STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

Remote Sensing Technologies for Long-Term Surveillance of DOE-LM Sites

DOE-FIU SCIENCE & TECHNOLOGY
WORKFORCE DEVELOPMENT PROGRAM

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Principal Investigators:

Eduardo Rojas (DOE Fellow Student)
Florida International University

Anthony Abrahao (Mentor)
Florida International University

Ravi Gudavalli, Ph.D. (Program Manager)
Florida International University

Leonel Lagos, Ph.D., PMP® (Program Director)
Florida International University

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FIU | Applied Research Center
FLORIDA INTERNATIONAL UNIVERSITY

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EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science & Technology Workforce Development Initiative, an innovative program developed by the U.S. Department of Energy's Office of Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2020, a DOE Fellow intern, Eduardo Rojas, spent 8 weeks doing a summer internship at Grand Junction, CO with the U.S. Department of Energy's Legacy Management (LM) Office under the supervision and guidance of Ms. Jalena Dayvault, LM-FIU Liaison. The intern's project was initiated on June 1st, 2021 and continued through July 24th, 2021 with the objective of conducting a drone deployment at Rifle Disposal Site in Rifle, CO to acquire aerial imagery of the cells' top land cover.

This report provides an overview of the eight weeks of the internship, during which Eduardo worked on the initial phase of the project aimed at acquiring aerial imagery for the application of remote sensing technologies for the long-term surveillance of LM sites. Tasks included the deployment and evaluation of FIU technologies for remote sensing data capture and analysis; learning and participating in LM's stewardship work such as site inspections and sampling; obtaining an FAA Unmanned Aerial Vehicle (UAV) pilot's license to conduct the technology deployment at the Rifle Disposal Site; and delivering a presentation to LM Senior Management. Eduardo will use the acquired data to try to identify and monitor depressions on the site's top cell cover for LM's needs. This will also serve as a reference for LM and DOE as it continues its UMTRCA baseline surveys with the LM Aviation Program.

1. INTRODUCTION

In 2017, the U.S. Department of Energy's Office of Legacy Management (DOE-LM) determined that the majority of UMTRCA disposal sites did not have sufficient resolution, accuracy, and precision for use as a baseline to track change detection in land cover [4]. Ground ecological surveys lacked the scale to identify small changes in land cover, such as vegetation density and site health. Around the similar time frame, DOE-LM had initiated baseline surveys of the Bluewater Disposal site using lidar on a manned fixed wing aircraft in order to detect gradual quantitative changes from increasing depressions in the top slope of the cell. Environmental factors, such as different forms of erosion, wind deposition, etc., can slowly affect the structural integrity of the disposal site cell covers over time. The formation of depressions was evident in two disposal sites, Mexican Hat [1] and Bluewater [2], after performing lidar surveys as a precautionary safety measure. Another challenge DOE-LM face is determining how to house and monitor the extensive amount of aerial data to track the environmental changes over time. Therefore, Florida International University (FIU) in collaboration with DOE-LM will investigate the long-term effects of climate change by investigating the land cover and land use at LM sites, analyzing variations in land development, management, vegetation, surface hydrology, wildlife migration patterns, along with erosion impact. FIU will examine studies on land use and land cover, and their correlation with severe weather events in order to address climate change effects over time through two principal methods, public and commercially available remote sensing imagery databases and on-demand Unmanned Aerial Vehicle (UAV) in-house site surveying. The use of UAVs for surveying provides centimeter level precision, broad custom-built sensory, and a strikingly shorter timeframe compared to traditional methods, all the while being cost effective. The benefit of orchestrating onsite surveys via UAVs is the variety of deliverables for use. These include orthomosaic maps, 3D point clouds (photogrammetry and lidar), stockpile volumetric measurements, slope monitoring, and digital elevation and terrain models. With the facilitation of automated geospatial data analytics, machine learning and artificial intelligence (AI), the compiled data can be organized for record management. Data can be used for modeling and trend predictions for long-term study and observation. Therefore, on-demand UAV in-house site surveys, machine learning and AI demonstrate enormous potential in autonomously surveying LM sites and addressing climate change and resilience related issues. The goal of this internship is to acquire exposure to LM sites and procedures. This exposure included assisting in disposal site tours-functions and inspections to continuously monitor sites; learning the field sampling process and how it supports LM reach their environmental stewardship goals; and experiencing stakeholder and tribal community dynamics within LM.

In addition, the opportunity to deploy remote sensing technologies that have been researched at FIU throughout the academic year, exploring remote sensing technologies for the long-term surveillance of LM sites, technology evaluation, and data analysis of Digital Elevation Model (DEM) renderings for environmental factors to capture erosion in the cell cover.

2. RESEARCH DESCRIPTION

Eduardo Rojas, DOE-LM Fellow, participated in a summer internship experience based at the Legacy Management Grand Junction Office. The internship commenced with the Fellow being provided with basic resources needed to perform his duties upon arrival. This included receiving a laptop from the IT department, activation of an LM email and access key, and completing necessary training for entry access and GSA vehicle admittance. The training helped the Fellow learn about rules and behavior of the LM work environment, security awareness and safety, and many other pertinent subjects.

Once in-person access to the Grand Junction Office was granted, the Fellow met with Ms. Jalena Dayvault, LM-FIU Liaison, to discuss and plan the logistics of the summer program. This demonstrated the importance of proper project planning/management. The goal of the internship was to get exposure to LM's diverse culture and activities/responsibilities, work areas in the stewardship of the federal lands and providing public and environment safety. The program encompassed site inspections, LM's dynamic of working with stakeholders and contractors, sampling, and public engagement. The benefit of having the internship based in Grand Junction was that it allowed the fellow to travel to various site locations within the area, setting up visits to Durango, Rifle, Riverton, Westminster, and Rocky Flats. Another important aspect of the project planning was to incorporate the Fellow's ongoing LM research project and topic of interest.

Prior to attending the summer internship, the Fellow worked on integrating an in-house agnostic lidar module that would be mounted on an FIU unmanned aerial vehicle (UAV) for data collection. The Fellow prepared for a deployment by conducting photogrammetry surveys, capturing aerial imagery to compose a 3D DEM of the FIU Engineering building's parking lot (working area). This training prepared the Fellow for the deployment and evaluation of the in-house technology in a LM environment, the Rifle Disposal Site. To prepare for the deployment during the internship, the Fellow virtually met with the LM Data Management team to discuss data quality using ground control points, as well as Mexican Hat and Bluewater ongoing survey procedures. This interaction helped the Fellow understand LM's needs and data quality standards for their site work.

The first site visited by the Fellow for site inspection and sampling was the Durango Site. The intern met with David Atkinson, UMTRCA Site Lead; David Holbrook, Lead Ecologist; Morgan Williams, Lead Earth System Scientist; Angelita Denny, LM Site Manager; and Jalena Daylvault, LM-FIU Liaison. The purpose of the site visit was to perform an annual site inspection to document the site's features and note topographical changes from the previous year. The site inspection commenced with a pre-job safety briefing highlighting different hazards to watch out for including high temperatures, wildlife, and uneven terrain.

Figure 1. Eduardo Rojas, LM-FIU Fellow and Morgan Williams, Lead Earth System Scientist inspecting depressions on Durango Disposal Site.

The DOE-LM intern learned about different characteristics of disposal sites and environmental factors affecting the topographical integrity. One of the key characteristics to identify is localized erosion that can occur sparsely along the slopes. Sediment can fill the apron causing backup saturation of the cell, thereby enabling cycles of saturation ending in the formation of depressions.

Figure 2. Dr. Williams monitoring the apron drainage on the edges of the cell.

Dr. Morgan Williams' expertise of tracing the root cause of the topographical changes from residual clues and patterns are crucial to understanding the necessary maintenance procedures to conduct. For example, if depressions are found upslope this allows for the possible assumption of erosion occurring from the upslope to the downslope of the cell. Another important characteristic is the growth of invasive plant species growing on the top cell cover. This occurs due to wind deposition, weeds traveling with incoming rob cobble, and erosion. However, there are areas where plants can grow. Phytoremediation, the use of plants and soil to reduce hazardous effects of contaminants in the environment, is an approach being explored for mitigation of the nuclear waste

in the disposal cell. Lastly, piping is another active form of erosion that can affect the site. Piping is a sub-surface erosion that occurs when natural materials wear away due to seepage. The various geological processes are combated with sediment control devices and techniques.

Figure 3. Dr. Williams captures photography of cell cover condition for further analysis.

The Fellow's first interaction with the site inspection team introduced him to the collaboration between LM and their contractors, identifying the importance of working together, debating causes, and communicating solutions for the successful stewardship of the federal land. The insight and knowledge gained from Dr. Williams on the depressions proved valuable to the Fellow's research project on utilizing sensors to track environmental effects on the disposal site.

Figure 4. Final briefing of gained observations on the Durango Disposal site.

Upon finalizing the site inspection, the team gathered to discuss lessons learned and knowledge gained from the visit. The discussion was open to different observations and approaches for the ongoing protection of the site. In the following days after performing the site inspection, the Fellow assisted Gretchen Baer, Hydrogeologist and Pete Steves, Principal Research Scientist, with performing sampling at the Old Durango Processing Site. The execution of these procedures taught the Fellow the standard for data collection at LM, as well as risk mitigation by providing proper

maintenance of the site's water quality for the protection of the public's health and the environment.

Figure 5. LM's Mobile Water Quality Sampling Station.

Figure 6. Sampling team collecting surface water samples.

Figure 7. Fellow and Gretchen Baer, Hydrogeologist, probing for the well's depth limit to collect an accurate reading.

Figure 8. Eduardo Rojas, LM Intern, performing a turbidity test to gather data on an existing well's water quality.

Figure 9. pH water quality test run on collected ground water sample.

In addition, DOE-LM Fellow Eduardo Rojas worked and finalized his Aviation Safety Plan in accordance with the Legacy Management (LM) Aviation Program's standards to perform a drone survey of the Rifle Disposal Site. A project overview was prepared including lists of equipment specifications, the purpose and goal of the deployment, and an itinerary to establish the flight strategy with the visual observers and attending LM flight observers [1]. A drone mission statement including terrain and aeronautical sectional maps of which the Fellow had to learn to read as part of his Part 107 - Small Unmanned Aircraft Systems certification was also incorporated into the safety plan.

Figure 10. Eduardo Rojas, LM intern studied and scored a 92% on the FAA Part 107 Small Unmanned Aircraft Systems Exam to obtain his drone pilot's license at the Grand Junction PSI Testing Center.

An important part of the program was identifying the controlled airspace of the site as well as assuring the location of the drone deployment was not within a 5-mile radius of the airport. A preflight inspection of the site to determine 3 different flight termination points for the drone to land was performed to account for emergency landings the Fellow performed. The Aviation Safety Plan also included necessary logistics, drone mission hazards, and pre/post-mitigation measures for prioritizing safety and being prepared for any outcome. This is one of the biggest priorities for Legacy Management when conducting their work procedures.

Figure 11. DOE-LM Fellow Eduardo Rojas successfully conducted first drone survey of Rifle Disposal Site as the remote pilot in command.

Figure 12. Eduardo Rojas, LM intern, coordinating and leading flight crew through drone survey procedures and risk mitigation. Pictured from left to right: Eduardo Rojas, Bruce Akers, Deborah Steckley, and David Morton.

Figure 13. Inspection of aircraft and sensors prior to pre-flight checklist.

Figure 14. Fellow performing onsite preflight inspection of Phantom 4 RTK.

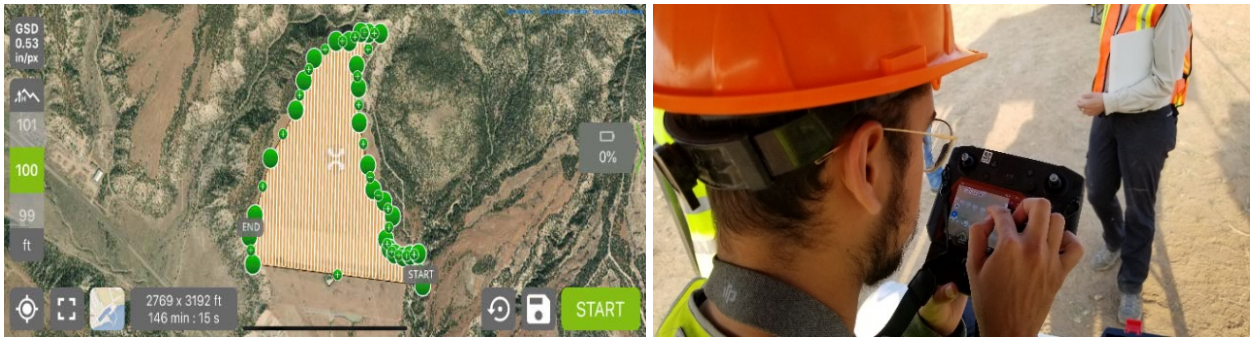

Figure 15. Modifying the flight path to execute the survey within the site boundaries.

Following the finalization of the Aviation safety plan, the DOE-LM Fellow successfully conducted the first drone survey of the Rifle Disposal Site as the remote pilot in command located in Rifle, Colorado. During this experience, Eduardo learned the importance of effectively communicating with the flight crew to mitigate any risk and enforce safety. The Fellow coordinated and lead the flight crew team through drone survey procedures, pre-flight and post-flight inspections, and risk mitigation for the duration of 5 days. Eduardo received lessons on leadership and risk mitigation throughout the survey process from Mr. David Morton, an experienced pilot from LM. LM's Aviation Program Manager, Ms. Deborah Steckley, provided Eduardo with the resources needed for preparing his Aviation Safety Plan, as well as supported the drone deployment. Mr. Anthony Abrahao, mentor and Research Scientist from Florida International University and Mr. Bruce Akers, LM Fleet Manager, served as visual observers in capturing the photogrammetry data of the 71-acre site. Their efforts were necessary to have a constant visual line of sight with the aircraft and remain within the project site boundary.

Figure 16. Fellow with George Squibb, Principal Environment Engineer, performing fieldwork at Rocky Flats site to collect water samples.

Figure 17. Eduardo Rojas, LM Fellow, accompanying Bill Frazier, Riverton Site Manager and Sam Campbell, Principal Environmental Engineer on a visit to the Riverton Site sampling station.

Figure 18. Eduardo Rojas and Olivia Bustillo, LM Interns; Bill Frazier, Riverton Site Manager; Sam Campbell, Principal Environmental Engineer; along with RSI contractors discussing gathered data sampling at Riverton sampling site.

Following the Rifle drone deployment, Eduardo traveled to Rocky Flats, CO where he aided with field sampling at the Rocky Flats site to collect groundwater samples to meet compliance and non-compliance standards with Principal Environment Engineer, George Squibb. He also met with Senior Ecologist, Jody Nelson, to learn about the vegetation and environmental transition of Rocky Flats from an LM site to a natural environment. Following his visit to Rocky Flats and Westminster, Eduardo traveled to Riverton, Wyoming where he accompanied LM Riverton Site Manager, Bill Frazier, to a stakeholder meeting with a local business council to communicate current projects at the Riverton Site. This council meeting helped the Fellow experience the interactions between LM and the public. The Fellow then accompanied Mr. Frazier and Principal Environmental Engineer, Sam Campbell, to a meeting with Shoshoni and Arapahoe representatives and Chemtrails facility members to discuss current DOE projects. Lastly, the Fellow successfully presented his internship accomplishments and experience to LM Senior Management and FIU-ARC staff.

3. RESULTS AND ANALYSIS

The DOE-LM Fellow post-processed the aerial data captured during his field survey and produced a DEM of the Rifle Disposal Cell, potentially completing the entire USGS data lifecycle in geological surveys: planning, acquiring, processing, analyzing, preserving, and eventually publishing the results in the next Waste Management Symposia conference. The DOE-LM Fellow dedicated efforts to post-processing the aerial data captured by piloting FIU's drones during the LM's Rifle Disposal Cell survey (Figure 19) and an orthomosaic map of the cell, presented in Figure 20.

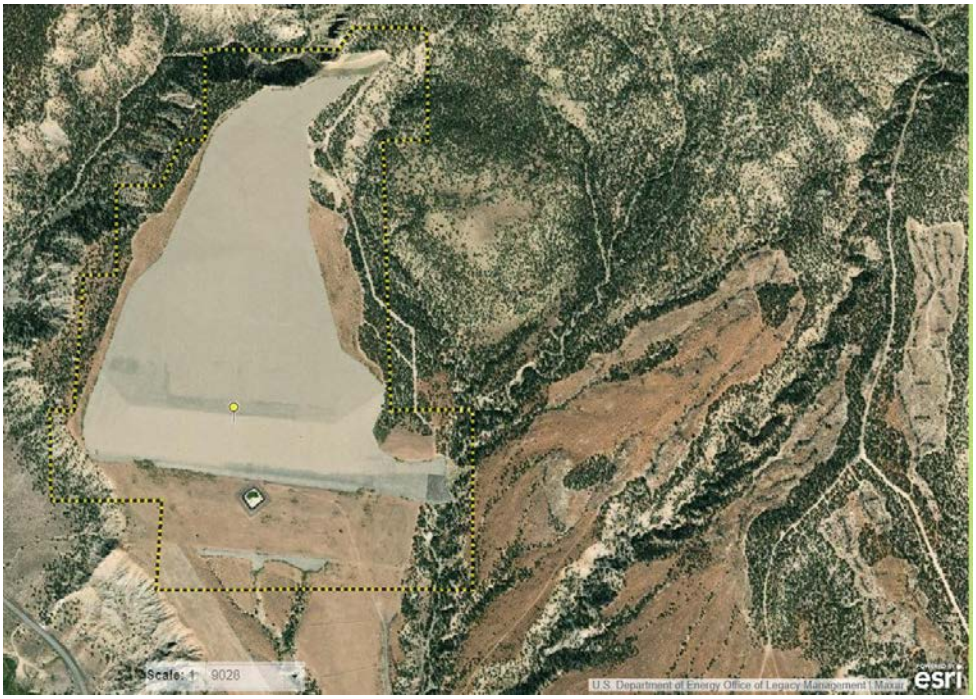

Figure 19. LM's Rifle Disposal Cell.

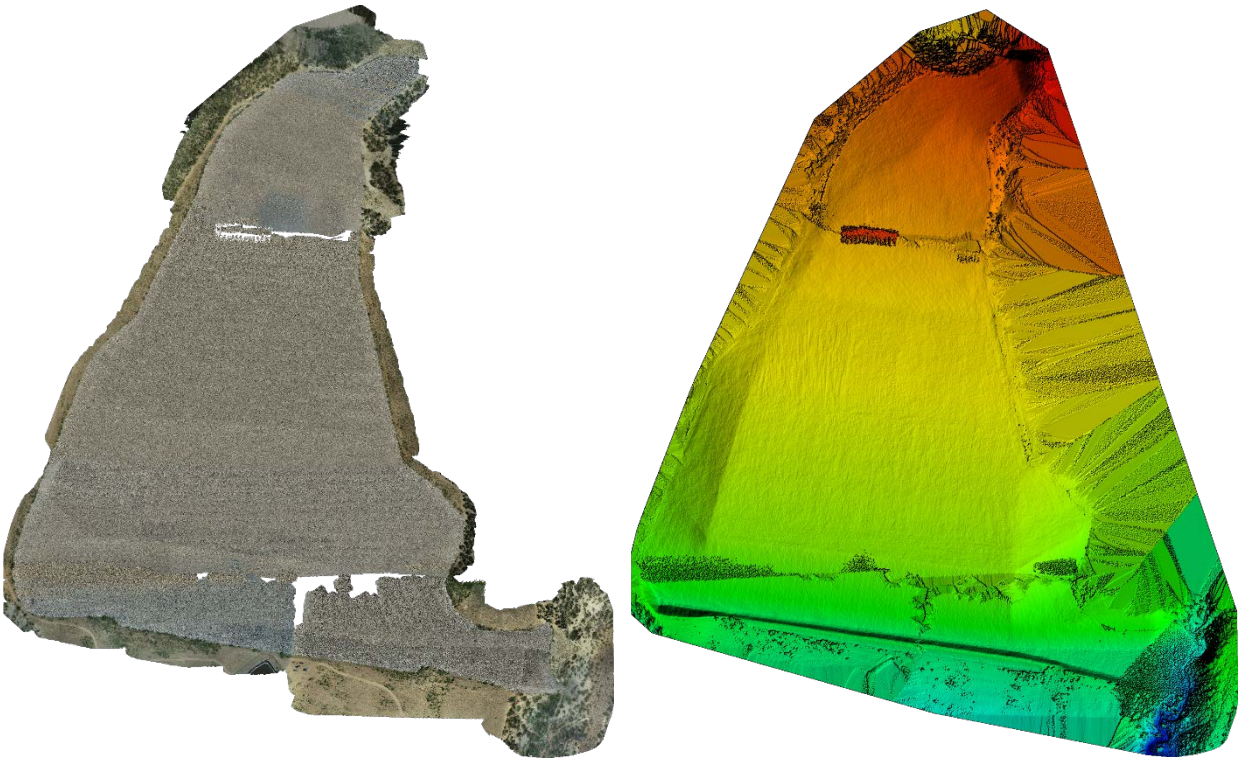

Figure 20. Captured orthomosaic map (left) and digital elevation model (right) of Rifle Disposal Cell.

Figure 21 shows the transect and image positions captured during the photogrammetry study. The photogrammetry post-processing used 5,266 high-resolution aerial images, processed using a computer with AMD EPYC 7451 24-Core Processor CPUs, 192GB RAM, and NVIDIA Quadro M2000 GPU, taking 6h:56m:49s for point cloud densification, 2h:58m:17s for 3D Textured Mesh Generation, 1h:55m:48s for DEM generation, and 23h:39m:36s for the orthomosaic generation.

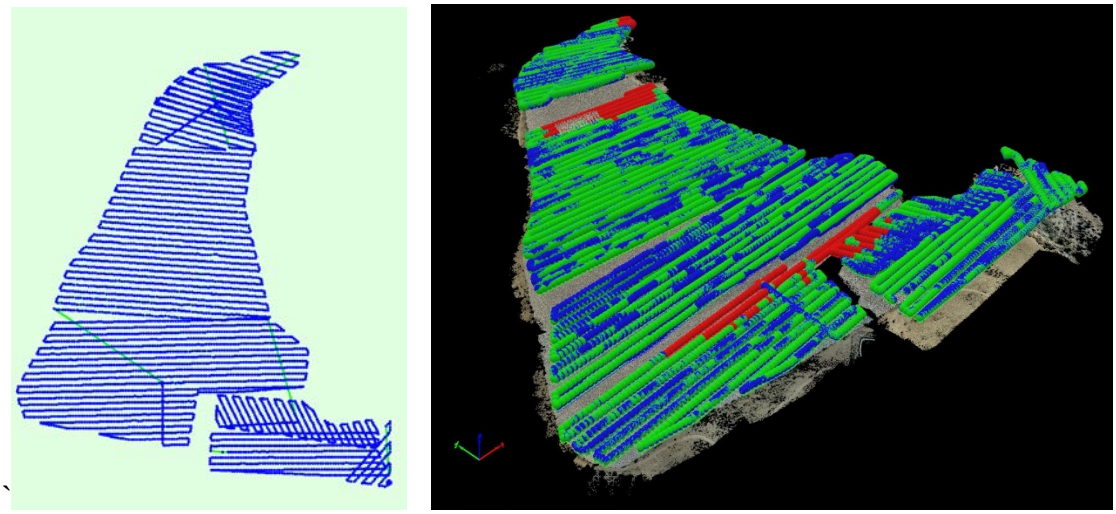

Figure 21. Aerial image positions and transects.

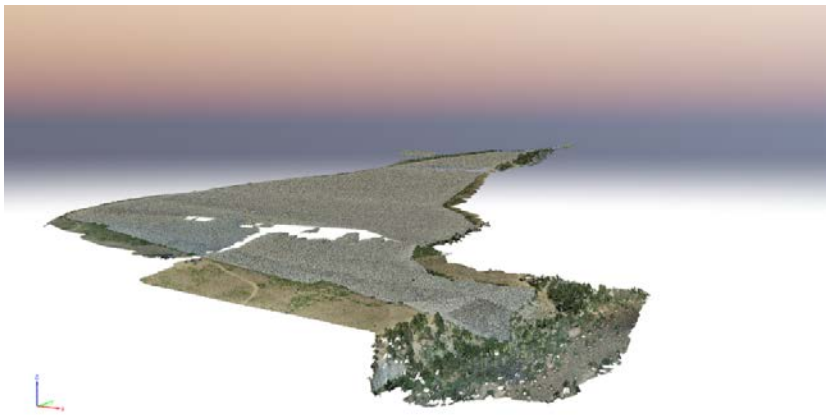

Figure 22. Isometric view of Rifle Disposal Site rendering.

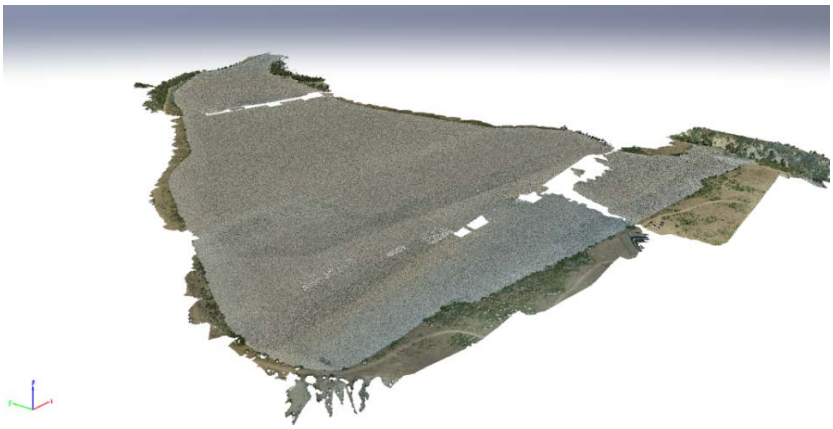

Figure 23. Different angle of Rifle 3D elevation model.

4. CONCLUSION

The goal of this internship was to acquire exposure to LM's mission, sites, and procedures. This exposure included assisting in disposal site tours-functions and inspections to continuously monitor sites; learning the field sampling process and how it supports LM's mission of environmental stewardship for its sites; experiencing stakeholder and tribal community dynamics within LM; obtaining his FAA Unmanned Aerial Vehicle (UAV) pilot's license to conduct the technology deployment at the Rifle Disposal Site. Additionally, the fellow managed to deploy and evaluate an in-house agnostic LiDAR module and aircraft for remote sensing data capture to serve as a reference for DOE-LM needs. This acquired data can then be used to try to identify and monitor currently existing cell cover depressions.

5. REFERENCES

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