

# RECLAMATION

*Managing Water in the West*

## **2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop: Executive Summary and Applications for Bureau of Reclamation Operations**

**Research and Development Office  
Science and Technology Program  
Final Report ST-2019-8120-01**



**U.S. Department of the Interior  
Bureau of Reclamation  
Research and Development Office**

**September 2019**

# Mission Statements

Protecting America's Great Outdoors and Powering Our Future

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

## **Cover Photograph:**

Demonstrating virtual reality at the 2019 Science and Technology Unmanned Aerial Systems Research Training Workshop.

## **Disclaimer:**

This document has been reviewed under the Research and Development Office Discretionary Peer Review Process [https://www.usbr.gov/research/peer\\_review.pdf](https://www.usbr.gov/research/peer_review.pdf) consistent with Reclamation's Peer Review Policy CMP P14. It does not represent and should not be construed to represent Reclamation's determination, concurrence, or policy.

<b>REPORT DOCUMENTATION PAGE</b>			<i>Form Approved</i> <i>OMB No. 0704-0188</i>		
<b>T1. REPORT DATE:</b> SEPTEMBER 2019		<b>T2. REPORT TYPE:</b> FINAL RESEARCH EXECUTIVE SUMMARY		<b>T3. DATES COVERED</b> 2019	
<b>T4. TITLE AND SUBTITLE</b> 2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop: Executive Summary and Applications for Bureau of Reclamation Operations Research and Development Office, Science and Technology Program, Final Report ST-2019-8120-01			<b>5a. CONTRACT NUMBER</b> 18XR0680A1-RY15412018WI18120		
			<b>5b. GRANT NUMBER</b>		
			<b>5c. PROGRAM ELEMENT NUMBER</b> 1541 (S&T)		
<b>6. AUTHOR(S)</b> Matthew Klein ( <a href="mailto:mjklein@usbr.gov">mjklein@usbr.gov</a> ), 303-445-2368			<b>5d. PROJECT NUMBER</b> ST-2019-8120-01		
			<b>5e. TASK NUMBER</b>		
			<b>5f. WORK UNIT NUMBER</b> 86-68530		
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Matthew Klein, Principal Investigator Bureau of Reclamation, Technical Service Center Concrete and Structural Laboratory, 86-68530 PO Box 25007, Denver CO 80225-0007			<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>		
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Research and Development Office U.S. Department of the Interior, Bureau of Reclamation PO Box 25007, Denver CO 80225-0007			<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> R&D: Research and Development Office BOR: Bureau of Reclamation DOI: U.S. Department of the Interior		
			<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b> ST-2019-8120-01		
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b> Final report can be downloaded from Reclamation's R&D Web site: <a href="https://www.usbr.gov/research/">https://www.usbr.gov/research/</a>					
<b>13. SUPPLEMENTARY NOTES</b>					
<b>14. ABSTRACT (Maximum 200 words)</b> Early in 2019, the TSC released a survey to aviation employees and area/regional supervisors to better understand the need and applications of UAS technology. The Science and Technology Program hosted the first UAS Research Training Workshop on May 28 and 29, 2019. This report provides and executive summary, the workshop agenda, a summary of each presentation, list of workshop attendees and the poll results.					
<b>15. SUBJECT TERMS</b> Unmanned Aerial Systems, UAS, survey, workshop, training					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b> U	<b>18. NUMBER OF PAGES</b> 35	<b>19a. NAME OF RESPONSIBLE PERSON</b> Matthew Klein
<b>a. REPORT</b> U	<b>b. ABSTRACT</b> U	<b>c. THIS PAGE</b> U			<b>19b. TELEPHONE NUMBER</b> 303-445-2368



# BUREAU OF RECLAMATION

Research and Development Office  
Science and Technology Program

Concrete and Structural Laboratory, Technical Service Center, 86-68530

Final Report ST-2019-8120-01

## 2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop: Executive Summary and Applications for Bureau of Reclamation Operations

---

Prepared by: Matthew Klein, P.E., Ph.D.

Civil Engineer, Concrete and Structural Laboratory, Technical Service Center, 86-68530

---

Peer Review: Bobbi Jo Merten, Ph.D.

Chemist, Materials and Corrosion Laboratory, Technical Service Center, 86-68540

**For Reclamation disseminated reports, a disclaimer is also required for final reports and other research products; this language can be found in the peer review policy:**

*This document has been reviewed under the Research and Development Office Discretionary Peer Review Process [https://www.usbr.gov/research/peer\\_review.pdf](https://www.usbr.gov/research/peer_review.pdf) consistent with*

*Reclamation's Peer Review Policy CMP P14. It does not represent and should not be construed to represent Reclamation's determination, concurrence, or policy.*



# Acknowledgements

Special thanks to the Science and Technology Program for funding, coordination and technical support for the 2019 Unmanned Aerial Systems (UAS) Research Training Workshop. Also, thanks to Technical Services Center for allowing the event to be hosted in the laboratories.





# Acronyms and Abbreviations

3D	three-dimensional
C-UAS	Center for UAS
DO	Denver Office
FHWA	Federal Highway Administration
GIS	geographical information system
GP	Great Plains
GPR	ground penetrating radar
GRASP	General Robotics, Automation, Sensing and Perception
IR	infrared
LC	Lower Colorado
LIDAR	Light Detection and Ranging
MP	Mid-Pacific
NA	not available
NAM	National Aviation Manager
P&A	Policy and Administration
PN	Pacific Northwest
RAM	Regional Aviation Manager
Reclamation	Bureau of Reclamation
RISE	Reclamation Information Sharing Environment
RGB NIR	red, green, blue, near infrared
RO	Research Office
RWIS	Reclamation Water Information System
TSC	Technical Service Center
UAS	unmanned aerial system/unmanned aircraft system
UC	Upper Colorado
USGS	U.S. Geological Survey



# Executive Summary

Principle investigators, unmanned aerial system (UAS) pilots, aviation managers and supervisors, and interested parties in UAS, UAS research and UAS technology met at Reclamation's Technical Service Center (TSC) laboratories in Denver, Colorado on May 28 and 29, 2019. Participants and presenters gathered in-person and online from Provo Area Office, TSC, Phoenix Area Office, Office of Policy and Administration (P&A) Asset Management, Montana Area Office, Nebraska-Kansas Area Office, Yuma Area Office, Trinity River Restoration Program, Emergency Management and Aviation Office, Reclamation's Research and Development Office, Columbia/Snake Salmon Recovery Office, Reclamation's Security, Safety, and Law Enforcement Office, Albuquerque Area Office, Lower Colorado Regional Office, Lower Colorado Dams Area Office, Bay-Delta Area Office, Tracy Field Office, Eastern Colorado Area Office, Lahontan Basin Area Office, Central California Area Office, South-Central California Area Office, Pacific Northwest Regional Office, Mid-Pacific Regional Office, Four Corners Construction Office, Western Colorado Area Office (Durango and Grand Junction), Upper Colorado Regional Office, Glen Canyon Field Division, United States Geological Survey (USGS) National UAS Project Office, University of Pennsylvania and TM Photogrammetry. See Appendix C for the list of attendees.

The objective of the workshop was to 1) provide state-of-the-art information on UAS and data processing techniques, applications, research, procedural requirements and opportunities, 2) encourage collaboration and facilitate partnerships and 3) identify UAS research needs related to Reclamation's mission. By the end of the workshop, several areas were identified and prioritized for future research including 1) UAS data artificial intelligence, machine learning and processing precision and accuracy as related to Reclamation facilities, 2) UAS automatic inspection of interior features such as tanks and tunnels, 3) exploring the benefits and limitations of UAS-borne LIDAR (light ranging and detecting) and 4) exploring how UAS can improve sedimentation monitoring.

Two keynote speakers presented at the workshop including Reclamation's National Aviation Manager (NAM), David Rosser, and the University of Pennsylvania's GRASP (General Robotics, Automation, Sensing and Perception) Laboratory Project Research Manager, Dr. James Keller. Regional Aviation Managers (RAMs) were invited to give UAS updates from each of Reclamation's five geographic regions and the TSC. Research principle investigators provided progress updates on seven UAS research projects (listed below). An update was given on a recent grant that was awarded to Reclamation by the Federal Highways Administration (FHWA). Then three presentations each were given on the subjects of UAS operations and UAS data processing. These presentations were used to foster a working discussion of Reclamation needs related to UAS operations and data processing. USGS, Tom Noble (retired Bureau of Land Management) and the TSC gave demonstrations on UAS sensor implementation, photogrammetry and virtual reality, respectively. Finally, the workshop ended with participants ranking the needs identified earlier.

Researchers provided presentations for the following Science and Technology research projects:

- UAS Applications at Bureau of Reclamation Operations
- UAS Data Collection at Reclamation Sites
- Explore the Feasibility of using UAS in Managing Rockfall Hazard Areas
- Reclamation Data Council UAS Best Practices
- Improving Distributed Hydrologic Models using Multiscale Thermal Infrared, Near Infrared, and Visible Imagery from sUAS and Satellite-Based Sensors
- Application of UAS for Invasive Species Detection at Reclamation
- Researching UAS Options for Engineering and Large-Scale Mapping Projects

See Appendix A for the workshop agenda and Appendix B for a brief summary of the research presentations. In addition, the entire workshop was video recorded; please contact Ronda Dorsey (rdorsey@usbr.gov) for access.

## UAS Applications Survey

Earlier in the year, in an effort to help identify specific research needs related to UAS and UAS data products, the TSC with support from the Research Office, sent out a survey to Reclamation RAMs, UAS pilots, area and regional office managers and those who were previously identified with having an interest in UAS. Of the 117 recipients of the poll, 55 responded.

The poll was distributed on January 6, 2019 and was open for submissions for a two-month period ending March 2. The survey consisted of four simple questions, two of which were multiple choice, multiple answer; one was open-answer paragraph; and the last question was yes/no. The results of the poll are shown in Appendix D.

The questions in the poll were:

- 1) What UAS operations currently being conducted at Reclamation area you familiar with? (multiple choice, multiple answer)
- 2) What UAS applications are useful to you or your office? (multiple choice, multiple answer)
- 3) What UAS Technology(ies) NOT listed above would you be interested to see evaluated at your office or facility? (paragraph)
- 4) Would you be interested in evaluating a UAS technology if Reclamation's research office were to partner with your office or facility? (yes or no)

The first question asking what UAS operations were currently being conducted was used to find out which operations Reclamation employees were familiar with and to understand if employees knew about UAS operations at Reclamation. The top three ranking answers were aerial photography and/or videography (84%), 3D modeling and measurements using photogrammetry (62%) and geographical information system (GIS) mapping (56%). After the top three ranking questions, the rest of the categories are less than 50% meaning that only half of the respondents knew about the services that Reclamation can currently offer.

The second question is used to calibrate the first question and to rank which applications were the most useful. For instance, 84% of respondents knew about aerial photography and/or videography but 95% of respondents thought it would be useful. It could be inferred that 11% (95% - 84%) of the respondents did not know about UAS aerial photography/videography. The top three ranking answers were the same as Question 1; aerial photography and/or videography (95%), 3D modeling and measurements using photogrammetry (82%) and geographical information system (GIS) mapping (78%). This means that over three-quarters of the respondents could use these services. Several other applications also included building/bridge/road/dam inspection (73%), orthoimagery/topography/contours (69%), LIDAR (Light Detection and Ranging) scanning (65%), seepage detection (64%) followed by several types of monitoring including inaccessible features, rock face, construction site, sedimentation, landslide/sinkhole.

The third question was designed to capture new UAS applications not previously thought of. Many of the answers were related to water monitoring such as water quality analysis, geomorphic change detection, bathymetry, and below-water-surface monitoring. Other responses included asking for more information provided to Reclamation about what are the UAS applications, how to become a UAS pilot, and setting up UAS operations.

The last question response was that 89% of the respondents said they would be interested in evaluating a UAS technology by partnering with the Research Office. This demonstrated that the majority of the respondents were favorable to UAS technology at their office.

## Future Work

The UAS Research Training Workshop received positive feedback with the expectation that it would be continued in the future. TSC, Emergency Management and Aviation Office and the Research Office will continue collaboration to determine interest in the future. The 2019 workshop attendees identified the following outcomes;

- Develop S&T proposals to address the ranked needs identified in the workshop discussions
  - 1) UAS data artificial intelligence, machine learning and processing precision and accuracy as related to Reclamation facilities. *Action: Matthew Klein*
  - 2) UAS automatic inspection of interior features such as tanks and tunnels. *Action: Carter Gulsvig*
  - 3) Exploring the benefits and limitations of UAS-borne LIDAR. *Action: Meyer Jay*
- Setup quarterly aviation calls to encourage collaboration and knowledge sharing. *Action: David Rosser*

For questions related to Reclamation aviation and UAS, please contact Reclamation's National Aviation Manager, David Rosser, 208-443-5050, [drosser@usbr.gov](mailto:drosser@usbr.gov).



# Contents

**Executive Summary .....ix**  
UAS Applications Survey .....x  
Future Work.....xi  
Appendix A – Workshop Agenda.....A-1  
Appendix B – Summary of Workshop Presentations .....B-1  
Appendix C – List of Training Workshop Attendees .....C-1  
Appendix D – UAS Applications Poll Results .....D-1





# Appendix A – Workshop Agenda

## **Unmanned Aerial Systems (UAS) Research Training Workshop**

### **Workshop Objectives**

1. Provide state of the art information on unmanned aerial systems (UAS) and data processing techniques, applications, research, procedural requirements, and opportunities across regions.
2. Encourage collaboration among Reclamation researchers, regional pilots, stakeholders, and the broader communities.
3. Facilitate partnerships on existing and proposed research geared towards advancing and implementing UAS and data processing.

### **Workshop Date**

May 28 and 29, 2019

### **Workshop Location**

*Denver Federal Center, Lakewood, CO:* Technical hub for Reclamation UAS and data processing, including research, collaboration, and implementation. Myriad case studies for completed UAS missions across all Reclamation regions. State of the art 3D data processing capabilities.

### **Workshop Outcomes**

- Foster the growing Reclamation and stakeholder community interested in UAS.
  - o Examine existing and forthcoming UAS applications.
  - o Orient the UAS community on Department and Agency policies.
  - o Share best practices for UAS data processing, storage, and presentation.
  - o Disseminate active S&T research project approaches and findings to the broader research, pilot, and stakeholder communities.
  - o Produce list of contacts and capabilities for UAS and data processing community.
- Provide hands-on experience with data processing techniques.
- Identify partnership opportunities for existing and new research proposals on advancing UAS and data processing techniques.

### **Workshop Agenda (Below)**

**May 28, 2019:**

**1:00 – 1:30 Workshop Training Objectives and Introductions**

- Welcome and Safety, *Janet White*
- Workshop Overview, *Matthew Klein/Bobbi Jo Merten/Erin Foraker*
  - Introductions
  - Agenda overview
  - Workshop executive summary report

**1:30 – 2:30 Keynote speakers**

- Reclamation National Aviation Manager, *David Rosser*
- Keynote Speaker, U Penn, *Jim Keller*

**2:30 – 2:45 Regional Updates:**

- GP: Cory Stokesberry
- PN: Cory Stokesberry
- DO: Cory Stokesberry
- UC: Stacey Smith
- LC: Bridget Johanning for Kevin Tibbs
- MP: Larry Welch?

**2:45 – 3:00 Break**

**3:00 – 5:00 S&T Research: UAS**

- 3:00 – 3:15 UAS applications at Bureau of Reclamation operations, *Trevor Stockton*
- 3:15 – 3:30 UAS data collection at Reclamation sites, *Jakeb Prickett*
- 3:30 – 3:45 Explore the Feasibility of using Unmanned Aircraft Systems in managing Rockfall Hazard Areas, *Bryan Simpson*
- 3:45 – 4:00 Reclamation Data Council UAS Best Practices, *Jade Soddell*
- 4:00 – 4:15 Improving distributed hydrologic models using multiscale thermal infrared, near infrared, and visible imagery from sUAS and satellite-based sensors, *Lindsay Bearup*
- 4:15 – 4:30 Application of Unmanned Aerial Systems (UAS) for invasive species detection at Reclamation, *Aaron Murphy*
- 4:30 – 4:45 Researching UAS Options for Engineering and Large-Scale Mapping Projects, *David Salas*
- 4:45 – 5:00 Day 1 Recap

2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop:  
Executive Summary and Applications for Bureau of Reclamation Operations

**May 29, 2019:**

**8:00 – 8:25 UAS Research**

- 8:00 – 8:10 FWHA CTIP Summary, *Dan Staton*
- 8:10 – 8:25 C-UAS Status, *Troy Ethington*

**8:25 – 10:25 UAS Mission Case Studies and Group Breakouts**

- 8:25 – 9:35 UAS Case Studies
  - UC Region – Flaming Gorge or Vallecito, *Stacey Smith? or Matthew Klein*
  - PN Region – Black Canyon Emergency Management Test, *Cory Stokesberry*
  - DO/LC Region – Brock Reservoir Crack Mapping, *Jonathan Pomeroy*
  - GP Region – Seepage Monitoring at Altus Dam, *Meyer Jay*
  - DO/UC Region – Ridges Basin IR Monitoring, *Jakeb Prickett*
- 9:35 – 10:05 Group Breakouts – Promising UAS Applications
  - What are the success stories?
  - What are remaining gaps or challenges?
  - What are top three research needs?
- 10:05 – 10:25 Group presents findings to workshop

**10:25 – 10:40 Break**

**10:40 – 12:00 UAS Data Processing and Group Breakouts**

- 10:40 – 11:15 Overview of 3D data processing advancements
  - UAS Data Analysis Overview, *Trevor Stockton*
  - UAS Data Standardization, *David Salas*
  - Using data from the RWIS/RISE, *Deena Larsen*
- 11:15 – 11:45 Group Breakouts – Data Processing and Analysis Challenges
  - What are the success stories?
  - What are remaining gaps or challenges?
  - What are top three research needs?
- 11:45 – 12:00 Group presents findings to workshop

**May 29, 2019, Continued:****12:00 – 1:00 Lunch****1:00 – 3:00 UAS Data Processing Lab Hands-On**

- UAS airframes, mods and sensors, *Jeff Sloan/Joe Adams, USGS*
- MetaShape 3D processing, *Tom Noble*
- Virtual reality, *Matthew Klein*

**3:00 – 3:15 Break****3:15 – 5:00 Research Roadmapping**

- 3:15 – 4:15 Research Roadmapping
  - Review tallied and ranked list research needs for UAS and data processing
  - Identify new needs
  - Prioritize combined lists based on need and potential benefit
  - FY2020 research proposals team members and partners
- 4:15 – 4:30 UAS Research Workshop Recap and General Adjourn
- 4:30 – 5:00 UAS Coordination Group Overview, *UAS Pilots*



# **Appendix B – Summary of Workshop Presentations**

**2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop:  
Executive Summary and Applications for Bureau of Reclamation Operations**

<b>Project ID</b>	<b>Title</b>	<b>Presenter</b>	<b>Description</b>
8120	UAS Applications at Bureau of Reclamation Operations	Trevor Stockton-Salas	Results of a survey to highlight relevant and novel applications of UAS technology
7104	UAS Data Collection at Reclamation Sites	Matthew Klein (for Jakeb Prickett)	Summary of UAS training, equipment and demonstration projects conducted by the TSC
7109	Explore the Feasibility of using Unmanned Aircraft Systems in managing Rockfall Hazard Areas	Bryan Simpson	Progress from a demonstration project to use UAS for rockface monitoring at Hoover Dam
NA	Reclamation Data Council Data Management and Support	Jade Soddell	Latest updates on solutions for Reclamation UAS data management
19249	Improving Distributed Hydrologic Models using Multiscale Thermal Infrared, Near Infrared, and Visible Imagery from sUAS and Satellite-based Sensors	Lindsay Bearup	Progress from a demonstration project using and comparing UAS and satellite derived data and how it can improve hydrologic models
19012	Application of Unmanned Aerial Systems (UAS) for invasive species detection at Reclamation	Aaron Murphy	Summary of literature search projects using UAS for invasive species detection
1886	Researching UAS Options for Engineering and Large-Scale Mapping Projects	David Salas	Overview of current DOI UAS, UAS with features that meet our needs and how to acquire them



# **Appendix C – List of Training Workshop Attendees**

2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop:  
Executive Summary and Applications for Bureau of Reclamation Operations

**Table 1: List of In-Person Attendees**

<b>Name</b>	<b>Directorate</b>	<b>Office</b>
Joe Adams	USGS	USGS National UAS Project Office
Lee Baxter	Upper Colorado Region	Provo Area Office
Lindsay Bearup	Technical Service Center	Water Resources Engineering
Glenda Besana-Ostman	Technical Service Center	Seismology and Geomorphology
Roland Cheng	Technical Service Center	Electrical Controls
Jay Corum	Lower Colorado Region	Phoenix Area Office
Ginger Dill	Policy and Administration Office	Asset Management Division
Alex Duwe	Great Plains Region	Nebraska-Kansas Area Office
Erin Foraker	Research and Development Office	Research and Development Office
Todd Gaston	Technical Service Center	Economic Analysis
Carter Gulsvig	Technical Service Center	Materials and Corrosion Laboratory
Charles Harde	Great Plains Region	Montana Area Office
Aung Hla	Great Plains Region	Nebraska-Kansas Area Office
Bridget Johanning	Lower Colorado Region	Yuma Area Office
James Keller	University of Pennsylvania	GRASP Laboratory
Matthew Klein	Technical Service Center	Concrete and Structural Laboratory
Toni Linenberger	Safety, Security and Law Enforcement Office	Security Office
Bobbi Jo Merten	Technical Service Center	Materials and Corrosion Laboratory
Aaron Murphy	Technical Service Center	Hydraulic Investigations and Laboratory Services
James Nagode	Information Resources Office	Information Management Group
Tom Noble	BLM (retired)	TM Photogrammetry
Eric Peterson	Mid-Pacific Region	Trinity River Restoration Program
Jonathan Pomeroy	Technical Service Center	Geographic Applications and Analysis
Jakeb Prickett	Technical Service Center	Geographic Applications and Analysis
Ken Rice	Upper Colorado Region	Albuquerque Area Office
David Rosser	Safety, Security and Law Enforcement Office	Emergency Management and Aviation Office
David Salas	Technical Service Center	Geographic Applications and Analysis
Jeff Sloan	USGS	USGS National UAS Project Office
Trevor Stockton-Salas	Technical Service Center	Concrete and Structural Laboratory
Janet White	Technical Service Center	Engineering and Laboratory Services Division
John Whitler	Research and Development Office	Research and Development Office
Kurt Wille	Technical Service Center	Water, Environmental and Ecosystems Division

**Table 2: List of Online Attendees**

**2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop:  
Executive Summary and Applications for Bureau of Reclamation Operations**

<b>Name</b>	<b>Directorate</b>	<b>Office</b>
Corey Albright	Upper Colorado Region	Provo Area Office
Jeffrey Beaty	Upper Colorado Region	Provo Area Office
Susan Behery	Upper Colorado Region	Western Colorado Area Office - Durango
Whitney Brown	Mid-Pacific Region	Central California Area Office
Christian Buenrostro	Mid-Pacific Region	Central California Area Office
David Coan	Great Plains Region	Eastern Colorado Area Office
Laura Couron	Mid-Pacific Region	South-Central California Area Office
Kendra Fallon	Pacific Northwest Region	Pacific Northwest Regional Office
William Fellman	Upper Colorado Region	Four Corners Construction Office
John Flores	Upper Colorado Region	Upper Colorado Regional Office
Michael Freeman	Upper Colorado Region	Provo Area Office
Allen Giger	Upper Colorado Region	Western Colorado Area Office - Grand Junction
Bryon Green	Lower Colorado Region	Yuma Area Office
Tara Gregg	Pacific Northwest Region	Columbia/Snake Salmon Recovery Office
Christopher Grosso	Upper Colorado Region	Albuquerque Area Office
David Gundlach	Lower Colorado Region	Lower Colorado Regional Office
Eve Halper	Lower Colorado Region	Phoenix Area Office
John Hannon	Mid-Pacific Region	Bay-Delta Office
Christopher Hart	Mid-Pacific Region	Tracy Field Office
Janet Hegarty	Great Plains Region	Eastern Colorado Area Office
Cameron Herrington	Upper Colorado Region	Albuquerque Area Office
Karen Hutchins	Mid-Pacific Region	Lahontan Basin Area Office
Stephen Jalbert	Pacific Northwest Region	Pacific Northwest Regional Office
Lesli Kirsch-Burke	Lower Colorado Region	Lower Colorado Regional Office
James Knowles	Lower Colorado Region	Lower Colorado Regional Office
Jedediah Lewis	Mid-Pacific Region	Trinity River Restoration Program
Derek MCGovern	Upper Colorado Region	Provo Area Office
John Lee Mercado	Mid-Pacific Region	NA
Andrew Minks	Mid-Pacific Region	Mid-Pacific Regional Office
Darcy Nelson	Pacific Northwest Region	Pacific Northwest Regional Office
Samuel Newcom	Mid-Pacific Region	Mid-Pacific Regional Office
Todd Plain	Mid-Pacific Region	Mid-Pacific Regional Office
Francisco Rodriguez	Lower Colorado Region	Yuma Area Office
Ryan Royer	Upper Colorado Region	Four Corners Construction Office
Christine Sapien	Upper Colorado Region	Albuquerque Area Office
Tami Sheldon	Upper Colorado Region	Western Colorado Area Office - Durango
Torrence Stockard	Pacific Northwest Region	Columbia/Snake Salmon Recovery Office
Clint Stone	Upper Colorado Region	Upper Colorado Regional Office

James Stone	Upper Colorado Region	Glen Canyon Field Division
Senuka Weerahandi	Upper Colorado Region	Glen Canyon Field Division
Daniel Wood	Upper Colorado Region	Provo Area Office



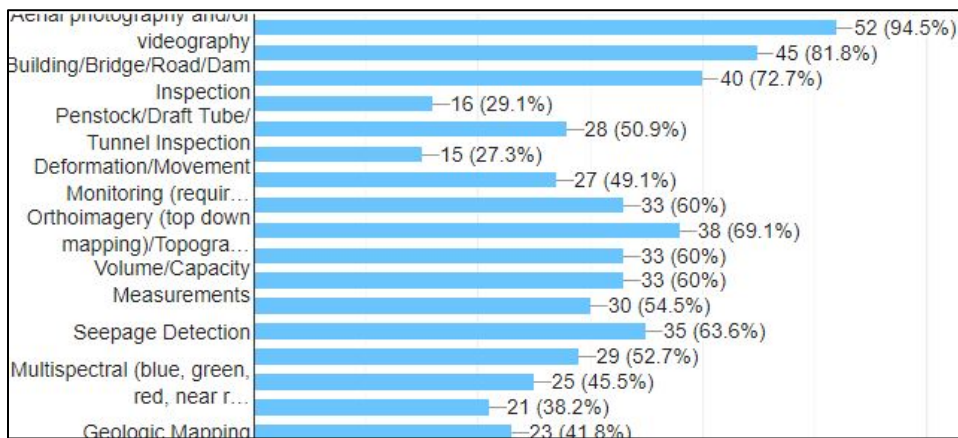
# Appendix D – UAS Applications Poll Results

# RECLAMATION

*Managing Water in the West*

## Poll Results

### UAS Applications at Reclamation: January 8 to March 2, 2019



U.S. Department of the Interior  
 Bureau of Reclamation  
 Technical Service Center  
 Concrete, Geotechnical and Structural Laboratory  
 Denver, Colorado

April 2019



## DESCRIPTION

The Technical Service Center (TSC) Unmanned Aerial Systems (UAS) Team has been conducting UAS data collection in partnership with the Reclamation Research Office (RO) for the past two years. Each time a mission has been completed, the UAS Team members review the data collection with the facility, area office and regional participants. During this review, additional UAS applications are always discovered.

In January 2019, members of Reclamation's TSC UAS Team sent out a poll to try and capture some of these unknown UAS applications. The poll was generated using Google Forms and included 4 questions to minimize the time required to complete the poll and increase the response rate. The distribution list was generated using area and regional office contacts from Reclamation's website and aviation/research related personnel.

The poll began accepting responses for about a 2-month period beginning January 6 and closing March 2. A total of 55 out of 117 people responded. The questions and the results are given below.

## QUESTIONS

1. What UAS operations currently being conducted at Reclamation are you familiar with?
  - Aerial photography and/or videography
  - Geographical Information System (GIS) Mapping
  - Orthoimagery (top down mapping)/Topography/Contours
  - 3D Modeling and Measurements using Photogrammetry
  - Building/Bridge/Road/Dam Inspection
  - Seepage Detection
  - Thermal Infrared (IR) Data Collection
  - Multispectral (blue, green, red, near red and near IR wavelengths) Data Collection
  - Concrete Surface Deterioration (cracks, spalls) Mapping
  - Deformation/Movement Monitoring (requires data collection over time)
  - Transmission Infrastructure Inspection
  - Construction Site Monitoring
  - Long-term Time-Lapse Capture
  - Rock Face Monitoring
  - Geologic Mapping
  - Sedimentation Mapping
  - Cultural Resource Documentation and Monitoring
  - Remote Location Monitoring
  - Observing/Inspecting Inaccessible Features
  - Vegetation Mapping

2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop:  
Executive Summary and Applications for Bureau of Reclamation Operations

- Landslide/Sinkhole Monitoring
  - 2. What UAS applications are useful to you or your office?
    - Aerial photography and/or videography
    - 3D Modeling and Measurements using Photogrammetry
    - Building/Bridge/Road/Dam Inspection
    - Transmission Infrastructure Inspection
    - Penstock/Draft Tube/Tunnel Inspection
    - Powerhouse Inspection (Indoors)
    - Deformation/Movement Monitoring (requires data collection over time)
    - Rock Face Monitoring
    - Orthoimagery (top down mapping)/Topography/Contours
    - Construction Site Monitoring
    - Volume/Capacity Measurements
    - Concrete Surface Deterioration (cracks, spalls) Mapping
    - Seepage Detection
    - Thermal Infrared (IR) Data Collection
    - Multispectral (blue, green, red, near red and near IR wavelengths) Data Collection
    - Long-term Time-lapse Capture
    - Geologic Mapping
    - Geographical Information System (GIS) Mapping
    - Sedimentation Mapping
    - Cultural Resource Documentation and Monitoring
    - Remote Location Monitoring
    - Observing/Inspection Inaccessible Features
    - Vegetation Mapping
    - Landslide/Sinkhole Monitoring
    - Search and Rescue Operations
    - Hazardous Locations Monitoring
    - Security Monitoring
    - Disaster Response
    - Animal/Fish Tracking
    - Habitat Monitoring
    - Invasive Species Tracking
    - Restoration Activities Monitoring
    - Audio Recording
    - Water Sampling
    - Radar/Ground Penetrating Radar (GPR) Scanning
    - Lidar Scanning
    - Inundation Modeling
    - Water Surface Elevation Measuring
    - Velocity/Flow Monitoring
  - 3. What UAS Technology(ies) NOT listed above would you be interested to see evaluated at your office or facility?
-

4. Would you be interested in evaluating a UAS technology if Reclamation's Research Office were to partner with your office or facility?
- Yes
  - No

## RESPONSES

1. What UAS operations currently being conducted at Reclamation are you familiar with? (Answers organized in order of percentage of responses)

Aerial photography and/or videography	84%
3D Modeling and Measurements using Photogrammetry	62%
Geographical Information System (GIS) Mapping	56%
Orthoimagery (top down mapping)/Topography/Contours	49%
Building/Bridge/Road/Dam Inspection	47%
Concrete Surface Deterioration (cracks, spalls) Mapping	40%
Thermal Infrared (IR) Data Collection	35%
Seepage Detection	31%
Rock Face Monitoring	31%
Observing/Inspecting Inaccessible Features	29%
Vegetation Mapping	29%
Deformation/Movement Monitoring (requires data collection over time)	22%
Construction Site Monitoring	22%
Multispectral (blue, green, red, near red and near IR wavelengths) Data Collection	20%
Geologic Mapping	18%
Sedimentation Mapping	16%
Cultural Resource Documentation and Monitoring	16%
Landslide/Sinkhole Monitoring	16%
Remote Location Monitoring	11%
Long-term Time-Lapse Capture	9%
Transmission Infrastructure Inspection	5%

2. What UAS applications are useful to you or your office? (Answers organized in order of percentage of responses)

Aerial photography and/or videography	95%
3D Modeling and Measurements using Photogrammetry	82%
Geographical Information System (GIS) Mapping	78%
Building/Bridge/Road/Dam Inspection	73%

2019 Science and Technology Unmanned Aerial Systems (UAS) Research Training Workshop:  
Executive Summary and Applications for Bureau of Reclamation Operations

Orthoimagery (top down mapping)/Topography/Contours	69%
Lidar Scanning	65%
Seepage Detection	64%
Observing/Inspection Inaccessible Features	62%
Rock Face Monitoring	60%
Construction Site Monitoring	60%
Volume/Capacity Measurements	60%
Landslide/Sinkhole Monitoring	60%
Sedimentation Mapping	56%
Vegetation Mapping	56%
Concrete Surface Deterioration (cracks, spalls) Mapping	55%
Thermal Infrared (IR) Data Collection	53%
Cultural Resource Documentation and Monitoring	53%
Penstock/Draft Tube/Tunnel Inspection	51%
Deformation/Movement Monitoring (requires data collection over time)	49%
Inundation Modeling	47%
Multispectral (blue, green, red, near red and near IR wavelengths) Data Collection	45%
Water Surface Elevation Measuring	44%
Geologic Mapping	42%
Habitat Monitoring	40%
Velocity/Flow Monitoring	40%
Long-term Time-lapse Capture	38%
Invasive Species Tracking	38%
Security Monitoring	35%
Remote Location Monitoring	31%
Restoration Activities Monitoring	31%
Transmission Infrastructure Inspection	29%
Disaster Response	29%
Powerhouse Inspection (Indoors)	27%
Radar/Ground Penetrating Radar (GPR) Scanning	27%
Animal/Fish Tracking	24%
Water Sampling	24%
Hazardous Locations Monitoring	20%
Search and Rescue Operations	9%
Audio Recording	5%

3. What UAS Technology(ies) NOT listed above would you be interested to see evaluated at your office or facility?

replacing out dated and unsafe practices
Most of them
We might be interested in more if we had a better idea of the services your could offer and cost. An over webinar would be useful for planning purposes.
Pairing surface and subsurface data to develop a complete model. Interferometry for long range mapping of movement of features (landslides, etc.). Detailed geologic mapping of structural features for use in stability analysis. Unlined spillways.
I answered question 1, but we are not currently using UAS for anything. All the above, we have been very interested in this technology for several years but have been getting clear direction and support has been difficult.
Detecting weak or weaker spots in steel structures (potential points of failure).
Water Quality Analysis Multispectral (RGB NIR)
None.
Anything that is novel or could be utilized in new ways to overall increase safety, reduce costs, or generally improve Reclamation's execution of mission would be useful to the Research and Development Office.
This may fit "sedimentation monitoring"... geomorphic change detection and measurement of deltas for tributary sediment inputs
Vegetation health and green lidar for bathymetry
Below water surface monitoring
to review with potential candidates interested in becoming UAS pilots

4. Would you be interested in evaluating a UAS technology if Reclamation’s Research Office were to partner with your office or facility?

Yes	89%
No	11%