional photogrammetry software was used to process the 4,432 collected images and generate tiled-Tagged Image File Format (TIFF) orthophotos and a georeferenced GeoTIFF raster DEM, which is essentially a matrix of 6-inch squares, each assigned an elevation value and covering the area of interest (Figure 5a).



Figure 4. Unmanned aerial system- SenseFly eBee+

### Evaluating Inundation

The geospatially referenced DEM raster layers were loaded into the geographic information system (GIS) map file. For the regional extent of Andrew Lake, the 12-inch DEM raster grid was used to develop a 1-foot contour interval using the Esri GIS contour generation tool (Figure 5b). For the area including and immediately surrounding SWMU 4 the finer resolution 6-inch DEM raster was used to generate a similar set of 1-foot interval surface contours. The raster DEM files were symbolized using a blue color code indicating increasing 1-foot increments from 1 to 4 feet of lake level increase (Figure 6). Lake level increases from 4 to 18 feet were shown in 2-foot increments until the area of concern was completely inundated or the lake level reached an 18-foot increase (at which point the causeway would theoretically overtop).

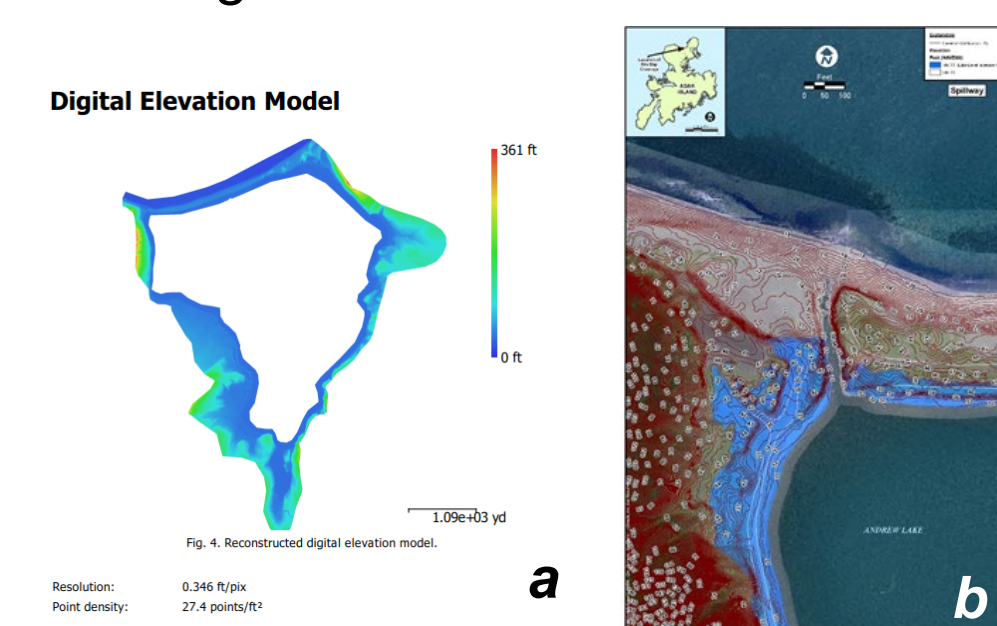


Figure 5. Digital elevation model (a) and detailed topographic information from UAS survey (b).

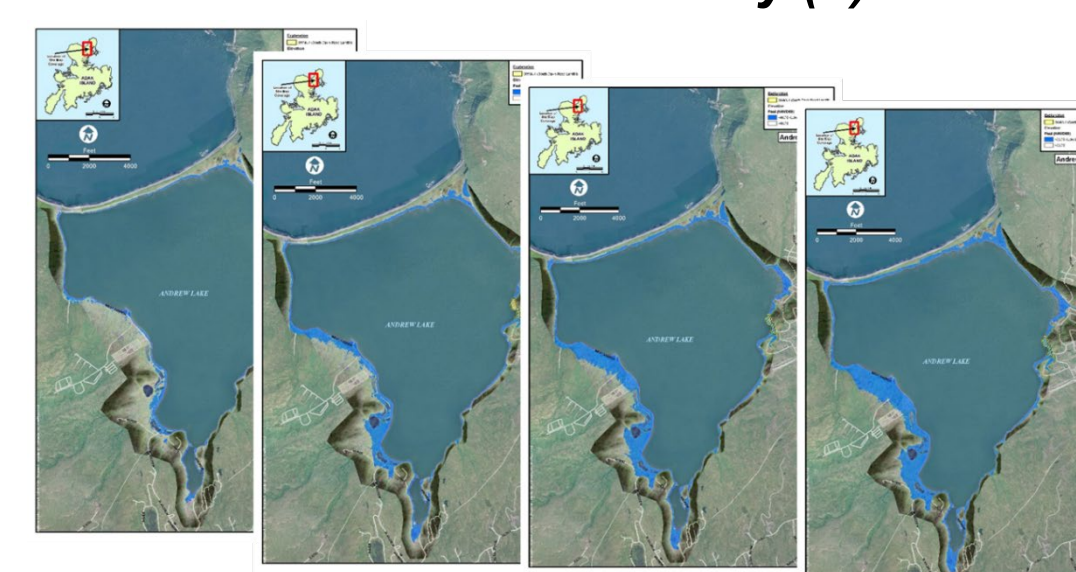


Figure 6. Progressive Inundation of the Lake Shore

## RESULTS – SHORELINE LANDFILL AT RISK

The UAS approach for generating elevation data was particularly well suited to the difficult conditions on Adak Island. The UAS generated data more quickly than a traditional land survey on foot and was able to fly beneath cloud cover that would have precluded use of manned aircraft at higher altitudes. The UAS was able to collect data despite gusty winds up to 35 knots, and executed preplanned safety measures several times to avoid raptor strikes.

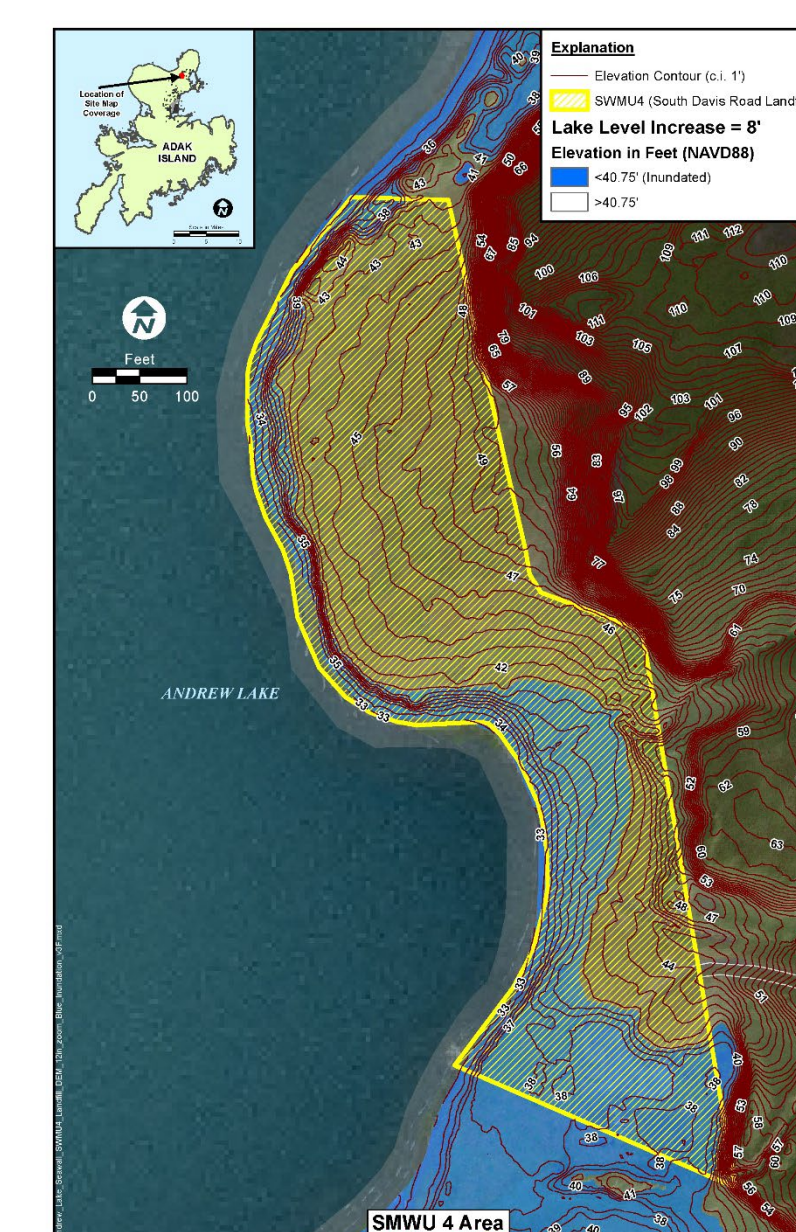


Figure 7. Inundation of SWMU 4 Landfill with 8 feet of lake level rise.

The degree of inundation and the potential effects at the SMUW 4 landfill were assessed for each increment of lake level rise (Figure 7). Even under current conditions, the steeper northern bank of SWMU 4 exhibits mass wasting erosion from wind-wave action across the 2-mile fetch from the northwest, and therefore shore armoring is warranted. Rising lake level is expected to increase this bank erosion by changing how and where the waves impact the bank and saturating the bank soil. Submergence of the landfill is expected to kill the grass holding the cap in place and allow erosion of the cap material – thus requiring cap armoring. With enough submergence, small boat traffic could possibly transit over the cap causing prop wash and anchor-drop erosion. There could be unexpected effects on contaminant leaching with submergence. The study recommended that spillway clearance be continued, or a culvert be installed to maintain lake level and minimize future armoring requirements.

In addition to impacts at SMUW 4, the study assessed the impacts of lake level rise on key infrastructure along the lake shore (Table 1).

Lake Level Rise (ft)	Notable Outcomes						
	SWMU 4	Spillway	Moffett Creek	VW Creek	Recreation Center	Lake Jean	Parcel 4 Boat Launch
1	No impact	Partial road flooding	No impact	No impact	No impact	No impact	No impact
2	Waves impact higher on bank	Complete road flooding	No impact	Partial road flooding	No impact	Partial flooding of eastern shore road	No impact
3	No additional impact	No Additional Impact	Delta Submerged	No Additional Impact	No impact	No Additional Impact	No impact
4	Top of bank at south end	No Additional Impact	Partial road flooding	Complete roadway flooding	Shoreline inundation	Partial flooding of western shore road	Launch and partial road flooding
6	No Additional Impact	No Additional Impact	No Additional Impact	No Additional Impact	Complete road flooding	Complete flooding of shoreline roads	Complete road flooding
8	Top of bank north end, north swale flooded	No Additional Impact	Complete road flooding	No Additional Impact	No Additional Impact	No Additional Impact	No Additional Impact
10	Southern half flooded	Lake discharge to sea at road.	No Additional Impact	No Additional Impact	Water at the building	No Additional Impact	No Additional Impact
12	No Additional Impact	Spillway widened 100 feet west	No Additional Impact	No Additional Impact	No Additional Impact	No Additional Impact	Entire area submerged to hillsides
16	Entire landfill submerged	No Additional Impact	No Additional Impact	No Additional Impact	No Additional Impact	No Additional Impact	No Additional Impact

Table 1. Predicted impacts of lake-level rise on shoreline features.

References:  
 U.S. Navy. 1997a. Final Remedial Investigation/Feasibility Study Report, Operable Unit A, Adak Naval Complex, Adak Island, Alaska. Prepared by URS Consultants under Contract N62474-89-D-9295, Task Order 214, September 23.  
 U.S. Navy. 1997b. Construction Closeout Report. Preparation and Execution of Remedial Design for SWMU 4, South Davis Road Landfill, Naval Air Facility, Adak, Alaska. Prepared by Foster Wheeler Environmental Corporation under Contract N44255-93-D-4050, Delivery Order 0079. July 17.