RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Evaluation and Development of Rapid Geophysical Profiling for Canal Embankment Seepage Detection

Combining rapid geophysical profiling, satellite remote sensing data, and smart semi-automated data analytics to better assess the Nation's aging canals and levees

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Results of this research provide a complimentary set of tools for canal and levee assessment that go beyond conventional visual inspection techniques.

Mission Issue

This research has developed the capabilities needed for Reclamation to collect hundreds of miles of data along canals and perform semi-automated data analysis and interpretation in an extremely rapid manner.

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Problem

There are currently over 100,000 miles of canal and levee embankments and approximately 79,000 dams on the national inventory list. Many of these structures are reaching or have surpassed their initial design life, where most earthen embankment structures are over 50 years in age, and many are greater than 80 years in age. Development and urban encroachment along this aging infrastructure increases risk associated with seepage and internal erosion-caused failures, and water conveyance systems are known to lose significant quantities of water due to distributed seepage along canal embankments.

As a result, there is a need for efficient characterization of these vast infrastructural systems by means of rapid surveying and inspection technologies. Implementation of tools of this sort could provide a list of priority "hot spots" warranting more focused mitigation or investigation efforts along urbanized segments of canals and levees (e.g., using higher resolution geophysical methods or geotechnical investigation techniques at locations of elevated concern).

Solution

In order to help address these issues, this research has focused on developing a new approach for rapid assessment of earthen canal embankments for the detection and characterization of seepage. The investigated approach involves the use of Normalized Difference Vegetative Index (NDVI) remote sensing data images, combined with rapid continuous frequency-domain electromagnetic (FDEM) and magnetic gradiometry profiling surveys conducted along canal embankments.

This approach enables miles of data collection in a single day. These data are then combined to develop a new "Seepage Index" data attribute along inspected canals that shows areas of likely seepage. This research also investigated to use of machine learning algorithms applied to these data, and results show great promise for further automation of data interpretation and seepage detection using the developed approaches.

"While this approach to rapid interrogation of canals and levees will improve with additional development and testing efforts, it already provides a practical means for seepage detection and mapping along the nation's earthen canal and levee embankments."

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Collaborators

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More Information

https://www.usbr.gov/research/projects/detail.cfm?id=9918

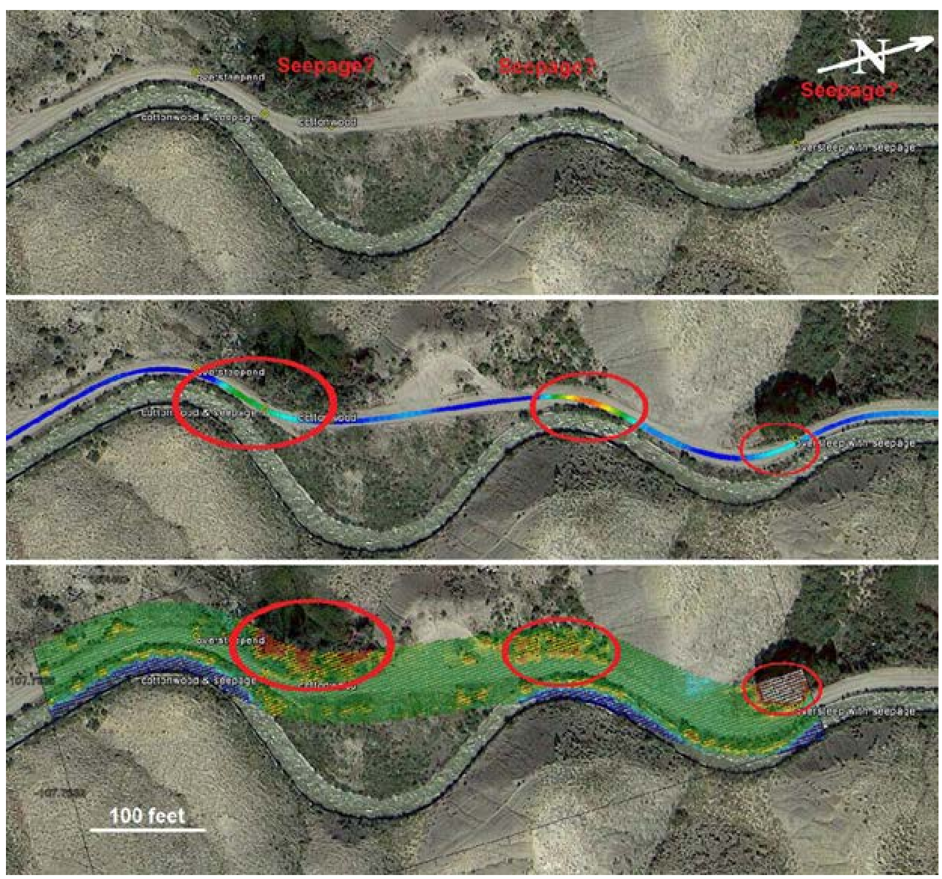
https://www.usbr.gov/research/projects/researcher.cfm?id=2810

Application and Results

This research involved partnerships with the Western Colorado and Provo Utah Area Offices, where a total of nearly 30 miles of data coverage was acquired along three separate canals systems: South Canal near Montrose, Colorado, Government Highline Canal near Grand Junction, Colorado, and Strawberry Highline Canal near Provo, Utah. These data enabled the testing and development of robust and semi-automated data processing and analysis workflows, resulting in a new approach to rapid detection of canal and levee seepage. Results from developing a new "Seepage Index" and applying machine learning to predict seepage locations were validated by comparison with known and observed seepage areas/features along each canal. These results have also helped to identify additional locations along these structures that are most likely experiencing seepage losses.

Future Plans

Future testing will be required to evaluate and develop various machine learning classification algorithms as reliable tools for predicting seepage or other issues along canals and levees using this study's approach. This will require ongoing cooperative partnerships with various stakeholders, in order to provide verified seepage location and performance data for use as training and validation sets. This information will also help to further evaluate integration of additional data types and help to update and optimize analysis workflows.



An example showing known and suspected canal seepage locations, and typical geophysical profiling anomalies and elevated NDVI values associated with these water losses that can be utilized to detect, map, and better characterize seepage.