Missouri River Macrophyte UAS Monitoring Report

Prepared for

NorthWestern Energy, Inc.
6700 Rainbow Dam Road
Great Falls, Montana 59404

NorthWestern Energy

Prepared by

RDG
RIVER DESIGN GROUP

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www.riverdesigngroup.com

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1 INTRODUCTION

1.1 Project Overview

River Design Group, Inc. (RDG) was contracted by NorthWestern Energy, Inc. (NWE) to conduct an initial monitoring survey of macrophyte extent on the Missouri River below Holter Dam (Figure 1). The Missouri River is a major recreational fishery for rainbow trout and brown trout in Montana. Macrophyte extent and intensity is believed to have increased to the current level despite recent high flow events in the reach. Recreational users have observed this increase and expressed concerns over expansion. NWE approached RDG to design a monitoring plan for mapping the extent of macrophytes with unmanned aerial systems (UAS) that could be repeated on a yearly basis to help assess the impacts of dam operations on macrophyte communities.

Limited research has been conducted on the effectiveness of UAS mapping for aquatic vegetation. Initial research has shown an ability to map different species of aquatic vegetation from drone-borne sensors in lakes and outlets between lakes (Husson et al. 2014). Recent research has confirmed that in rivers it is possible to map aquatic vegetation by species using object-based image analysis with 50-60% accuracy (Visser et al. 2018). Additional examples of high-resolution riverbed composition mapping focused on using hyperspectral airborne sensors, which prove effective at mapping different sediment facies (sand, gravel, cobble) and degree of periphyton development (Legleiter et al. 2016).

Given these demonstrated successes, this project aims to map the extent of submerged macrophytes in four reaches greater than 2,000 feet in length with the use of UAS. A standard automated image classification was used to determine the percent bed coverage of vegetation. This method is repeatable and quantifiable to measure changes in macrophyte communities through time.

1.2 Project Goals and Objectives

The goal of this project is to develop and demonstrate a repeatable, cost effective, monitoring program for macrophytes on the Missouri River below Holter Dam. To accomplish this goal the following objectives were completed:

- Identify four sites that are ideal for monitoring macrophytes;
- Conduct UAS surveys that produce high-resolution orthophotos for each site;
- Map macrophytes using automated image classification; and
- Make recommendations for continued monitoring efforts.

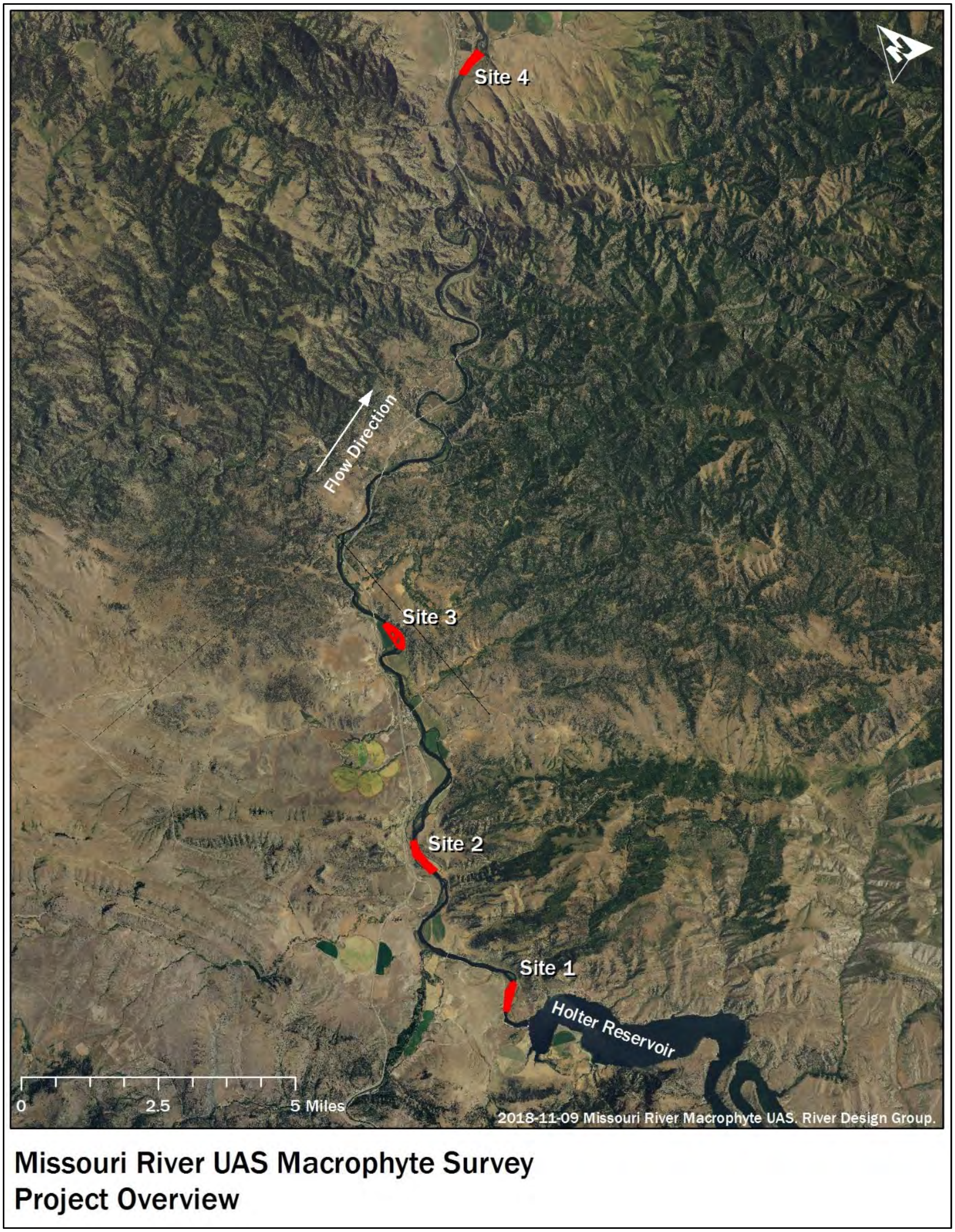

Figure 1. Vicinity map of the Missouri River UAS macrophyte survey project area.

2 METHODS

Sites were selected based on maximizing the area that would not be limited by depth and had existing macrophyte communities. Four sites were distributed throughout the reach to allow for greater spatial understanding of vegetation dynamics (Figure 1). Each site exceeded 2,000-feet in length.

UAS flights were conducted during August to maximize solar irradiance, capture lowest flow, and coincide with the end of the growing season. These conditions maximize the ability of the sensor to detect vegetation and should be repeated for continued monitoring. FAA Part 107 guidelines for commercial operations were followed with a maximum flight altitude of 300-feet above ground level.

A high resolution orthophoto was created using Agisoft Photoscan for each site and exported as a TIFF to ArcGIS 10.4 for remote sensing analysis. Additional image to image georeferencing was completed using NAIP 2017 imagery. Orthophotos were resampled to one-foot resolution for the remote sensing analysis. Image classification required manual selection of training data that identified different on the ground features including bare substrate, macrophytes, sand etc. at different depths throughout the image. This training data was then used to develop a supervised classification using the maximum likelihood algorithm. This was iteratively refined to maximize accuracy of the classification. The final classification was used to calculate the total area of macrophyte extent compared to the total area of the site.

3 RESULTS

Results are summarized in Table 1 and shown for each site in Figures 2-9. All four sites had macrophyte coverage exceeding 50% and Site NWE1 had the highest at 86% coverage. NWE1 had the largest macrophytes and is the closest to the dam which creates ideal clear water conditions for maximum sunlight exposure. There is a decreasing trend in coverage moving downstream to NWE4 where smaller macrophytes are prevalent on the bed, but do not extend through the water column as observed at NWE1. Additionally, NWE4 had the most difficulty classifying macrophytes due to the greater depth, increased turbidity, and sun glint due to excessive wind during flights. The classification models tended to over predict presence of macrophytes in deeper sections where the bed was not visible. This led to an overall overprediction in the models especially at NWE4.

Table 1. Results summary from image classification of macrophyte extent.

Monitoring Sites	Macrophyte Extent (Acres)	Total Classified Extent (Acres)	Macrophyte Extent (Percent)	Prediction Trend
Missouri River NWE1	27.49	31.85	86%	Overpredicted
Missouri River NWE2	25.12	36.93	68%	Overpredicted
Missouri River NWE3	19.37	36.69	53%	Overpredicted
Missouri River NWE4	17.99	23.76	76%	Overpredicted

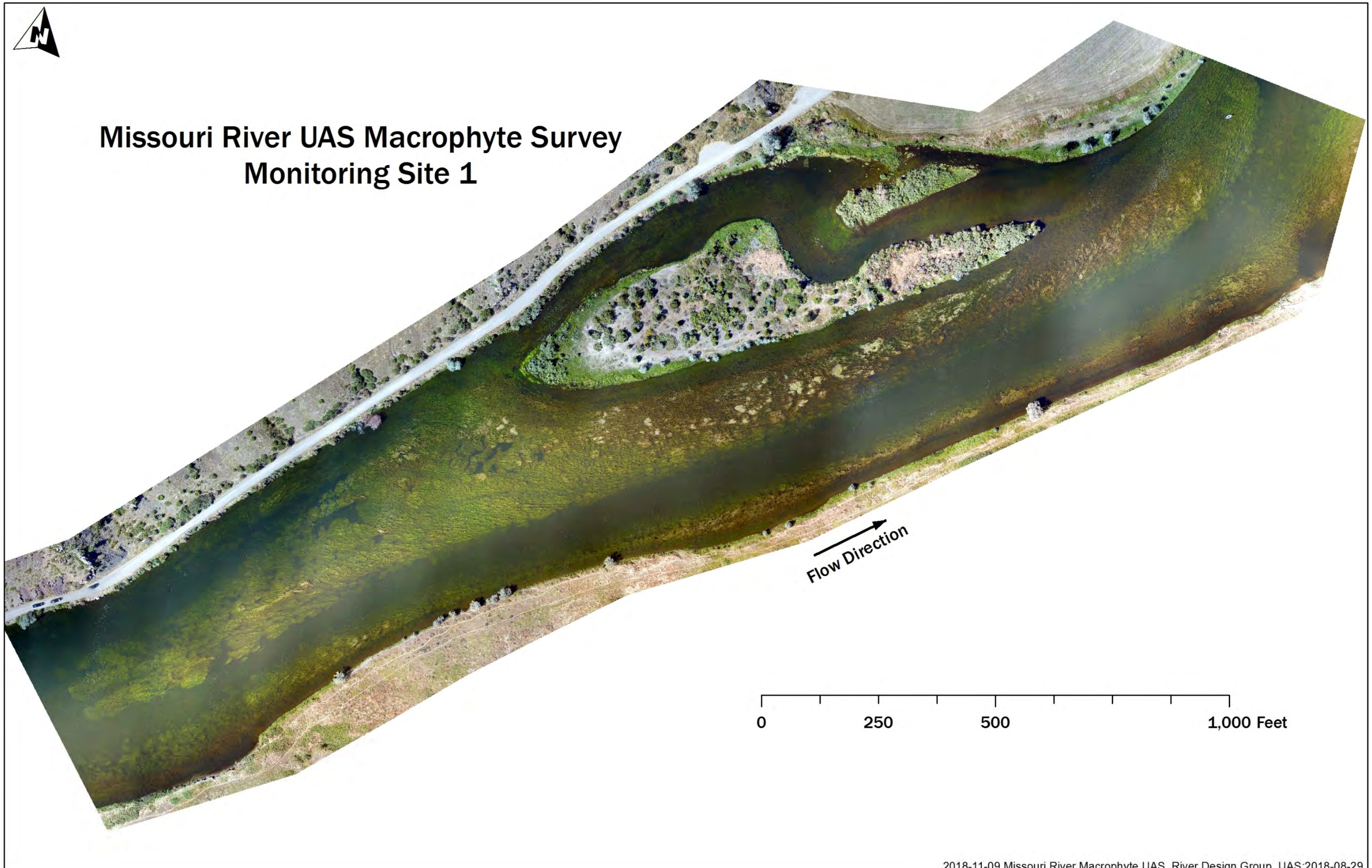

Figure 2. Orthophoto of macrophyte monitoring Site 1 collected 08/29/2018.

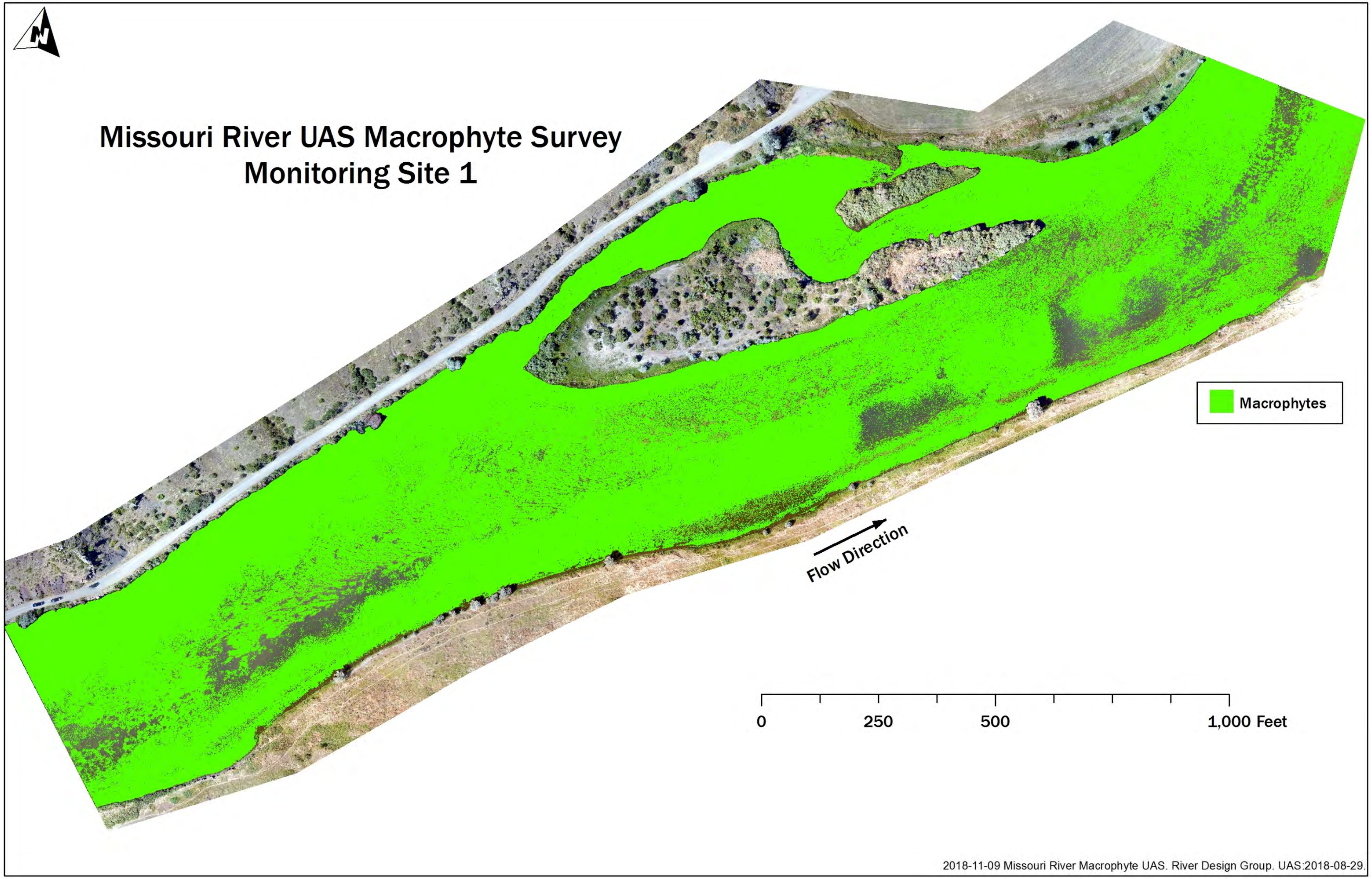

Figure 3. Results of supervised classification identifying macrophyte extent with one-foot resolution at Site 1 (86%).

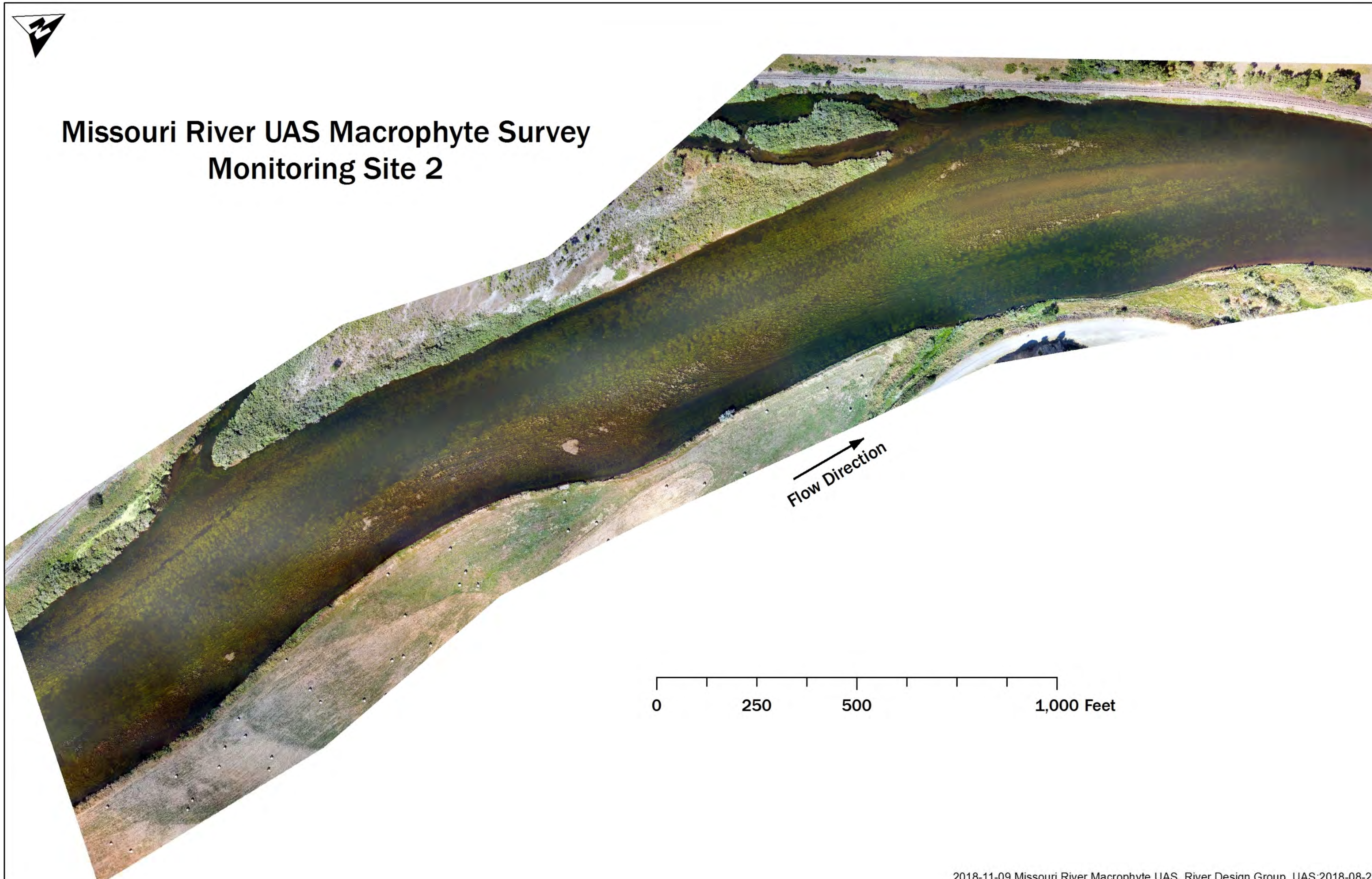

Figure 4. Orthophoto of macrophyte monitoring Site 2 collected 08/29/2018.

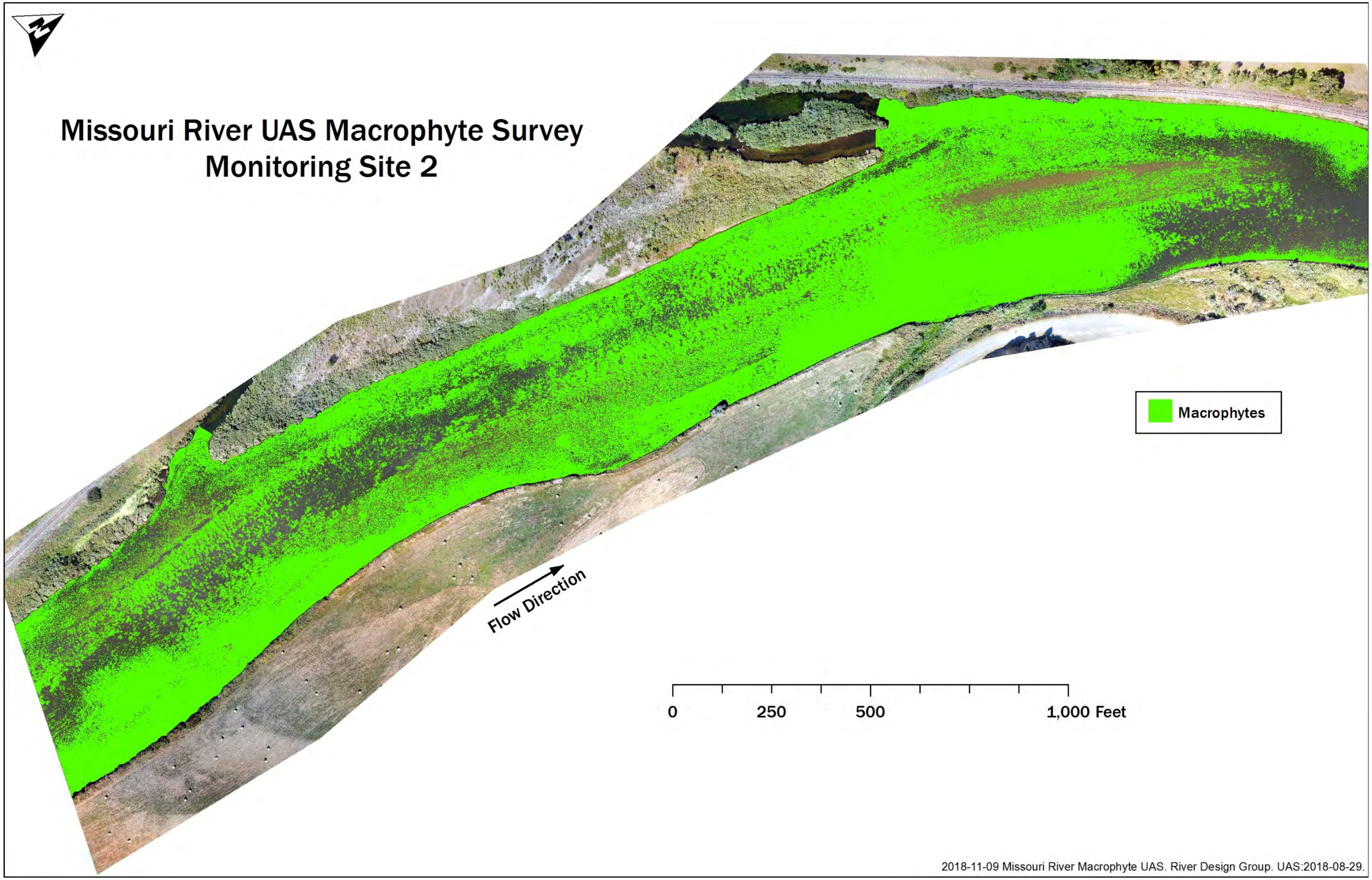

Figure 5. Results of supervised classification identifying macrophyte extent with one-foot resolution at Site 2 (68%).

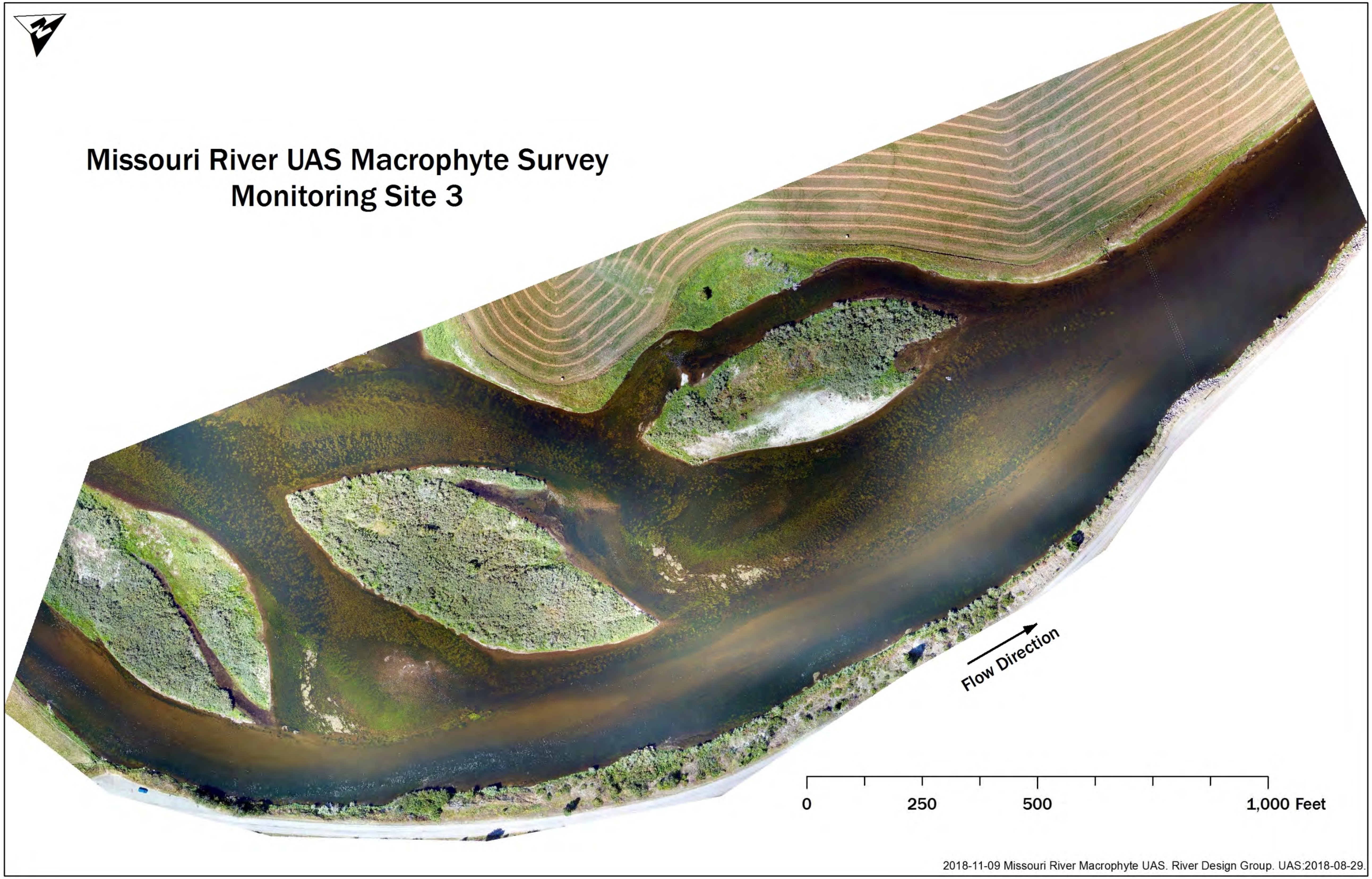

Figure 6. Orthophoto of macrophyte monitoring Site 3 collected 08/29/2018.

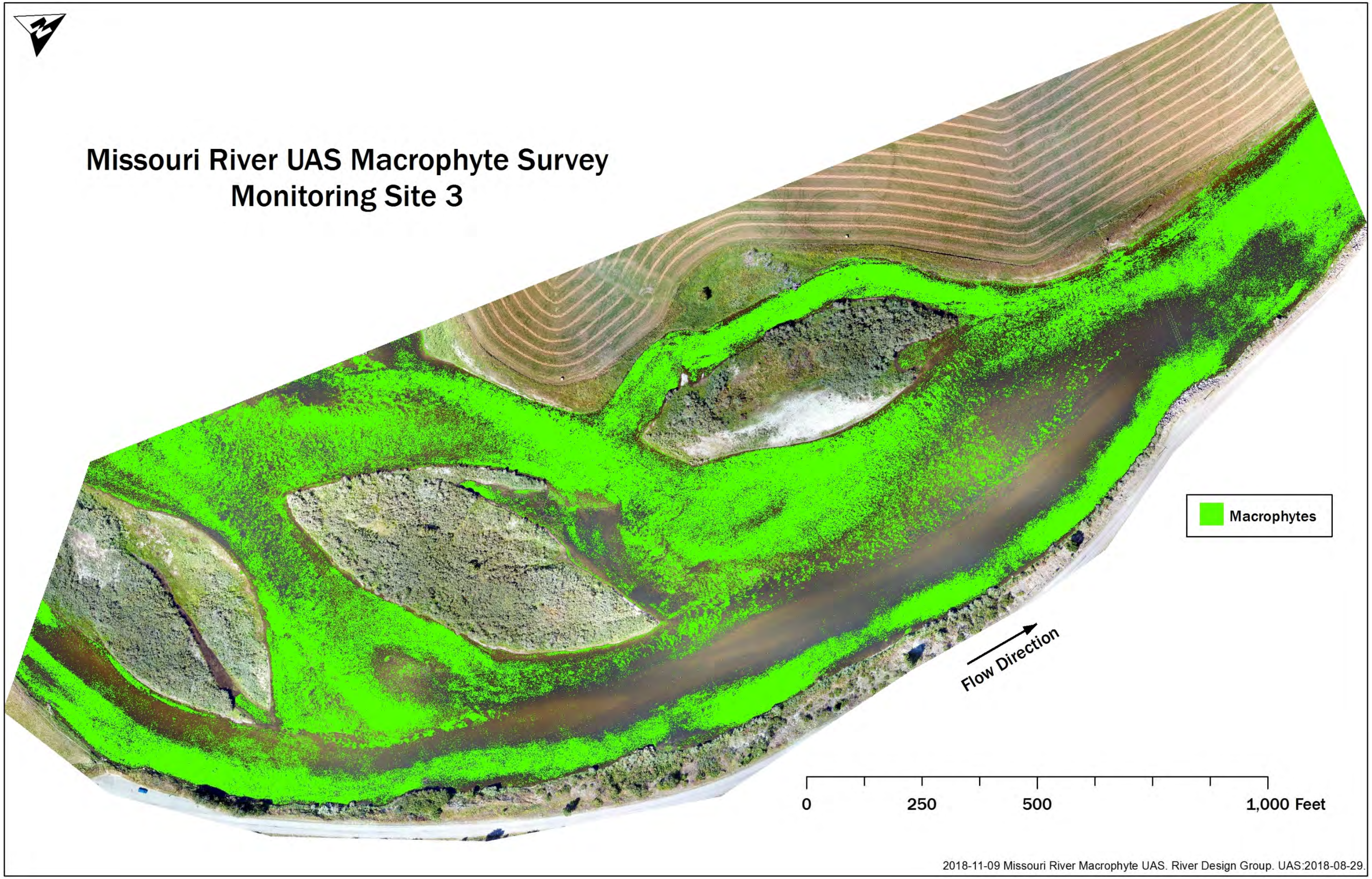

Figure 7. Results of supervised classification identifying macrophyte extent with one-foot resolution at Site 3 (53%).

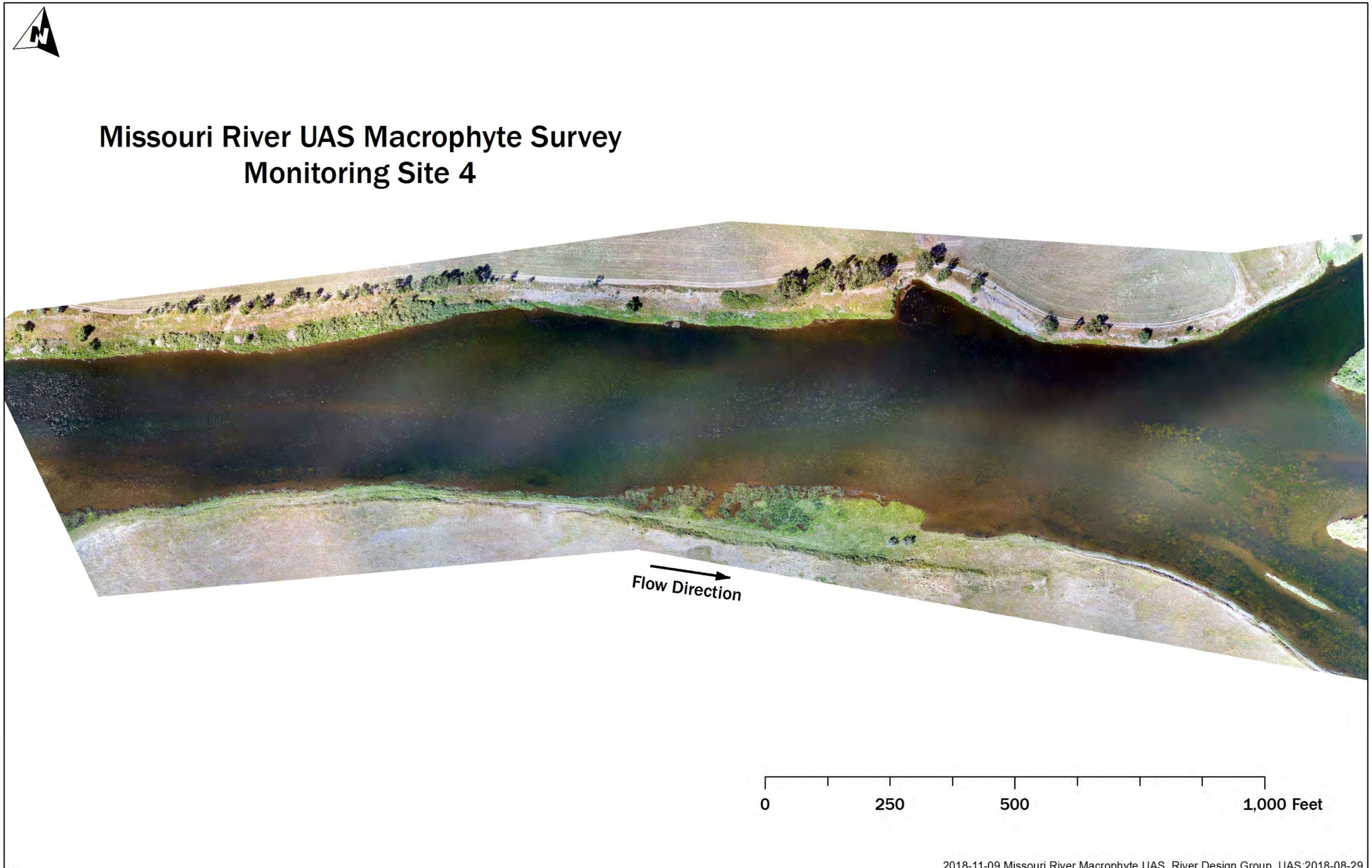

Figure 8. Orthophoto of macrophyte monitoring Site 4 collected 08/29/2018.

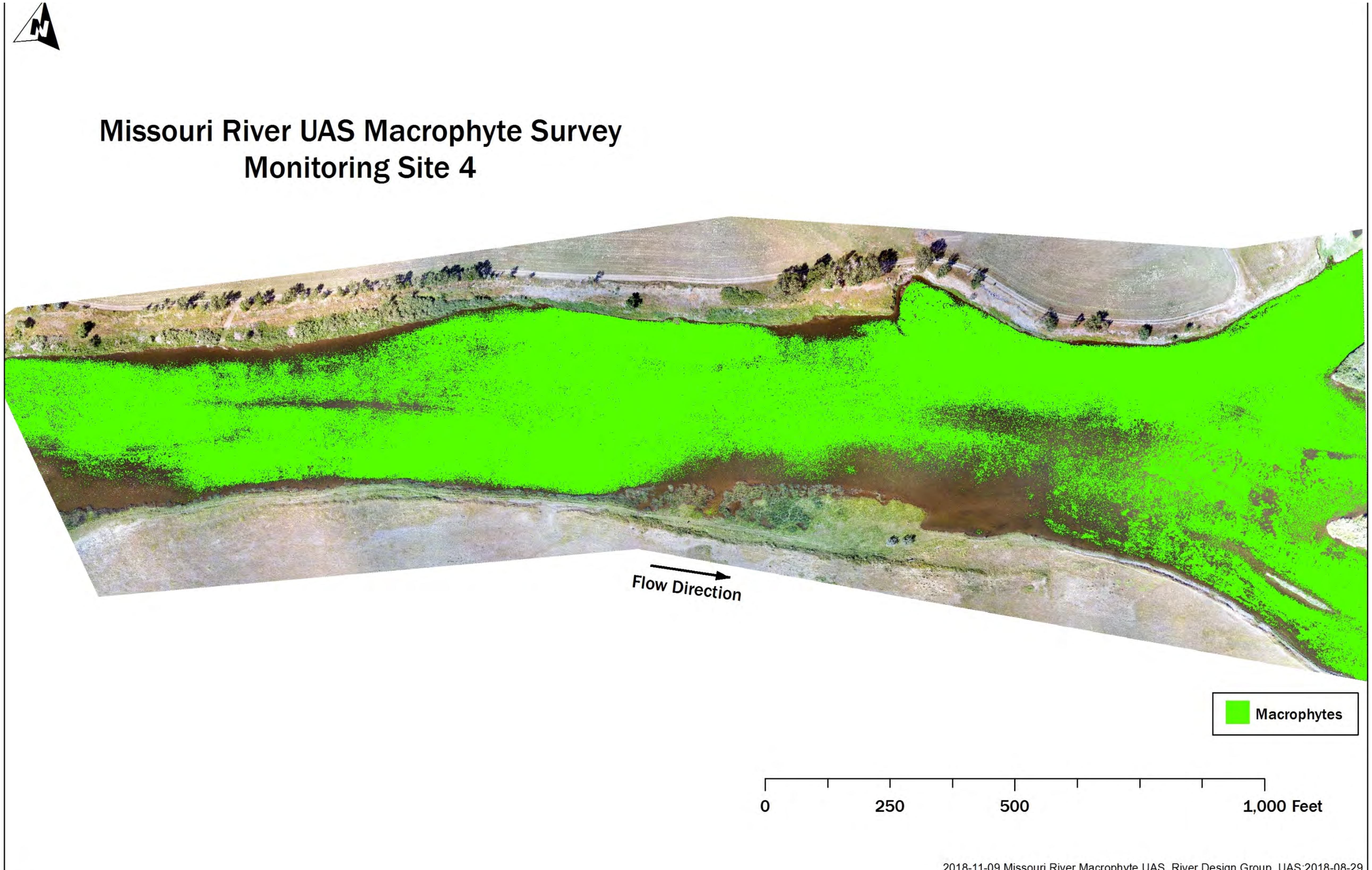

Figure 9. Results of supervised classification identifying macrophyte extent with one-foot resolution at Site 4 (76%).

4 Conclusion

The results from this study show that it is possible to map macrophytes in the Missouri River below Holter Dam and that macrophytes cover over 50% of the bed at all sites. Macrophyte abundance was greatest immediately below the dam (NWE1) and decreased downstream to NWE4, where macrophytes did not extend high into the water column, in general. Model overprediction in deeper sections of the monitoring sites is limited but does lead to overprediction. This is an issue that can be mitigated by planning flights during August when water is low, sun is high, and macrophytes large. Future monitoring should also consider additional band analysis to increase accuracy of the supervised classification. This would include structural image variation (texture and shape) bands and band ratios (red/green). These additional data could increase the predictive power of the model. A near infrared sensor would also prove useful for the project and may be an option worth pursuing as the technology become less cost prohibitive. Overall, this project met the project objectives of developing and demonstrating a monitoring program for macrophytes on the Missouri River.

5 References

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Visser, F., Buis, K., Verschoren, V. et al. Hydrobiologia (2018) 812: 157. https://doi.org/10.1007/s10750-016-2928-y