Van Norman Research Lab (V_N Project)

Prepared for:
Colorado Watershed Restoration Program
Attn: Chris Sturm

Date:

Applicant: River Science
Grant Amount: $99,900.00
Prepared by: River Science

Contents

Introduction

In 2018, the Van Norman's (project property owners) invited River Science to help them restore 2 miles of Oak Creek, which had become severely degraded, and to provide an outdoor education lab for local students. The proposal fits perfectly with River Science's mission to use education, technology, and information to improve river management and health.

River Science recognized this project as an opportunity to explore the use of Process-Based Restoration (PBR) and to tie in an educational component with our River Science course taught at Canon City High School (CCHS). Although we were excited about the opportunity, we knew the project would require planning (specifically around water rights) before implementation, which led to the development of the Van Norman Phase 1 proposal (V_N Project).

The primary purpose of Phase 1 is to understand PBR's benefits and potential impacts, provide education, and demonstrate how to approach PBR in the Arkansas River Basin. Funding from this grant application matched with local contributions provided the required planning and collaboration to move into the implementation phase, which will require multiple stages.

Background

We have had PBR on our radar for some time and have been eager to utilize these techniques in a restoration project. We also know the potential impacts on water rights and understand the ongoing debate concerning restoration projects and water rights protection. We set out with a mission to develop a PBR project that would demonstrate the steps necessary to move PBR forward while assuring that vested water rights are protected. We realize this is an ambitious goal, but a goal we feel is essential to pave a path forward for restoration in the Arkansas Basin while also protecting our organization, landowners, senior water rights holders, and the water community at large.

The primary objectives of this phase of the project were to:

1. Develop a path forward for PBR in the Arkansas River Basin.
2. Establish baseline data and data collection systems.
3. Create an implementation plan that all stakeholders support.
4. Create educational opportunities for students & professionals.
5. Document the process to be utilized for other restoration projects in the future.

The objectives of the planning phase of the project are designed to set the foundation for long-term restoration goals. These goals include restoring a portion of Oak Creek & developing a pilot project demonstrating the benefits, processes, and tools that restoration organizations (including our own) can utilize to accomplish PBR in the Arkansas River Basin.

Methods

Water Rights

To approach and accomplish this task, we took a step-by-step procedure. Our first step was to research water rights on Oak Creek. We then engaged the senior water rights holder (The Town of Rockvale), who is directly downstream of the project. We spent considerable time working with the Rockvale Board of Directors to explain our project and receive their approval. Next, we asked the Upper Arkansas Water Conservancy District (UAWCD) to partner with us on the project. We held several project tours with the UAWCD and worked with their General Manager, Water Resource Engineer, and Hydrologist to understand their concerns and help us develop a path forward. In conjunction with the UAWCD, we partnered with Anabranch Solutions' Joe Wheaton, a leading expert in PBR, to join our tours and our team

(Figure 1). Lastly, we presented our project to the State Engineers Office and Division of Water Resources Division 2 for feedback and advice.

Figure 1: Two men wearing ridiculous hats (Jord Gertson (left) of UAWCD and Joe Wheaton (Right)), freestyle rap about river processes and water rights at the Van Norman Project, June 29, 2021.

Through this stakeholder engagement, we found that we could move forward with implementing the Post-Assisted Log Structure (PALS), which would provide several benefits to the incised stream and not cause injury. We also learned that the primary concern for injury was through the development of Beaver Dam Analogs (BDAs). We need to continue to work with our partners in a later phase to develop a plan of action if we decide to use BDAs and to research other restoration tools and techniques. We feel that this process was valuable and provided us with the information we needed to move into implementation without the fear of potential water rights impacts.

Data Collection Systems

As part of our long-term objectives, we wanted to collect existing data and to establish baseline data for the project's long-term monitoring. This task aims to gather the information needed to understand PBR treatments' opportunities and potential concerns. We feel great speculation exists on this topic and need data to have meaningful and accurate conversations about PBR. The goal is to gather this information and use it as a tool in developing and implementing future projects.

Full details of the data collected and used can be found in the Appendices. Specifically, we collected:

- existing aerial imagery to assess the creek's morphologic signatures over time (Appendix A)
- land survey elevation model and hydraulic simulations to create an initial treatment proposal (Appendix A).

- Pre-treatment vegetation assessment (Appendix B).
- Water Quality Assessments (Appendix C).
- Evaluation of the August 2021 flood event for hydraulic understanding against future treatments (Appendix D).
- Reference Reach Comparison (Appendix E)
- Surface water data collection and analysis from drone imagery to understand gaining and loosing reaches as well as intermittency patterns (Appendix F).
- Groundwater well monitoring locations, installation, and data collection (Figure 2, and Appendix G).

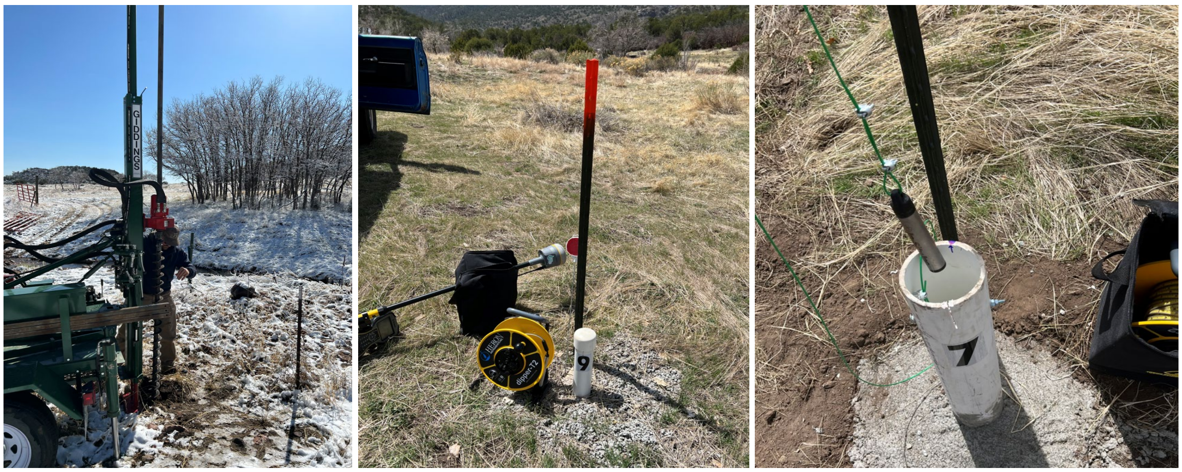


Figure 2. Shallow wells for Van Norman Project groundwater monitoring: A) well drilling with Giddings Rig, B) installed well location being surveyed and depth recorded, C) one of four wells equipped with depth data logger.

Research Lab for Students & Professionals

An essential aspect of the project is providing local students with educational opportunities. Through a partnership with Canon City High School (CCHS), River Science delivers the curriculum and outdoor engagement for two upper-level high school courses (Water Quality & Ecology; Hydrology & Watersheds). We utilize the V_N Project to provide students with hands-on experiences in the field (Figure 3). Students involved in the River Science courses assist in collecting data for the project and use the project as an example for discussions on water quality and quantity. Additionally, our River Science CCHS Teacher (Jessie Graski) completed her master's degree thesis in environmental education utilizing V_N Project and the River Science courses.

In addition to youth education, we want to utilize the V_N Project as an example to lead conversations on restoration & water rights. During our planning process, we held numerous project tours with diverse stakeholders. The V_N Project provided the context and allowed stakeholders to discuss concerns and create solutions on the ground. We feel this process created a platform for proactive debate and the creation of partnerships and creative solutions. We have also had the opportunity to present our ideas and findings in front of the water community through presentations at the Arkansas River Basin Water Forum & the Water Resources & Agricultural Review Committee (@ CO Water Congress).

Figure 3: Luke Javernick of River Science teaching CCHS students how to use survey equipment during the land survey and elevation model data collection.

Results

The results of this project are represented in the completion of our phase 2 implementation plan (Appendix H), developed partnerships, and continued engagement. Our initial implementation phase will utilize Post-Assisted Log Structures (PALS) to trap sediment and raise the creek channel. We have secured funding through Colorado Parks and Wildlife's Wetlands Fund to implement this phase as well as an approved US Army Corps Engineers 404 permit (Appendix I). We plan to have additional implementation phases in the future that may include BDAs or other treatments to meet our long-term restoration goals.

Conclusions and Discussion

We believe that we have met the objectives outlined in our grant application. We have created partnerships (on both sides of the aisle) that are invested in continuing the conversation of water rights and restoration. We have developed a comprehensive data collection system that can be used for long-term monitoring and as a tool for future restoration projects. Lastly, we have developed a path forward for PBR in the Arkansas River Basin utilizing PALS. We will continue to work with our diverse partners to explore additional restoration opportunities including, but not limited to, BDAs.

We are proud that we set out to work with leading experts from both the restoration community and the water rights protection community. We knew bringing these diverse perspectives together would be complex and contentious at times. Still, we knew these conversations were necessary if we wanted to move PBR forward in our basin. We feel we have made headway by developing an initial implementation phase supported by water rights protection agencies that also meets our restoration goals. We also think that we have now established the trust and communication needed to continue this conversation and create new opportunities for restoration in the future.

We feel that this is only the beginning of this project. We have all the right people at the table and will continue to work with our partners to explore future opportunities. Specifically, we are working with our partners to secure funding to establish the V_N Project and other restoration projects (Big Cottonwood) as pilot projects where we can continue to develop partnerships, collect data, and create innovative solutions.

We thank the CWCB and our local matching partners for supporting this essential planning phase which resulted in the development of diverse partnerships, new funding streams, and innovative and supported ideas.

Actual Expense Budget

Task	Description	Total Budget/Grant Funds	Previously Invoiced	Current Invoice	Remaining Total	Percent Complete
1	Study Design & Associated Research	$52,200.00	$52,188.61		$11.39	100%
2	Baseline Data Collection Systems/ Learning Lab	$44,100.00	$21,518.61	$22,565.78	$15.61	100%
3	Grant Administration	$3,600.00	$2,375.00	$1,225.00	$0.00	100%
	TOTALS	**$99,900.00**	**$76,082.22**	**$23,790.78**	**$27.00**	
Submitted by:	Allison Palmasano			**Total Invoiced**	**$99,873.00**	

Appendices

This Section focuses on any additional information that would benefit the understanding of the project progress and future planning. These include photos (before and after), site maps, design drawings, metadata, measurement data used in calculations, survey data, model data, etc. used or generated throughout Phase 1 and will continue during Phase 2's implementation.

Appendix A: Historical Aerial Imagery and Channel Morphologic Signatures vs. Current Imagery and Signatures.

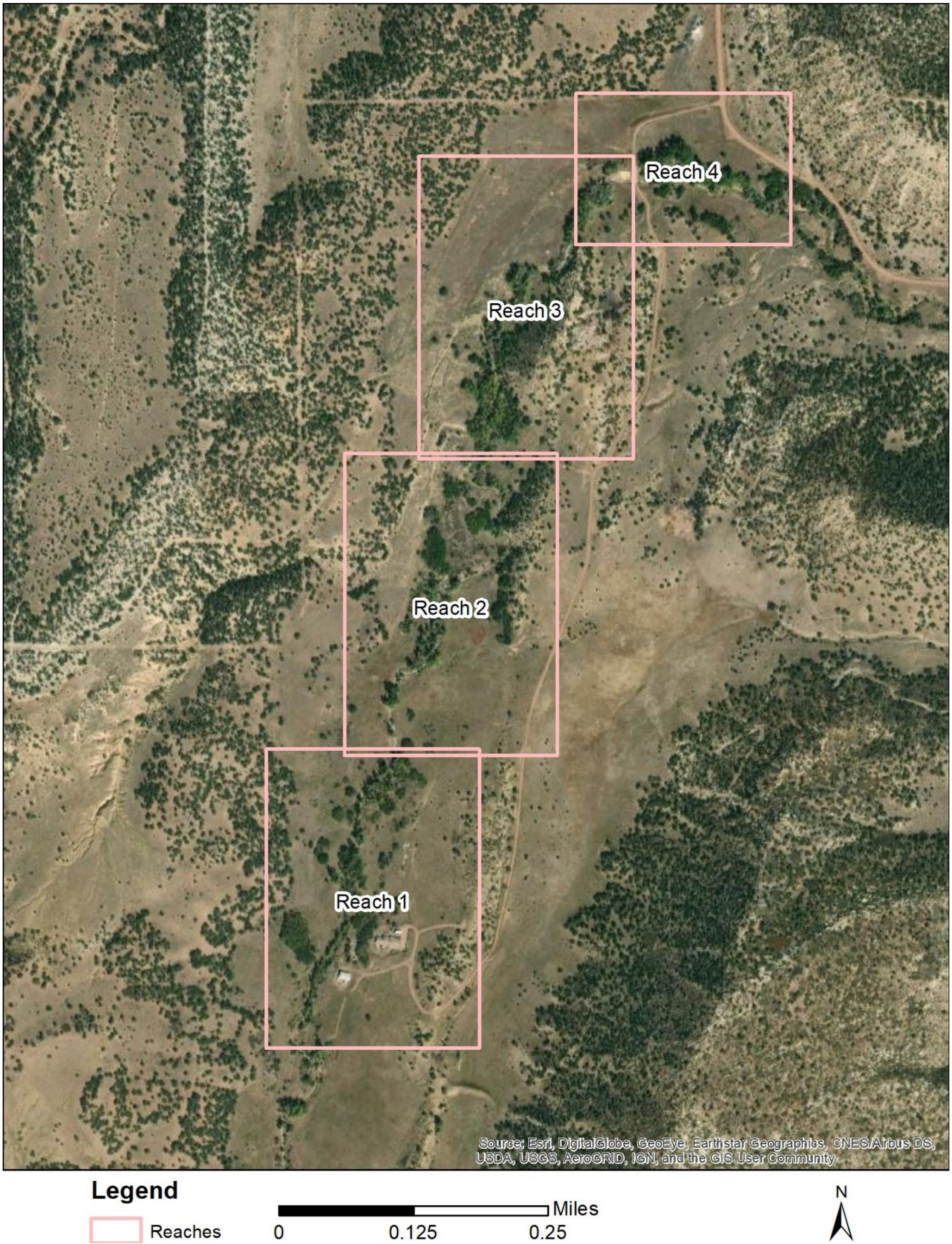
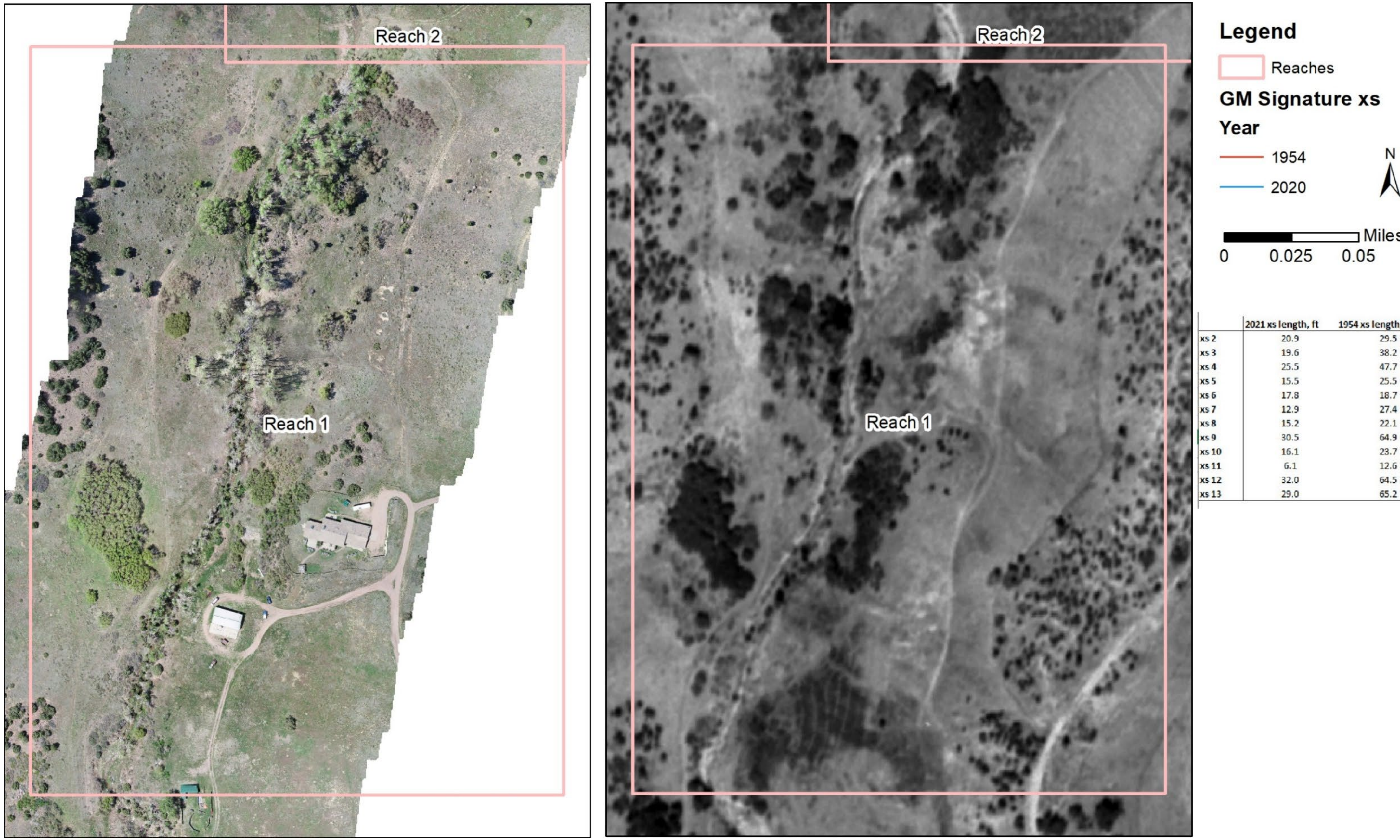
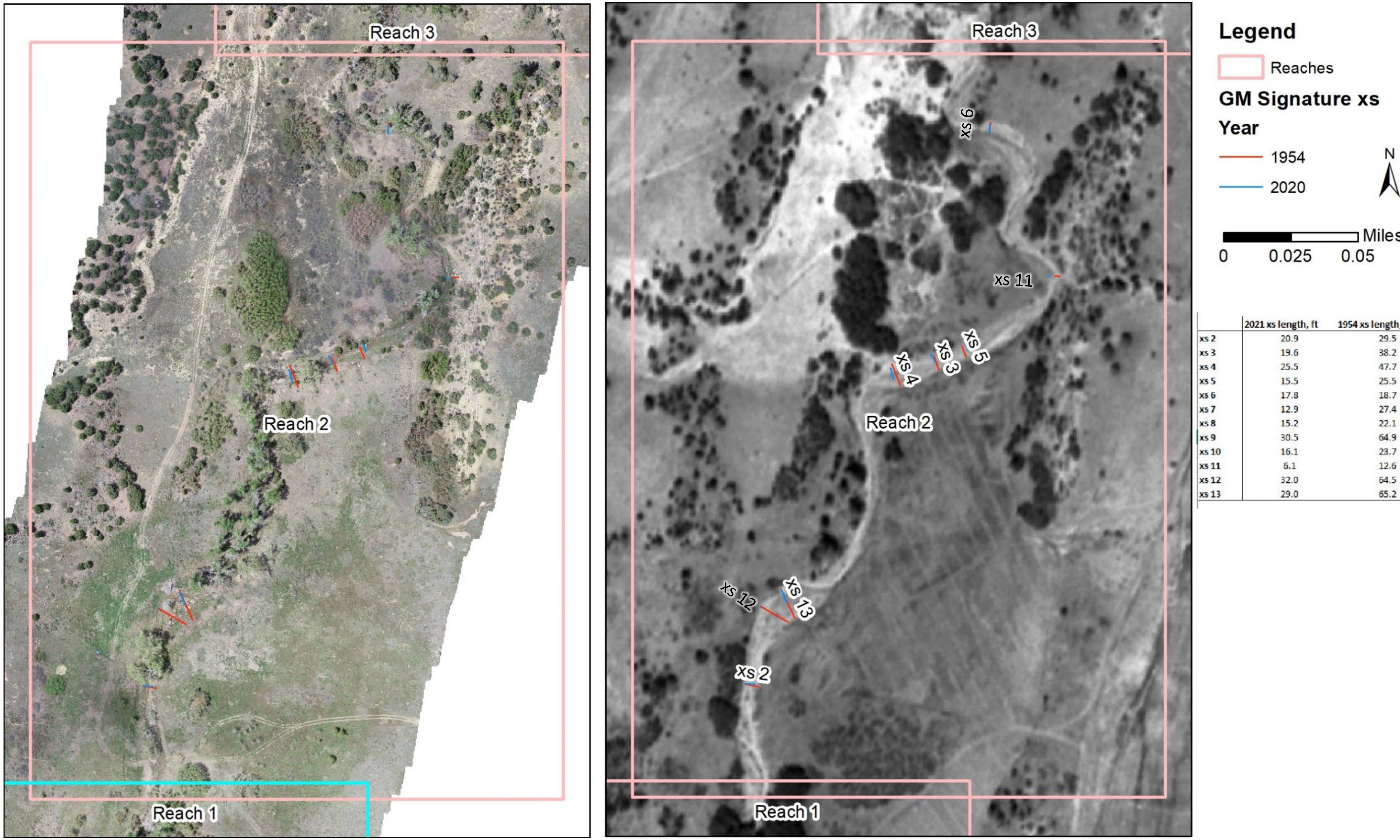


Figure A1: The portion of the Van Norman property where treatments are proposed (i.e. project site) divided into 4 reaches for mapping convenience.



	2021 xs length, ft	1954 xs length, ft
xs 2	20.9	29.5
xs 3	19.6	38.2
xs 4	25.5	47.7
xs 5	15.5	25.5
xs 6	17.8	18.7
xs 7	12.9	27.4
xs 8	15.2	22.1
xs 9	30.5	64.9
xs 10	16.1	23.7
xs 11	6.1	12.6
xs 12	32.0	64.5
xs 13	29.0	65.2

Figure A2: Aerial Imagery for Reach 1 with (Left) drone imagery collected in 2021, and (Right) archived aerial imagery from 1954.



	2021 xs length, ft	1954 xs length, ft
xs 2	20.9	29.5
xs 3	19.6	38.2
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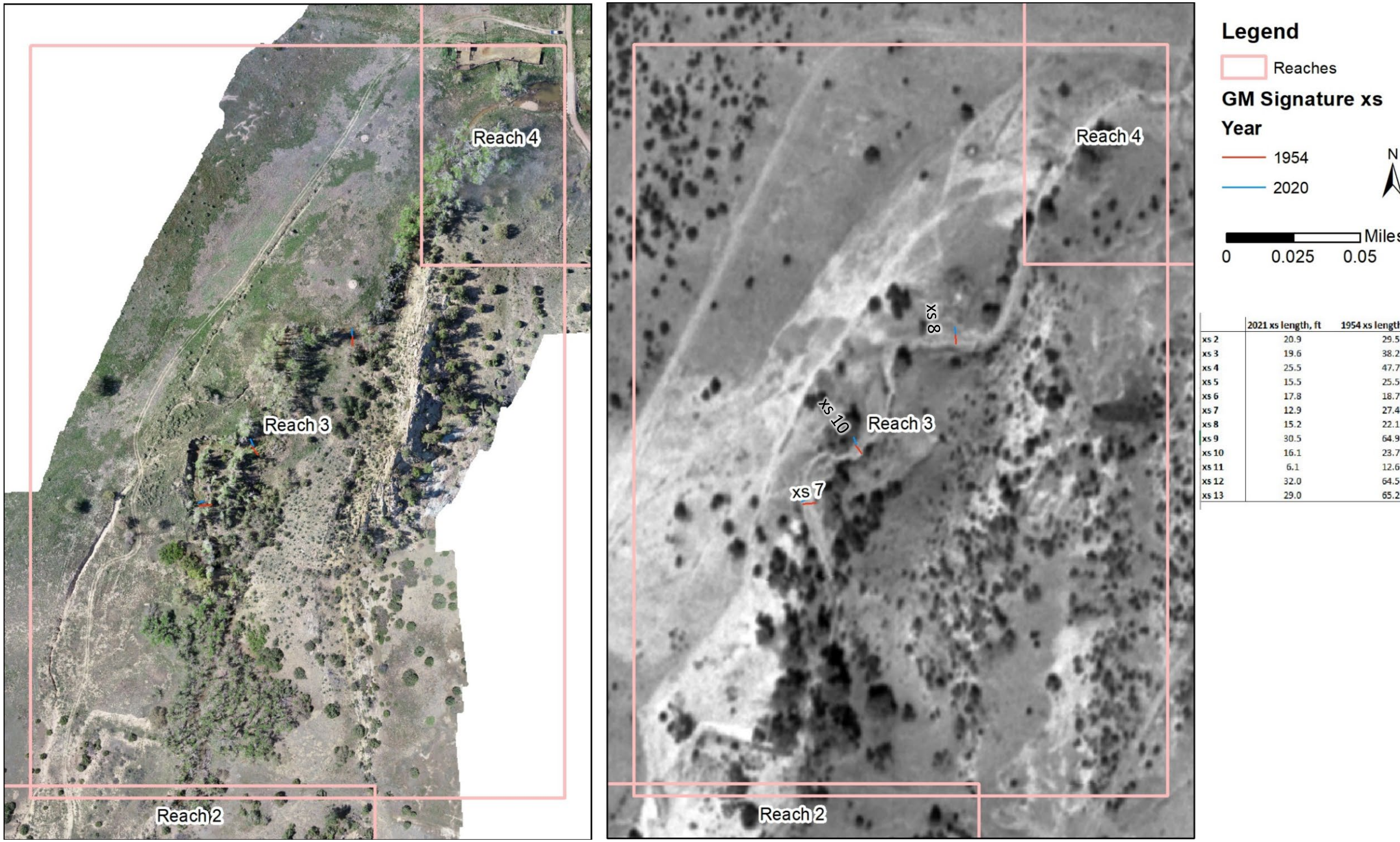
xs 7	12.9	27.4
xs 8	15.2	22.1
xs 9	30.5	64.9
xs 10	16.1	23.7
xs 11	6.1	12.6
xs 12	32.0	64.5
xs 13	29.0	65.2

Figure A3: Aerial Imagery for Reach 2 with cross sections 2-6 and 11-13 drawn to compare channel width of: (Left) drone imagery collected in 2021, and (Right) archived aerial imagery from 1954.



	2021 xs length, ft	1954 xs length, ft
xs 2	20.9	29.5
xs 3	19.6	38.2
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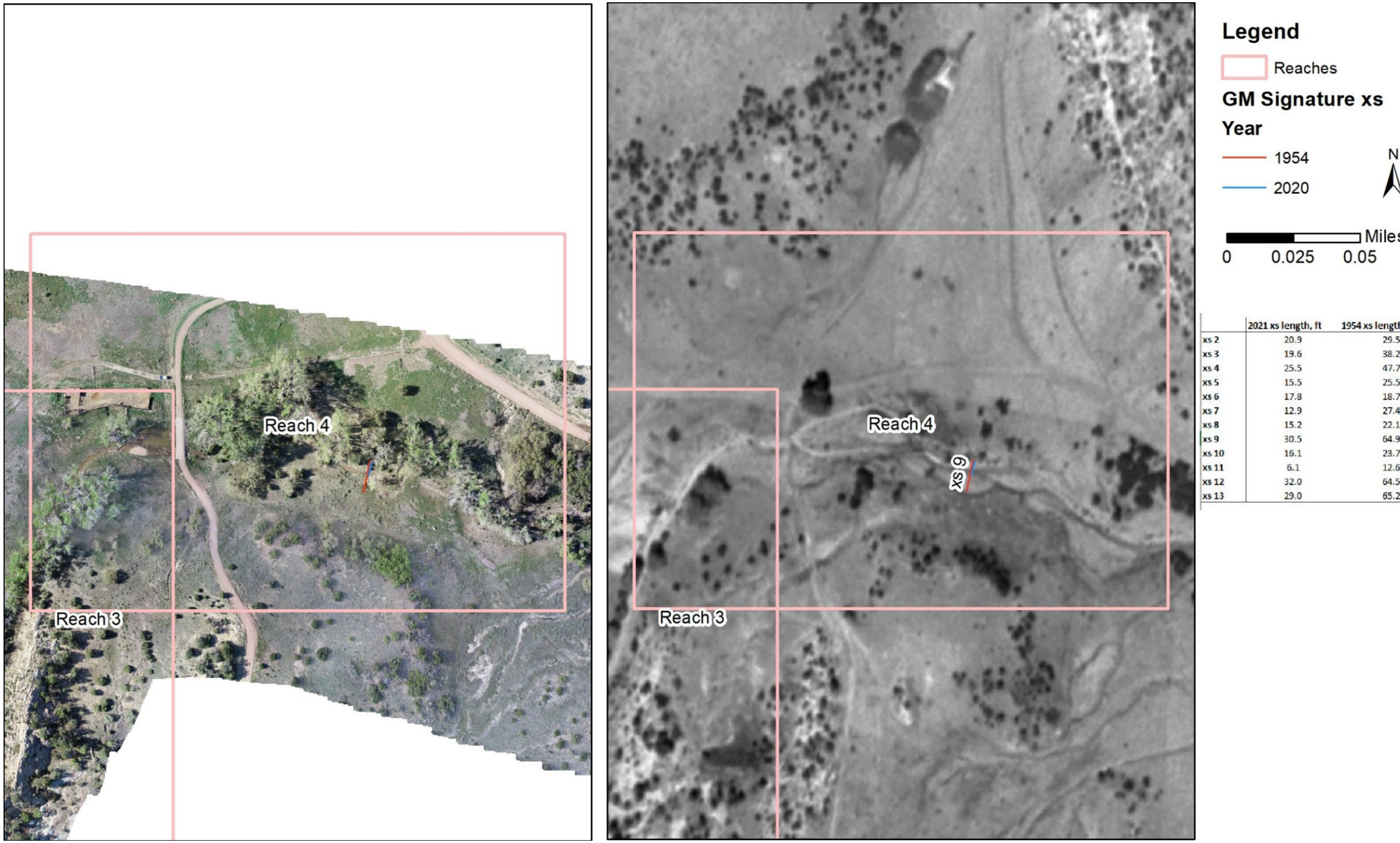
xs 9	30.5	64.9
xs 10	16.1	23.7
xs 11	6.1	12.6
xs 12	32.0	64.5
xs 13	29.0	65.2

Figure A4: Aerial Imagery for Reach 3 with cross sections 7, 8, and 10 drawn to compare channel width of: (Left) drone imagery collected in 2021, and (Right) archived aerial imagery from 1954.



	2021 xs length, ft	1954 xs length, ft
xs 2	20.9	29.5
xs 3	19.6	38.2
xs 4	25.5	47.7
xs 5	15.5	25.5
xs 6	17.8	18.7
xs 7	12.9	27.4
xs 8	15.2	22.1
xs 9	30.5	64.9
xs 10	16.1	23.7
xs 11	6.1	12.6
xs 12	32.0	64.5
xs 13	29.0	65.2

Figure A5: Aerial Imagery for Reach 4 with cross section 9 drawn to compare channel width of: (Left) drone imagery collected in 2021, and (Right) archived aerial imagery from 1954.

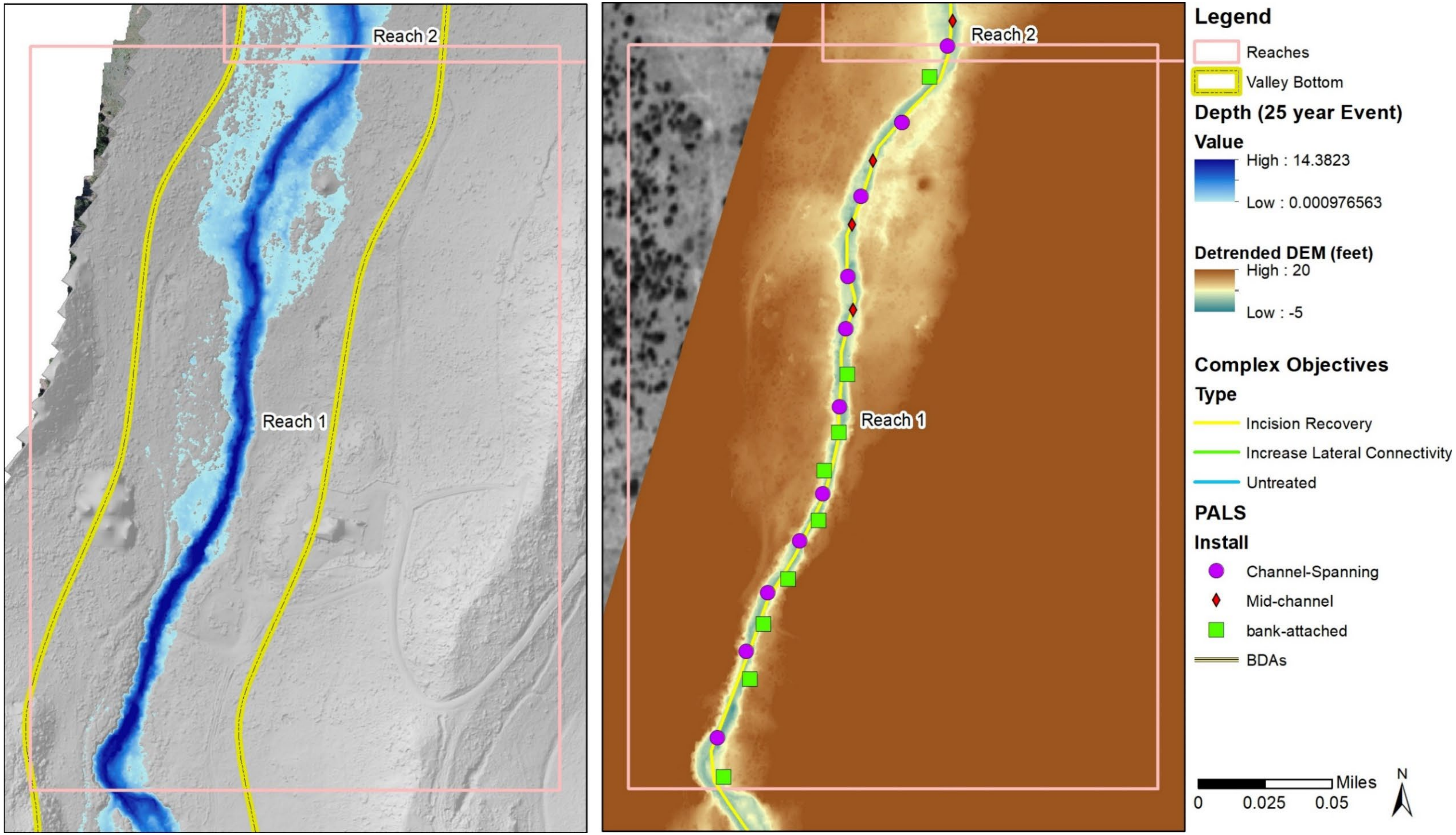


Figure A6: Elevation datasets of Reach 1 used to discuss with stakeholders the (Left) current (2020) elevation models and inundation for a 25-year flood event extents (i.e. the channels potential inundation), and (Right) detrended elevation model with initial PBR treatments to show potential treatment benefits.

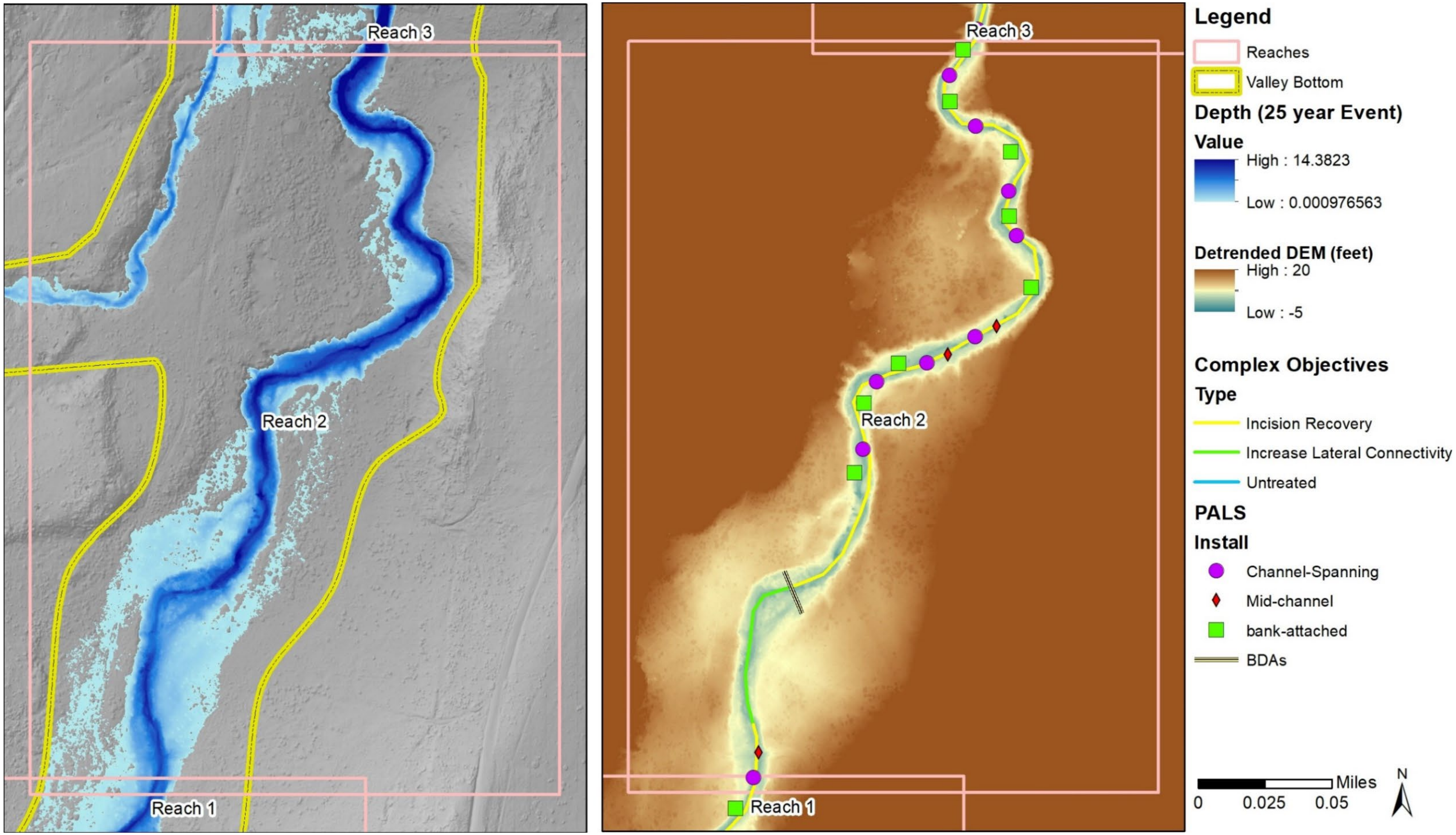


Figure A7: Elevation datasets of Reach 2 used to discuss with stakeholders the (Left) current (2020) elevation models and inundation for a 25-year flood event extents (i.e. the channels potential inundation), and (Right) detrended elevation model with initial PBR treatments to show potential treatment benefits.

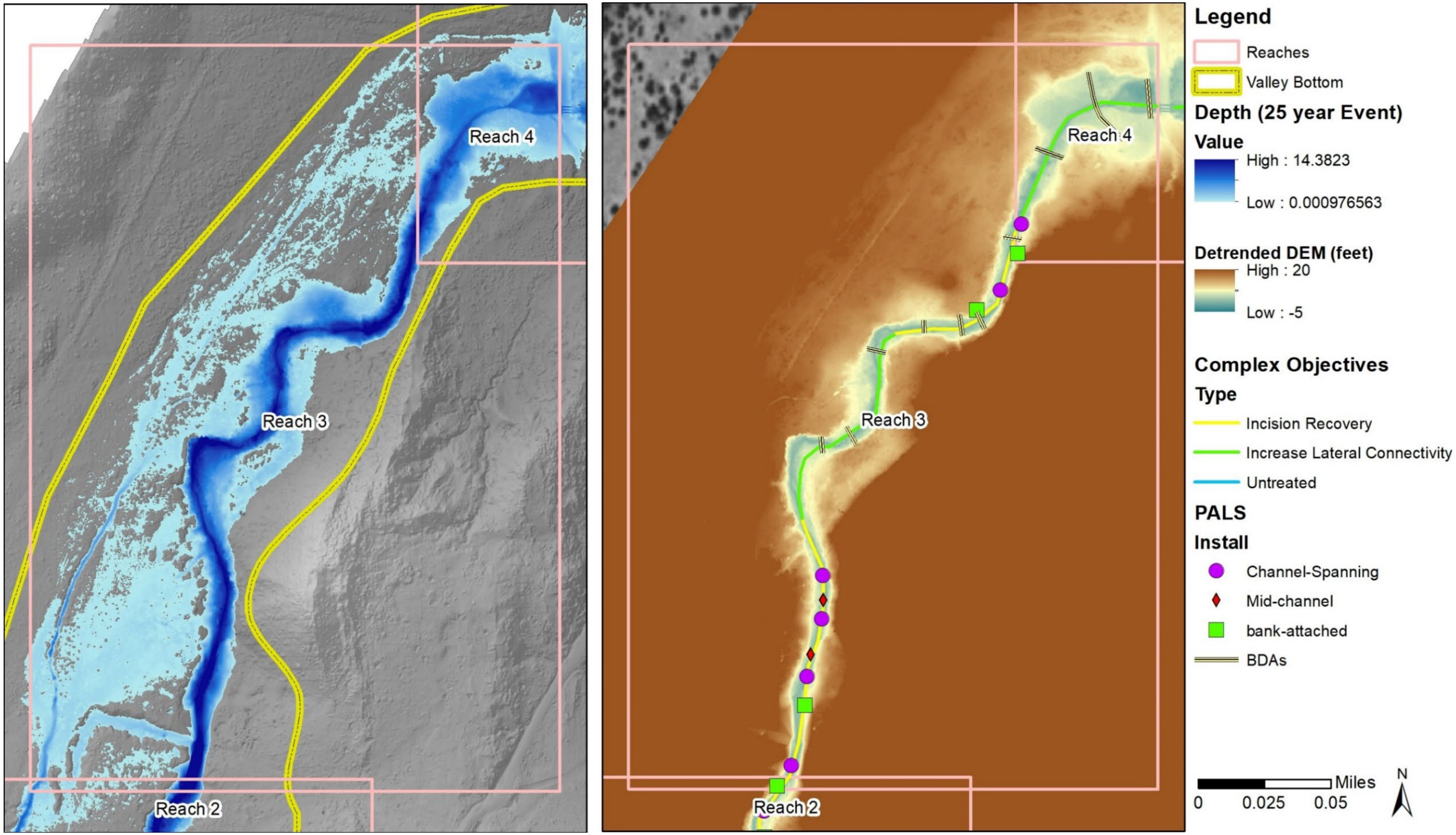


Figure A8: Elevation datasets of Reach 3 used to discuss with stakeholders the (Left) current (2020) elevation models and inundation for a 25-year flood event extents (i.e. the channels potential inundation), and (Right) detrended elevation model with initial PBR treatments to show potential treatment benefits.

Appendix B: Vegetation Assessment

Evaluation of Oak Creek Riparian Zone Vegetation June 17, 18 2021 Carrie Trimble

Raw data available upon request.

Using the Line-point Intercept method, four transect lines stretching in the riparian zone from the east to the west side of flood prone zone of Oak Creek traveling through the Van Norman Ranch in southeast Fremont County, Colorado.

Field Scientists:

- Carrie Trimble Biologist/Ecologist, Education Specialist River Science June 17 and 18, 2021, Plots 1-4
- Rick Romano Soil Conservationist Consultant, retired NRCS June 17, 2021, Plots 1-3
- Jessie Graski Environmental Science / Horticulture Instructor-CCHS, River Science Pilot Instructor/Intern June 18, 2021, Plot 4

Transect 1

Location: Just upstream of Van Norman Home at Colorado River Watch Site #348 (reference Figure B1).

Transect one runs east to west for 34 feet from flood bank potential to flood bank potential. The plot line was intercepted with a pin flag every foot of the transect. Plants anywhere along that intercept above or under the intercept were recorded.

Approximately 71% of the transect line consisted of tree canopy, 30% of this cover consisted of dead limbs. Hackberry (Celtis accidentalis) covered 30% of the transect canopy, and the remaining canopy consisted of Narrow Leaf Cottonwood (Populus augustifolia). The portion of the transect under open sky was about 29% of line.

Woody and herbaceous liter covered approximately 41% of the line. A cobbled stream was approximately 7 feet wide, and a small amount of sand was found at only 1 intercept point along the line. There was no point along the transect line that was void of plant biomass except the stream itself. However, only 4 of the 7 stream point interceptions were exposed to open sky.

Majority of the herbaceous plants, found along 73.5% of the transect were graminoids, consisting of mostly Sleepy (Achnatherum robustum) and Wheat Grass (Triticum aestivum). Horsetail, clematis, wild lettuce, and bindweed were along the flowering plant species found sparingly along the plot of herbaceous plants.

Figure B1: Location of vegetation transect 1, located in an old beaver habitat (i.e. reference reach).

Transect 2

Location: Above Van Norman home at the junction of irrigation ditch. (reference Figure B2)

Transect two runs east to west for 44 feet from flood bank potential to flood bank potential. The plot line was intercepted with a pin flag every foot of the transect. Plants anywhere along that intercept above or under the intercept were recorded.

Only 29.5% of the transect plot line is covered in canopy, none of which is over the stream itself. Of the species making up the canopy, dead Narrow-leaf Cottonwood (Populus angustifolia) was just under half the total canopy population. Two interceptions were under a Rocky Mountain Juniper and 38% of the canopy was from the Peach Leaf Willow (Salix amygdoides). The actual spring was approximately 8 foot wide at the plot site and small number of filamentous algae was growing in the cobble substrate. A third of the terrestrial portion of the line was bare soil and rock.

Almost half (47%) of the graminoids identified was Smooth Brome Grass (Bromus inermis). The rest of the identified forbs were a mix of Orchard Grass (Dactylis glomerata), wild geranium species, false clover, Blue Prickly Lettuce, Bindweed, Horsetail, Knotgrass, Alfalfa, Timothy Grass (Phleum pratense), Curly Gumweed, Bluegrass, and mint.

Figure B2: Location of vegetation transect 2, located 120 feet upstream of the River Watch water quality site as well as the Site 2 flow rate cross section.

Transect 3

Location: Downstream approximately a quarter mile from Van Norman home (reference Figure B3)

Transect three runs east to west for 39 feet from flood bank potential to flood bank potential. The plot line was intercepted with a pin flag every foot of the transect. Plants anywhere along that intercept above or under the intercept were recorded.

Canopy consists of 38% Willow (Salix amygdaloides), 38.5% Choke Cherry shrubs (Prunus virginiana), and dead Narrow-leaf Cottonwood for the remaining portion of canopy. Canopy covers a third of the line transect.

Stream width was approximately 7 feet with 4 of those feet containing water and three feet of dry cobble and sand. The willows covered the entire stream bed with shade. Over half of the line is covered with bare soil and stone. Sparce amounts of forbs take are found on 64% of the terrestrial portion of the transect. Forbs consists of Fringed Sage, Clematis, Sand Drops, Pascque Flower, Thistle, Gooseberry, and Tansey Mustard.

Grasses were sparsely found along 61% terrestrial line segment, mostly consisting of Sleepy Grass (Achnatherum robustum) and Cheat Grass (Bromus tectorum).

Figure B3: Location of vegetation transect 3, located near the old Van Norman camping site (1800 feet upstream of the low water crossing).

Transect 4

Location: Approximately 400 yards upstream from cement bridge on Van Norman Ranch Road, just around the corner where tree line ends (reference Figure B4).

Transect four runs east to west for 59 feet from flood bank potential to flood bank potential. The plot line was intercepted with a pin flag every foot of the transect. Plants anywhere along that intercept above or under the intercept were recorded.

The transect line is 100% covered by canopy of both dead and living Narrow-leaf Cottonwoods. Three incepts had Rocky Mountain Juniper over hangs as well. The area is covered with woody liter because of the trees along the line. No bare soil or stone was discovered along the ling, most of it covered with plenty of woody and herbaceous litter.

Stream bed was sand, gravel, and cobble along its 8-foot width. An unknown aquatic plant was found at intercept 34. Sleepy Grass was the most consistent graminoid, making up 37% of all the species found. The west side of the Oak Creek had more Rye Grass than the east side, making up 35% of species found along line transect. Wheat grass and blue grass were also identified along the fourth segment. No other herbaceous plants were found on the line.

Figure B4: Location of vegetation transect 4, located 350 feet upstream of the low water crossing, or 400 feet downstream of site 3's flow rate).

Appendix C: Water Quality Analysis

Analysis of Oak Creek Water Quality at Van Norman's Ranch

Data collection to determine the baseline water quality of Oak Creek near the center of the 1 mile stretch crossing the Van Norman Ranch

Carrie Trimble

07-10-2021

River Science

INTRODUCTION

Using the Colorado River Watch protocol and following their QA/QC standards for sampling, students and teachers from Canon City High School tested the water in Oak Creek at the Van Norman ranch five times over the past 2 years. Because the COVID-19 pandemic hit at the beginning of the assessment period, the number of samplings is less than ideal. Nonetheless, the findings presented are sufficient to inform mitigation planning aimed at restoring the riparian ecosystem.

The health of a riparian ecosystem in this region can be measured not only via water testing but also by the presence or absence of the southern redbelly dace (Phoxinus erythrogaster), an indicator species, which (according to the USDA forest service) is critically imperiled only in our region, Rocky Mountain region 2. Redbelly Dace used to inhabit Oak Creek, but not anymore.

Until about 100 years ago (in other words, before the area was widely settled), Oak Creek was perennial; it flowed year-round. Now the creek has annual periods of dryness. One question this collection of data can help answer is whether these dry periods are responsible for the disappearance of the Dace or whether poor water quality is the cause.

Knowing the baseline water quality and monitoring its parameters will help decision-makers identify and implement best practices and desired treatments in the effort to restore the Oak Creek river ecosystem. The purpose of this report is to evaluate the water quality chemistry ahead of any restoration procedures.

HYPOTHESIS

Although Oak Creek no longer flows perennially, our data shows that when the creek is flowing, the chemistry of the water (i.e., the water quality) is sufficient to support life. A mayfly hatch, midge larva, and water striders were identified in the flowing creek at various times during this study. These benthic invertebrates are food sources for class 2 stream fish, including the redbelly dace, which lived in the creek as recently as 20 years ago, according to the Van Norman family. Notably, no redbelly dace minnows were found during this study.

Although the exact number is unknown, several natural springs feed Oak Creek. Two aquifer-based springs exist at the test site; they released a small amount of water in 2020, and the creek continued to flow through that winter. However, in 2021, the aquifer did not release water through these springs; although the ground was never completely dry, there was insufficient water for flow.

Because the creek, when it is flowing, demonstrably supports life--and because the water-quality measures look good--there is no reason to suspect that water-quality problems up-stream or in the aquifer are the reason that the dace is missing from the ecosystem. I hypothesize that Oak Creek would support the southern redbelly dace minnow if the water were to remain flowing throughout the year.

MATERIALS & PERSONNEL

1. River Watch Kit #14
2. Station 348 at Van Norman's Ranch
3. Trained students and Science Instructors from Canon City High School

PROCEDURE

1. Use Colorado River watch Protocol and follow the QA/QC procedures exactly, throughout the assessment period.
2. Test for dissolved oxygen, phenolphthalein and total alkalinity, hardness, pH, and temperature of Oak Creek approximately midway on the one-mile stretch used in the assessment on the Van Norman property.
3. Measure the velocity and flow rate of the creek, using a flow meter when available.
4. Collect water samples for metals testing, using a filtered and unfiltered sample.
5. In fall and spring, collect water samples for nutrient testing and benthic invertebrate population count.

In the fall of 2019, Dr.Luke Javernick of River Science and Carrie Trimble, a science instructor from Canon City High School (CCHS), combined their resources and efforts to evaluate the water quality of Oak Creek near the center of its flow through the Van Norman Ranch in southeastern Fremont County. Initially, students collected water samples in order to measure water temperature, pH, alkalinity, hardness, and dissolved oxygen using Hach test-kits. However, the team quickly realized that the Colorado River Watch protocol was a better testing tool and protocol, one that would give the conservation project legal and scientific credibility.

The team was trained at the end of February 2020, and one sample was collected in March 2020, just before the COVID-19 pandemic; after that and until the following May, quarantines prevented students from participating. CCHS science teachers, Carrie Trimble and Jessie Graski, collected samples in June of 2020. The 2020-2021 school year did not offer opportunities to collect more samples, due to a winter drought and a second student quarantine in the spring of 2021. Nonetheless, one more sample in May of 2021 was completed with students, and another sample in June of 2021 was collected by teachers.

DATA

2020-21 Data Collected under CO River Watch Protocol and Procedures

Date	3/11/20	5/7/20	6/29/20	4/27/21	5/20/21	6/18/21
Air Temp. C	None taken	None taken	None taken	None taken	29	35
Water temp C	9	19	16	None taken	15	21
pH	8.13	8.6	8.3	None takenNone taken	8.3	8.17

Phenoph-thalein Alkalinity mg/L CaCO3	36	13	20	None taken	8	16
Total Alkalinity mg/L CaCO3	192	176	196	None taken	84	170
Hardness mg/L CaCO3	208	194	226	None taken	130	196
Dissolved Oxygen mg/L & %	7.6 @ 85%	Equipment insufficient	Equipment insufficient	None taken	Equipment insufficient	Equipment insufficient
Metal Collection	yes	yes	yes	None taken	yes	yes
Nutrient Collection	no	yes	no	yes	no	No
Benthos Collection	None taken	None taken	Mayfly hatch	None taken	None taken	Midge pupa
Velocity	None taken	None taken	None taken	None taken	0.6 ft/s	None taken
Flow Rate	None taken	None taken	None taken	None taken	10.5 cfs	0.47 cfs

ANALYSIS

Mostly because of the COVID 19 pandemic, but partly because of drought, the data set is small and incomplete. My conclusions and recommendations would be strengthened by additional data; however, the current data set compares two spring seasons--the time of year when the stream is experiencing high flow due to the mountain runoff.

Additional data will be collected and should be considered during mitigation and restoration efforts. Going forward, the River Science class at Canon City High School will collect data at least once each fall during the lowest flow and again in the spring during highest flow. River Science students will perform basic water quality tests, sampling for benthic invertebrates, and water-sample collection for the purpose of metal and nutrient testing. Further testing through the rest of the months is tentatively being considered.

Temperature

Air temperature and water temperature were measured at every testing. Both measures fluctuated seasonally, as one would expect; as the temperature of the air increases so does the temperature of the water.

The southern redbelly dace prefers a summer water temperature between 17.2 to 23.8 degrees celsius according to Colorado Parks and Wildlife. Our late spring and early summer temperatures are well within the desired range. However, we do not have data for other times of the year.

pH

Class 2 streams in the Rocky Mountain Region, including in this part of the Arkansas River Drainage (through Fremont County and Chaffee County Colorado) tend to be basic in nature, ranging from 7.8 to 8.4. This is the pH range preferred by the Southern Redbelly Dace. If water continues to flow throughout the fall and winter, I would expect the pH to drop slightly, due to decomposition of detritus. The pH as measured at each testing occasion was within the range preferred by the fish and consistent to pH of other nearby running water sources.

Alkalinity and Water Hardness

Alkalinity and water hardness measures indicate that Oak Creek at the Van Norman Ranch is consistent with other streams in this part of the watershed. The headwaters of the Arkansas River, including class 1, class 2, and class 3 streams contain a high amount of $CaCO_3$, which was found in our testing. In other words, with regard to alkalinity and water hardness, our data indicates that Oak Creek is healthy with regard to these measures. A slight dip in the May 2021 data is likely the result of high water-volume due to spring thaw. Increased water volume results in increased flow rate, temporarily diluting the river and lowering the concentration of minerals.

Dissolved Oxygen

Only one measure of dissolved oxygen (using the QA/QC protocol for Colorado River Watch) was conducted. This test showed ample oxygen availability for the Redbelly Dace Minnow. Compared to the Hach tests conducted prior to the RW samples, the water flowing seemed to contain enough to meet the Biological Oxygen Demand to support the habitat of the minnow. More tests are needed and planned for the fall of 2021, when the school group receives a new biuret.

Nutrient Content

Nutrient testing includes measures of chloride and ammonia, which cannot exceed certain levels in order to be healthy for life.

The reports produced in response to collected samples show levels of chloride well below the acceptable level of 250 mg/L of chloride in surface water (14.42 mg/L in May of 2020 and 24.24 mg/L in April of 2021). This chloride is most likely due to the mineral deposits upstream..

Taking all of the samples into consideration, no ammonia was detected in the water. A trace amount of nitrates and nitrites were identified at one testing occasion (0.002 mg/L in the spring of 2021). These results indicate that there is probably no agricultural or human contamination of the water up stream; with regard to nutrients, the stream appears to be healthy.

Sulfates, again probably due to the geology of the region, were similar for each year at 40.99 and 40.66 mg/L (May 2020 and April 2021, respectively) and well below the acceptable level of 500 mg/L.

CONCLUSION & RECOMMENDATIONS

Although the data set is small and biased toward spring runoff results, one could conclude that when the creek is flowing through the Van Norman property, the water quality is consistent with other streams in this part of the Arkansas basin and healthy for life. Oak Creek water quality would support the redbelly dace; the issue causing their absence seems to be the annual periods of dryness, not water quality.

Many factors need to be considered.

1. Additional data is available (from 2019); it was not considered in this analysis because it was based on Hach testing and did not follow the stringent standards of Colorado River Watch Network. However, it is worth noting that Hach tests produced results similar to those of the more accurate RiverWatch protocols.
2. As mentioned before, data is biased toward typical spring results; additional water quality tests during other seasons, when water supply dwindles and disappears, would help us determine whether the habitat will be suitable for the reintroduction of Redbelly Dace after continuous flow has been restored. In addition, water quality testing during low flow would determine the health status of one Arkansas River tributary, for the good of the people who use the water downstream.
3. In the fall, nutrient concentration is expected to be at its highest due to the decomposition of detritus. However, in June 2021, the amount of visual algal growth and plant growth seemed healthy and natural. This implies only healthy levels of nutrient loading upstream, a hypothesis further supported by the data collected thus far, which shows nitrogen-containing molecules and other nutrients well within the safe levels for surface water.

The data considered in this report indicates that Oak Creek (near the center of the Van Norman Ranch) is healthy to support life. Not only was life actually observed, but also all measures (pH, alkalinity, hardness, dissolved oxygen, and nutrient content) indicate the creek is healthy enough to support life.

Instead, I believe a first approach to the problem should be to address the invasion of two species of juniper trees, Rocky Mountain juniper and one-seeded juniper, which have out-competed native cottonwood and willow trees. Although data has yet to be collected with regard to the juniper and their impact, it is safe to say that restoring the natural habitat (more cottonwoods and willows and fewer juniper) will keep the ecosystem cooler in the summer and protected in the winter. In this way, the return of the cottonwood and willows might help support perennial flow.

The impact of the juniper should be evaluated. A transect study of the flora along the 1-mile study area and a population count of the junipers is underway to determine impact. Soil samples near junipers and near willows and cottonwoods should tell us if and how the junipers could be affecting the water.

However, I do not believe mitigation efforts need to be on hold until this data is available. Eliminating invasive junipers and restoring native cottonwood and willow species would return the ecosystem to its natural state, as it existed before the area was settled. This would likely support the return not only of the Redbelly Dace but also other species not considered as indicators.

In summary, I recommend that initial Oak Creek water-flow mitigation efforts focus on the reintroduction of native tree species. In the meantime, water testing using the RiverWatch protocol should continue.

REFERENCES

1. Colorado River Watch Network
2. CPW - Southern RedBelly Dace Fact Sheet

3. USDA Forest Service - Southern Redbelly Dace Fact Sheet
4. EPA acceptable Standards for Surface Water Report, 2003

Appendix D: August Flood Images and StreamSTATS

In August of 2021, Oak Creek experienced a flood event that resulted in many debris piles and slight channel adjustments. Given that River Science had an elevation model and previous hydraulic modeling (Appendix A), this flood and available data provided the opportunity to quantify this flood event and to use this data for better understanding of the creek's hydrology, hydraulic processes, and floodplain connectivity. Collected flood extents that were surveyed (Figure D1), and hydraulic modeling demonstrated that the August flood was around 400 cfs. This data was helpful and later used to determine the appropriate deminsions of the future treatments size as StreamSTATS data was the only other source.

Figure D1: Site 1 location flood debris lines measure about 6' of water (left) and large debris jams piled up (right).

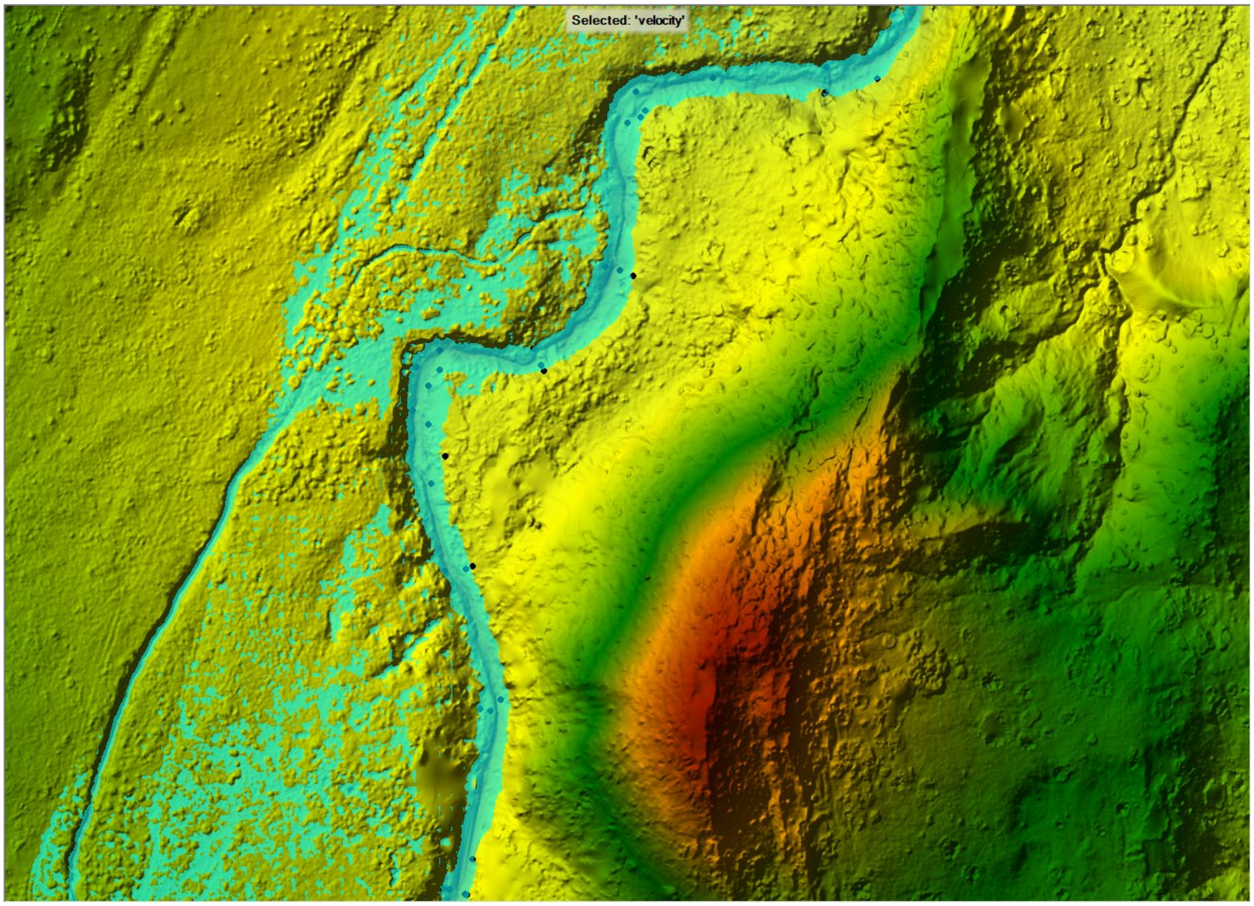
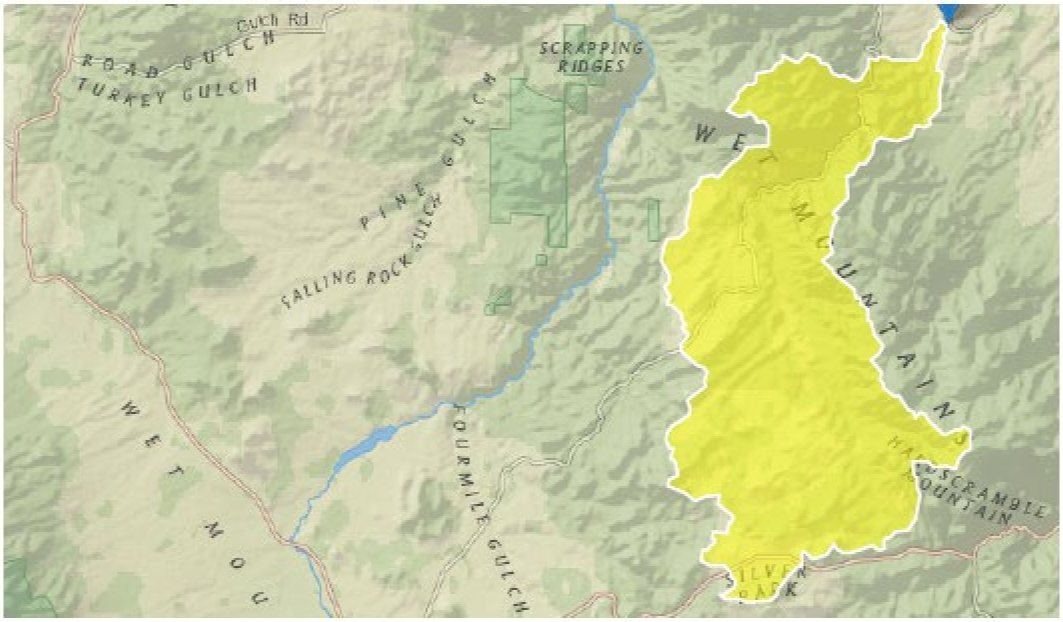


Figure D2: HEC-RAS simulation near 400 cfs (nearly a 2-yr return interval based on StreamSTATS) with inundation extent matching the outer limits of the surveyed flood debris (outer black dots).

StreamStats Report

Region ID: CO
Workspace ID: CO20210110221910842000
Clicked Point (Latitude, Longitude): 38.35123, -105.20197
Time: 2021-01-10 15:19:30 -0700



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	56.9	square miles
I6H100Y	6-hour precipitation that is expected to occur on average once in 100 years	4.26	inches
STATSCLAY	Percentage of clay soils from STATSGO	19.23	percent
OUTLETELEV	Elevation of the stream outlet in feet above NAVD88	5743	feet

Peak-Flow Statistics Parameters[Foothills Region Peak Flow 2016 5099]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	56.9	square miles	0.6	2850
I6H100Y	6 Hour 100 Year Precipitation	4.26	inches	2.38	4.89
STATSCLAY	STATSGO Percentage of Clay Soils	19.23	percent	9.87	37.5
OUTLETELEV	Elevation of Gage	5743	feet	4290	8270

Peak-Flow Statistics Flow Report[Foothills Region Peak Flow 2016 5099]

PIl: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
50_percent_AEP_flood	378	ft^3/s	117
20_percent_AEP_flood	1160	ft^3/s	87
10_percent_AEP_flood	2070	ft^3/s	80
4_percent_AEP_flood	3820	ft^3/s	80
2_percent_AEP_flood	5630	ft^3/s	83
1_percent_AEP_flood	8070	ft^3/s	88
0_5_percent_AEP_flood	11100	ft^3/s	94
0_2_percent_AEP_flood	16000	ft^3/s	104

Peak-Flow Statistics Citations

Kohn, M.S., Stevens, M.R., Harden, T.M., Godaire, J.E., Klinger, R.E., and Mommandi, A.,2016, Paleoflood investigations to improve peak-streamflow regional-regression equations for natural streamflow in eastern Colorado, 2015: U.S. Geological Survey Scientific Investigations Report 2016–5099, 58 p. (http://dx.doi.org/10.3133/sir20165099)

Appendix E: Reference Reach

Located at the upstream-most end of the Van Norman property exists a remnant beaver dam area whose old dam has acted as a temporary grade control – very similar to our proposed PALS influences. This site has become our restoration's reference site as the width, channel depth, riparian vegetation, and channel grade provide a vision of what the restoration reach may achieve with PALS. To compare and contrast the reference reach to the typical incised restoration reach, the following list of figures are provided.

Figure E1: Aerial view of the reference reach looking upstream

Figure E2: Ground view of the reference reach looking upstream.

Figure E3: Aerial view of an incised section of the future restoration reach looking upstream.

Figure E4: Ground view of an incised section of the future restoration reach looking downstream.

Riparian Comparison

Late summer's aerial imagery (August 2021) provides a good example to show the incisions impact on riparian extent. As shown below in Figure EA, the reference reach has an average riparian extent of 45 feet compared to a typical incised sections riparian extent of 12 feet.

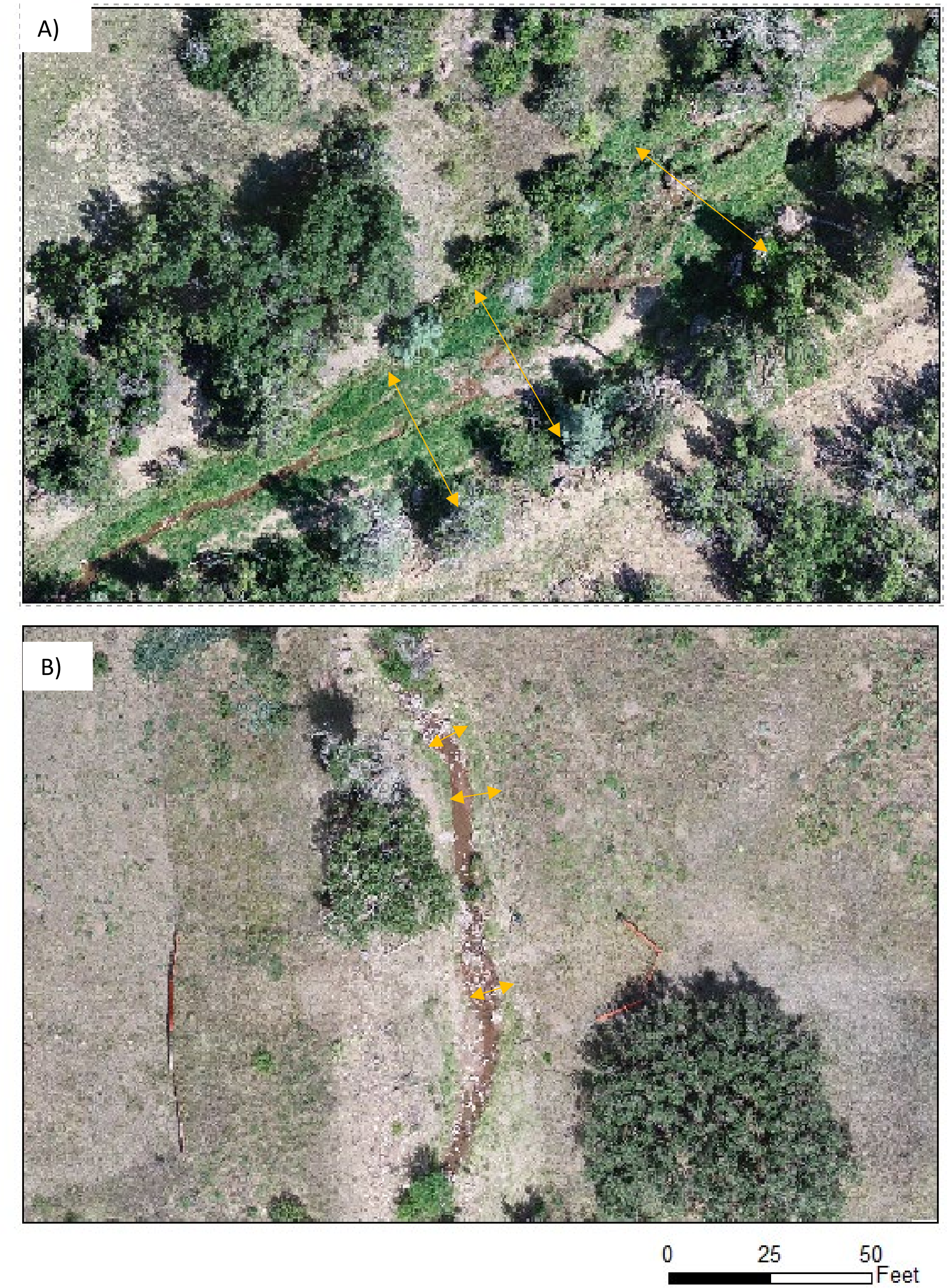


Figure E5: Aerial imagery taken in August, 2021 to show A) the reference reach's riparian extent, and B) at typical incised section's riparian extent.

Baseline data and profiles

Using HEC-RAS to conducted hydraulic simulations, Figures E6 and E7 show signifcant differences in hydraulic conditoins of flood depth and shear stress for the same flow rate of 300 cfs. As shown, depth and shear stresses of the reference reach are nearly half that of the typical incised reach. With the activity to install PALS, we believe that we can slow velocities and alter the channel bed slope overtime to make the incised reaches of this creek more like the reference reach.

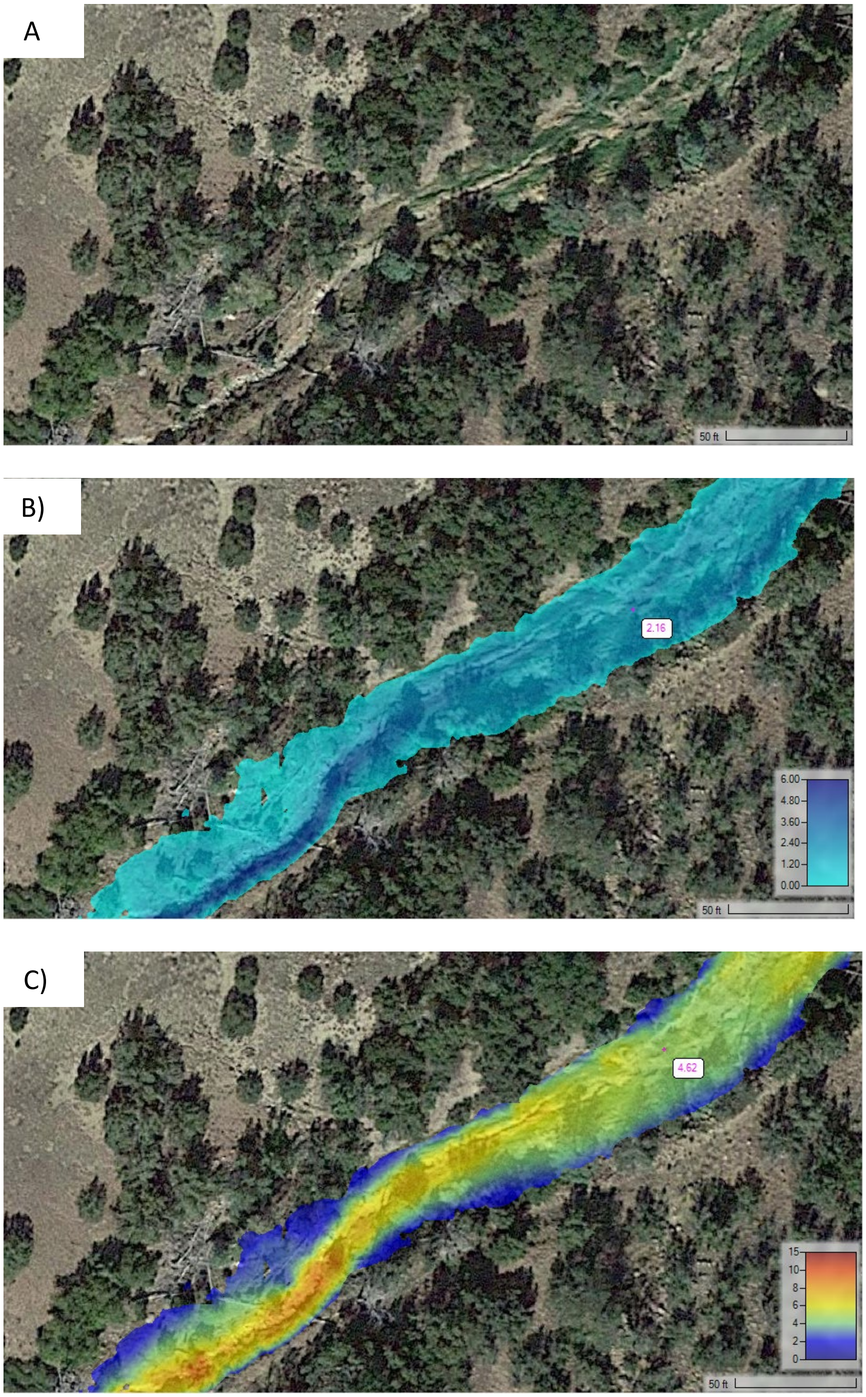


Figure E6: Hydraulic simulations at 300 cfs (simulated in HEC-RAS, 2d) of a 2021 flood event shows A) aerial imagery of reference reach, B) simulated depth (feet), and C) shear stress.

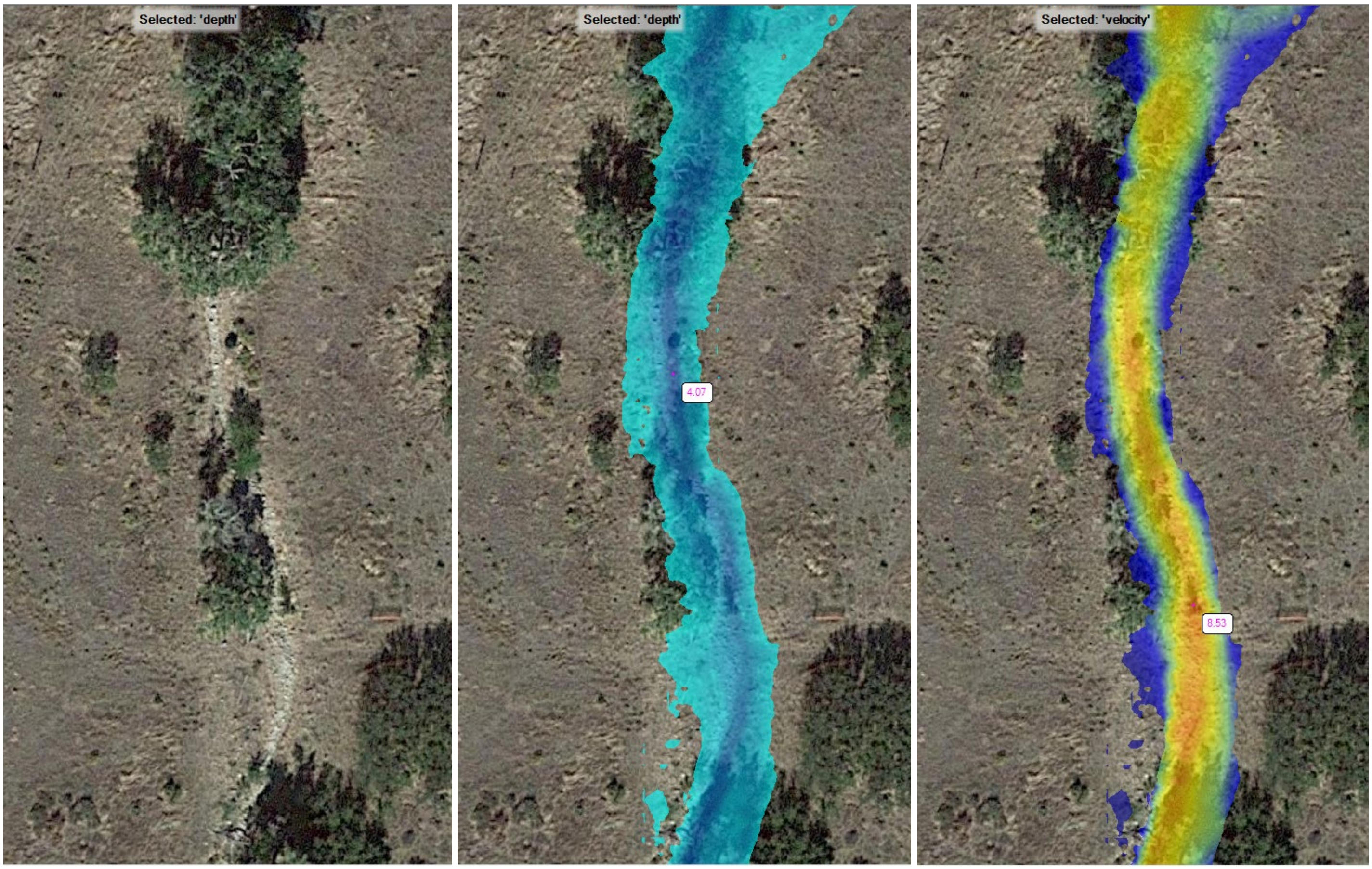


Figure E7: Hydraulic simulations at 300 cfs (simulated in HEC-RAS, 2d) of a 2021 flood event shows A) aerial imagery of a typical incised reach, B) simulated depth (feet), and C) shear stress. Note, both depth and shear stress are considerably higher than the reference reach's hydraulic conditions under the same flood event.

Finally, we provide elevation profiles. The project area's channel elevation profile (Figure E8) shows the incised channels slope of 0.023 with very few grade changes and ponds. Whereas the reference reach, albeit small, has a slope of 0.005. Again, we believe with constructed PALS, we can obtain significantly more areas will grade breaks that will slow flow velocity and encourage sedimentation. While not directly proposed, we believe these changes in the river processes can provide for greater future habitat and water right impacts. Figures E9 and E10 show cross section elevations of two sample areas of the project site and show incisions of 7 feet and 15 feet, respectively. Conversely, Figure E11 shows the cross section profile of the reference reach with a wide channel width and relatively low elevation relief to the banks.

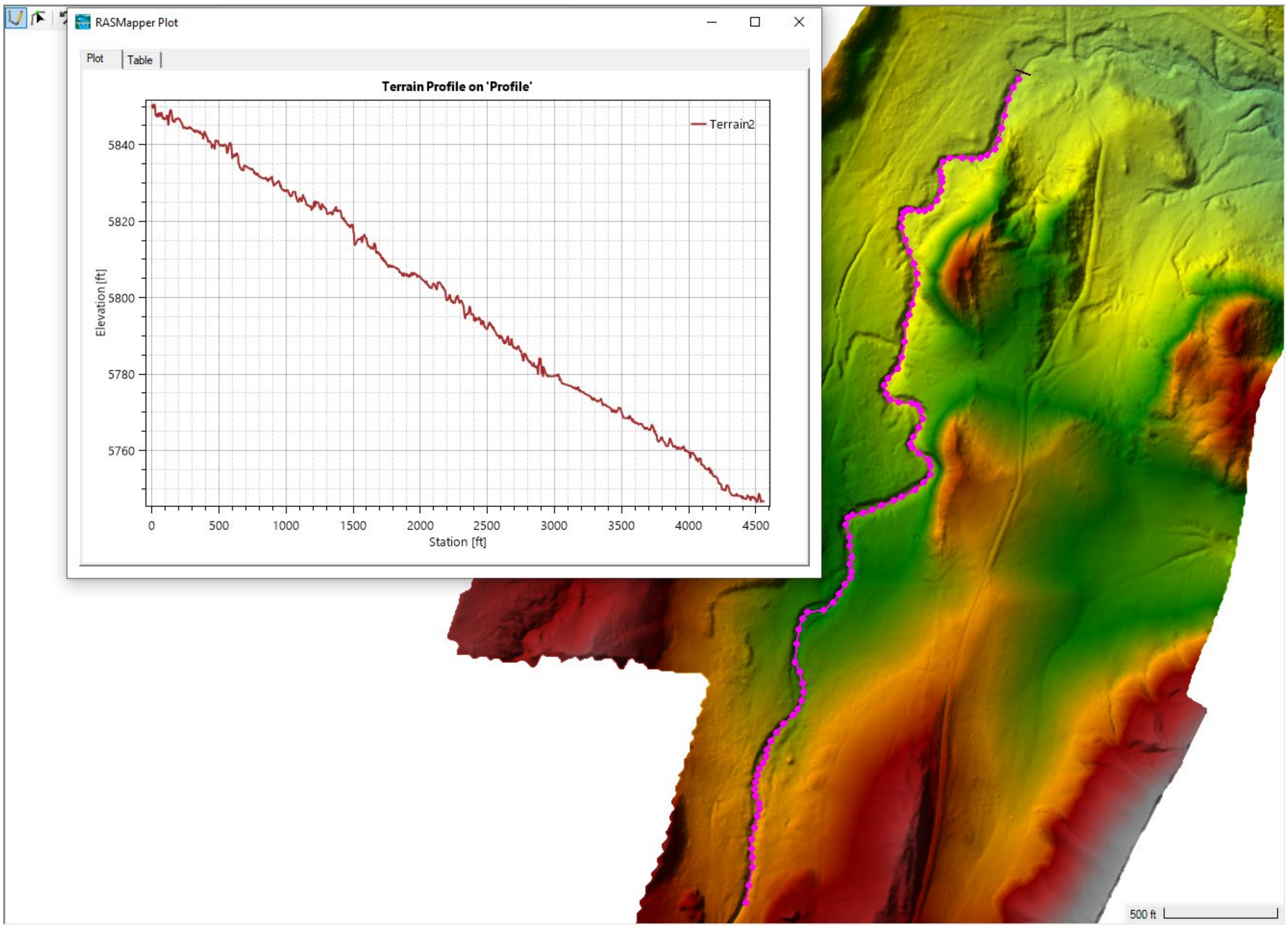


Figure E8: Channel elevation profile of the proposed project site. Note slope is 0.023

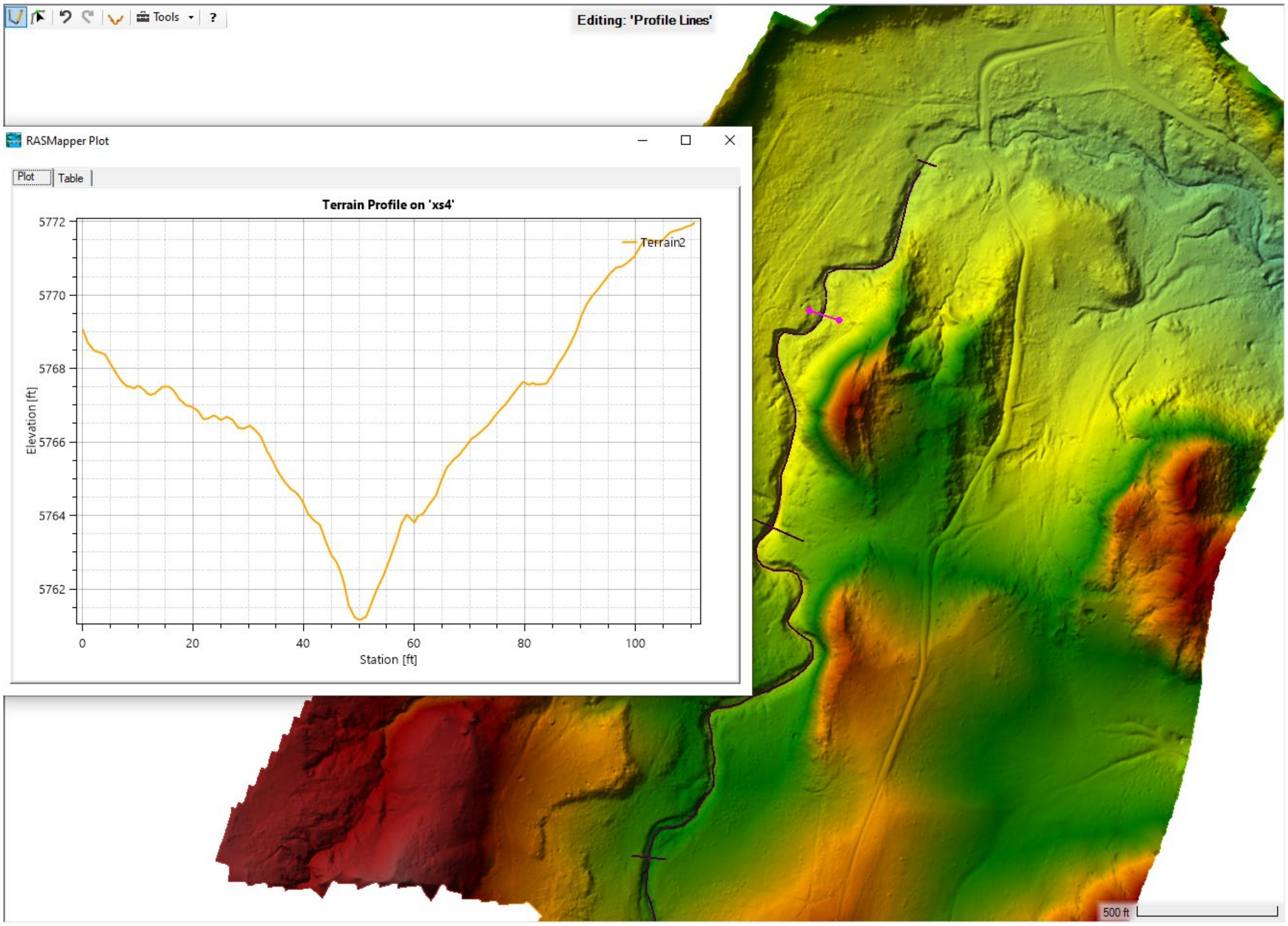


Figure E9: A cross section elevation profile of a section in the proposed project site. Note incision is nearly 7 feet.

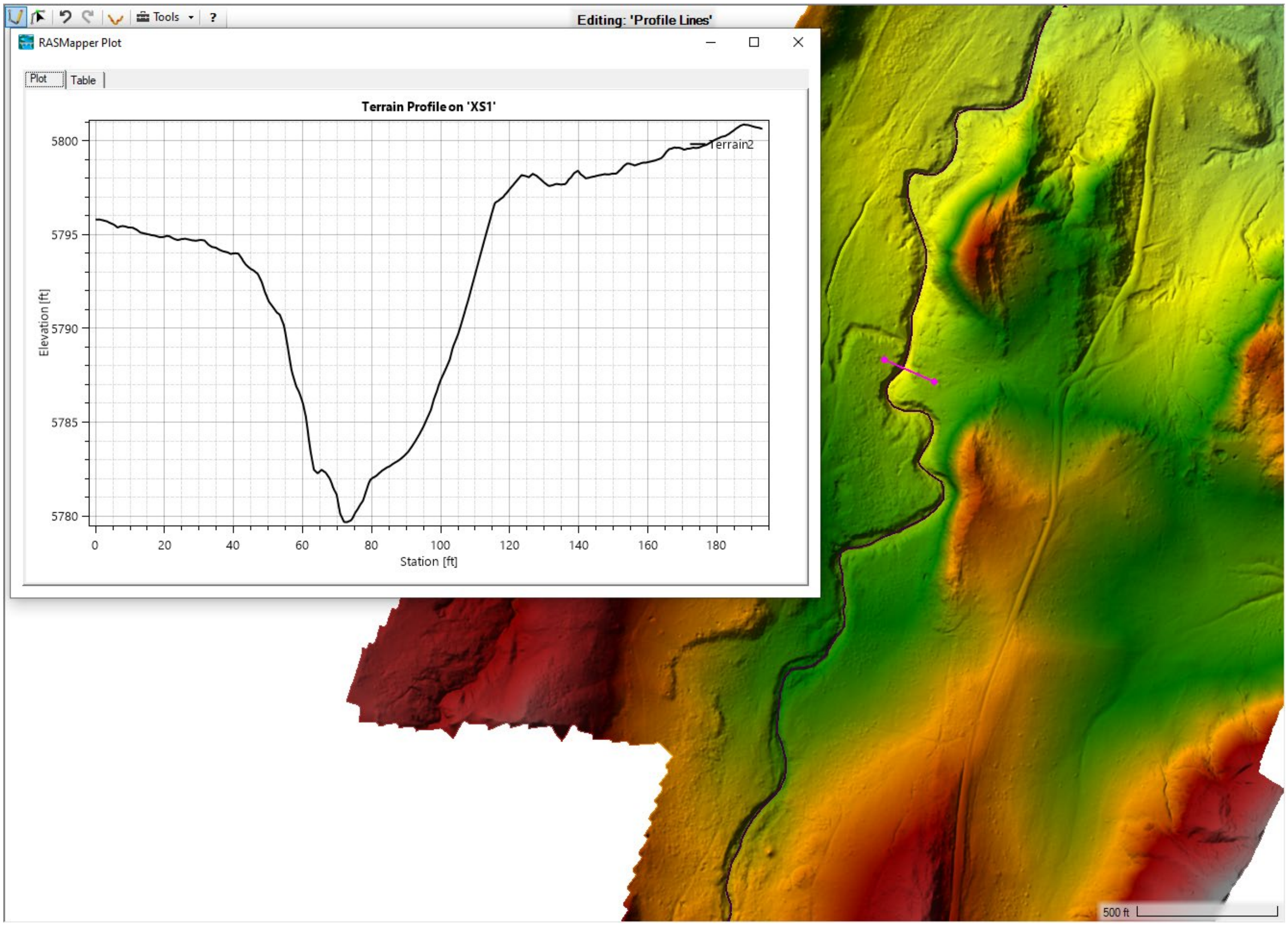


Figure E10: A cross section elevation profile of a section in the proposed project site. Note incision is nearly 15 feet.

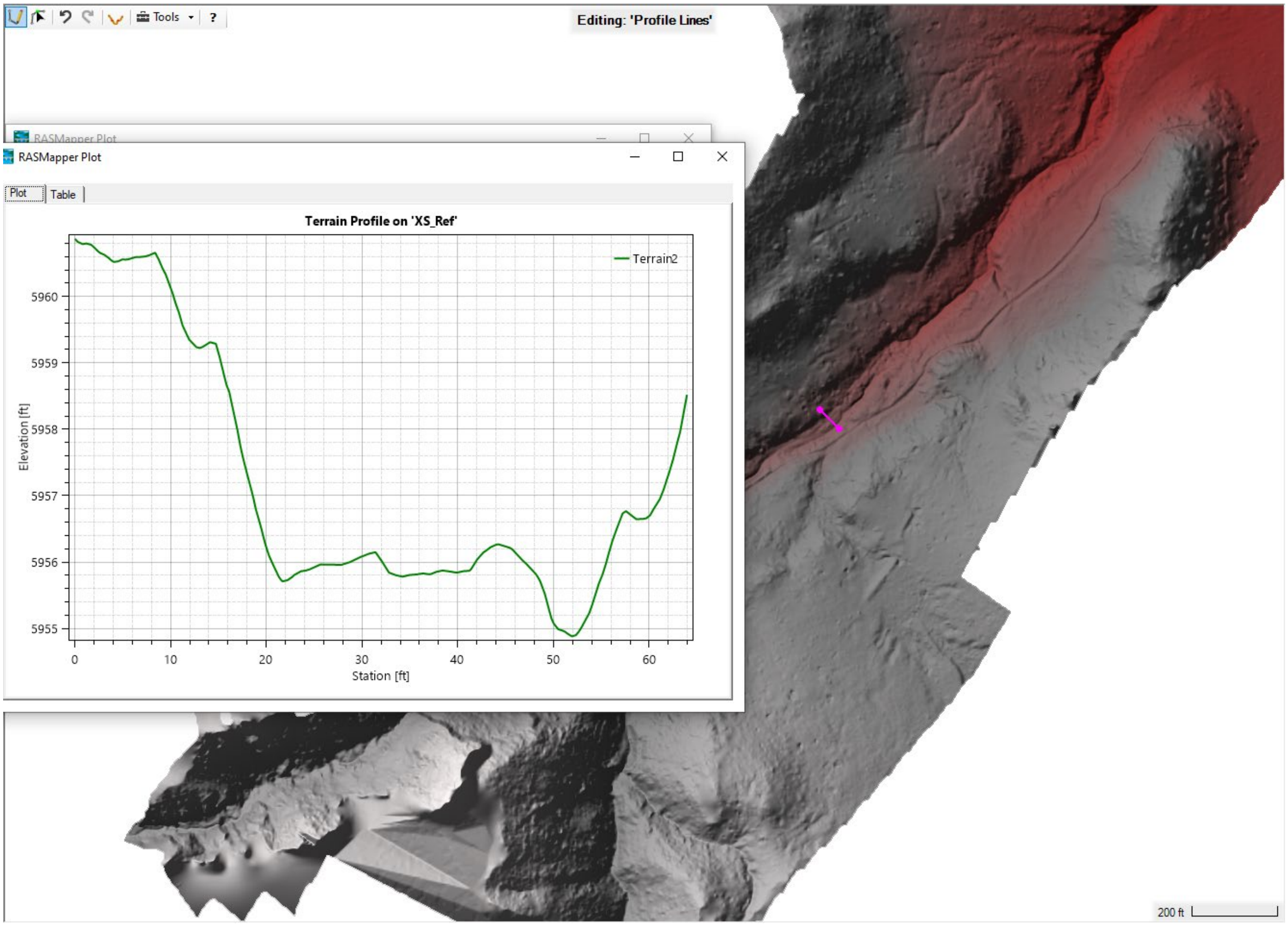


Figure E11: A cross section elevation profile of the reference reach. Note the wide channel width and relatively low bank elevations.

Appendix F: Surface Water Data

Surface water presence and absence has been monitored monthly with repeat drone imagery. The Oak Creek channel runs approximately 2 miles through the Van Norman property, and it's path is outlined in Figure E1A. The following Figures E1A-F4B show the areas where surface water was visible in aerial imagery. Figure E4C shows where the intersect of all datasets and determined the areas that had surface water in all datasets. As shown, the section near the Van Norman's house (midway on the stream length) is wet in every dataset. This area is known to have a small spring and has been the location of the River Watch water quality data collection as it does provide year-round flow.

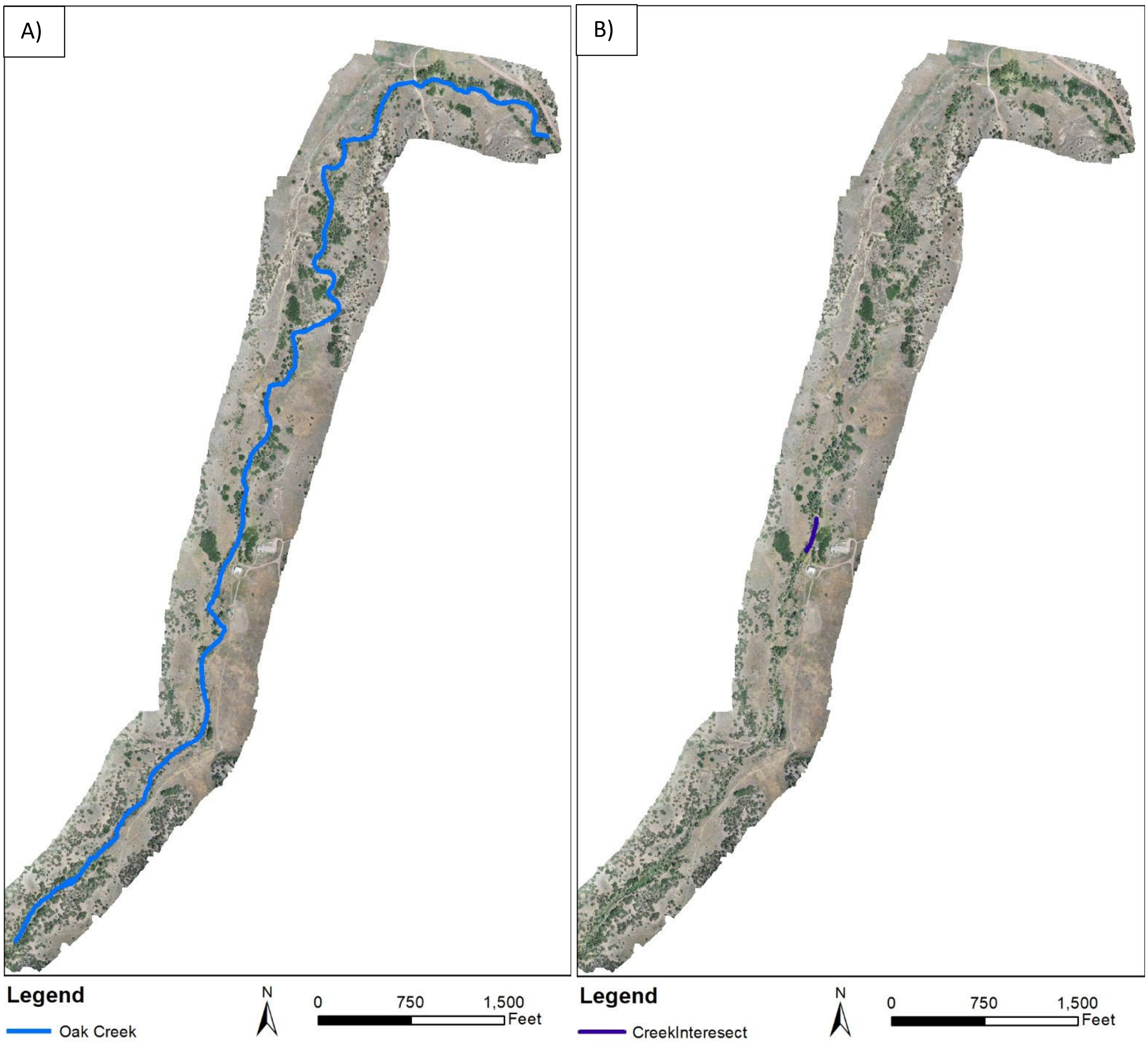


Figure F1: Oak Creek channel depicted for A) it's path through the Van Norman property, B) the intersect of wet areas for all datasets shown in Figure E2-E4 (i.e. the area that is wet every time).

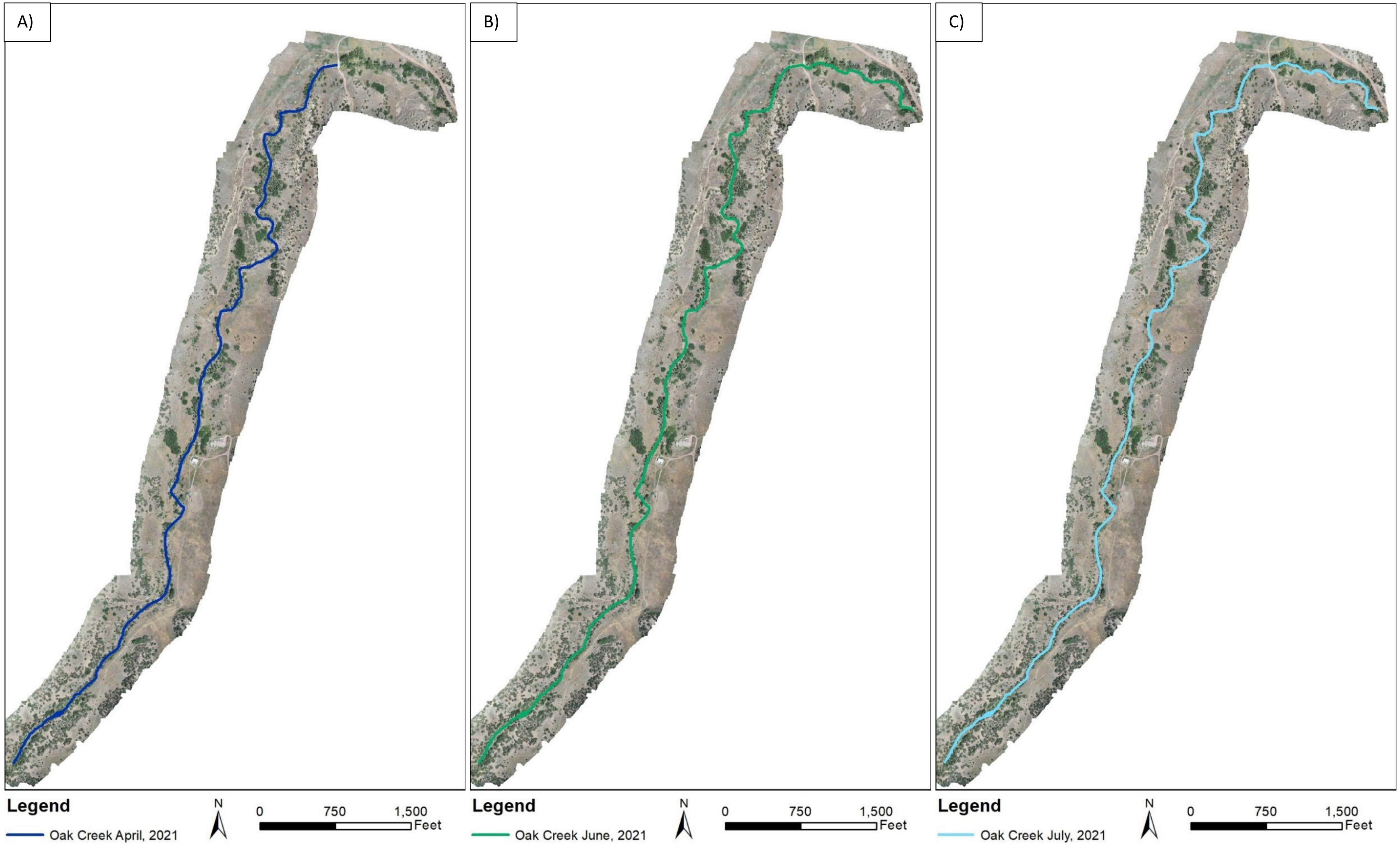


Figure F2: Oak Creek channel depicted for A) visible surface water in April 2021, B) visible surface water in June, 2021 and C) visible surface water in July 2021.

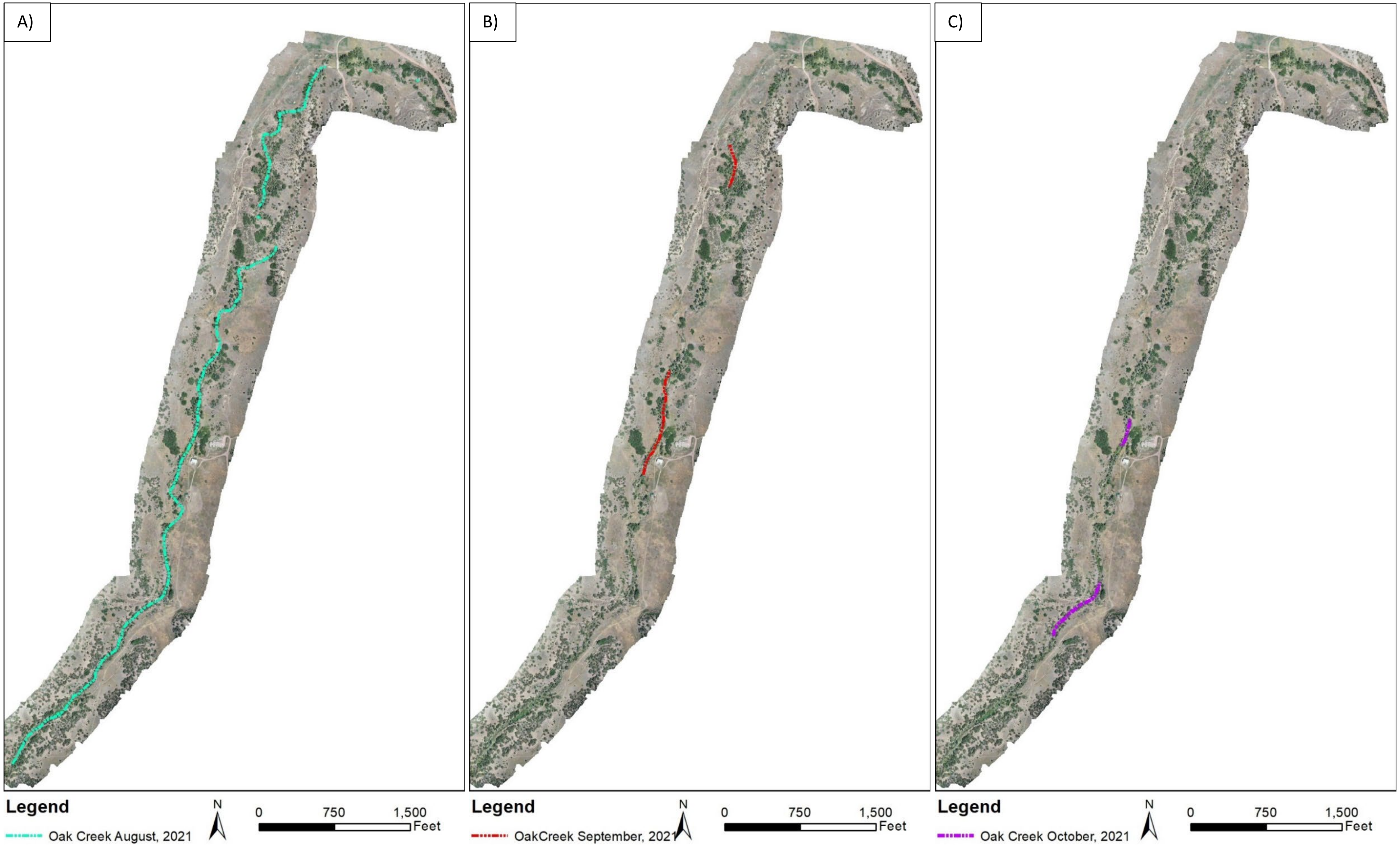


Figure F3: Oak Creek channel depicted for A) visible surface water in August, 2021, B) visible surface water in September, 2021, C) visible surface water in October, 2021.

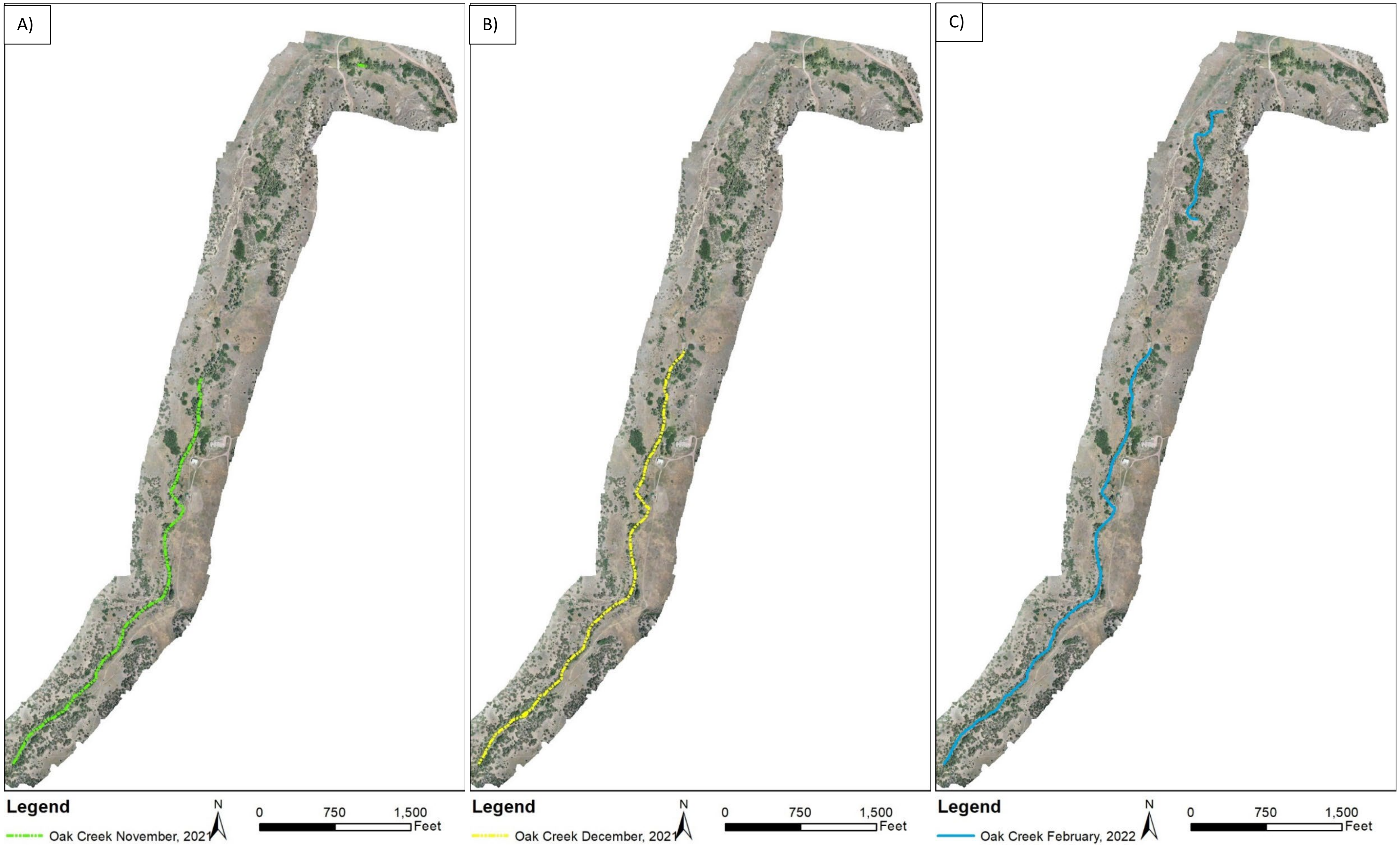


Figure F4: Oak Creek channel depicted for A) visible surface water in November, 2021, B) visible surface water in December, 2021, C) visible surface water in February, 2022.

Figure F5: Oak Creek channel depicted for visible surface water in March, 2022

Appendix G: Groundwater Data

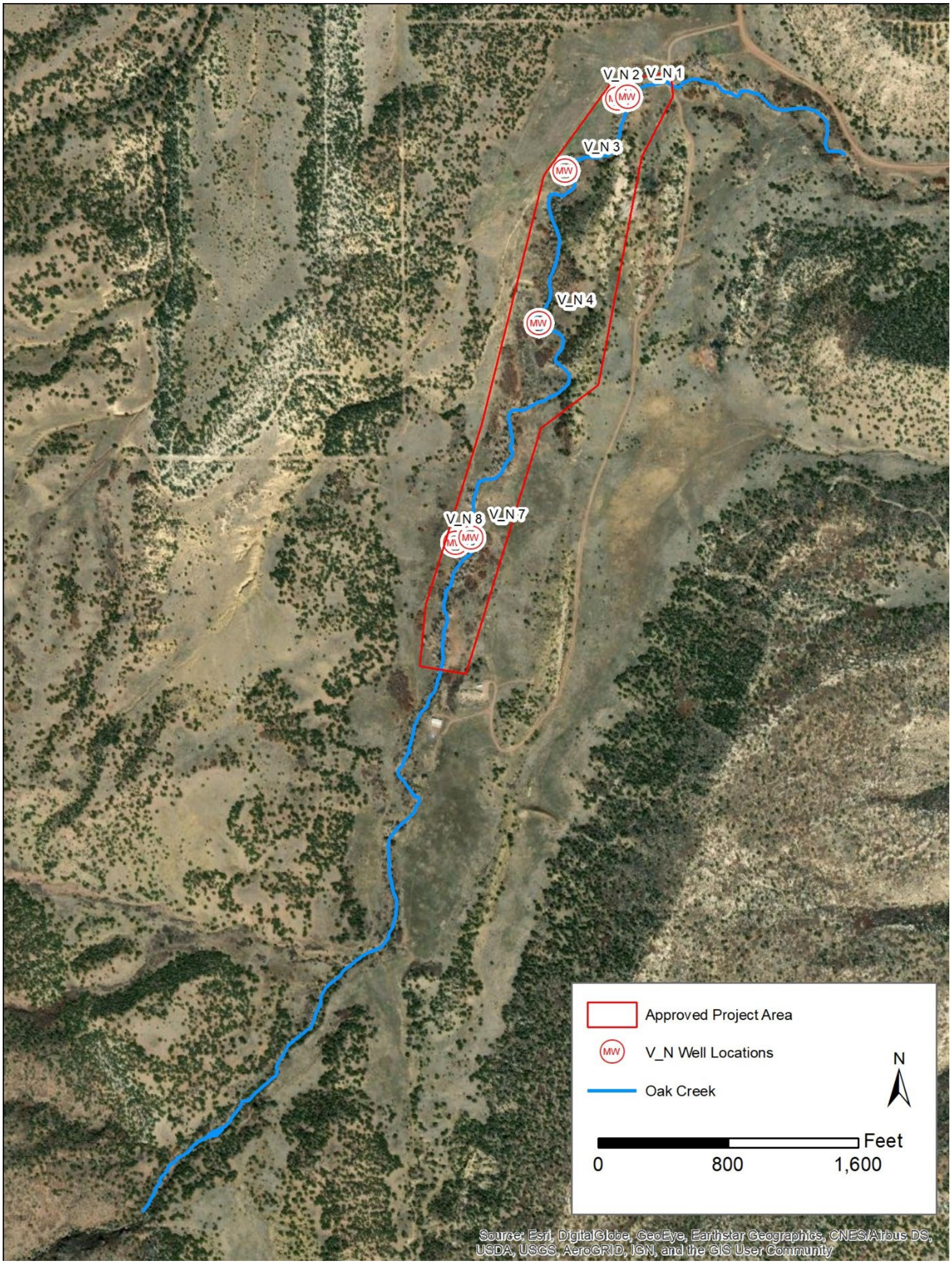


Figure G1: Shallow groundwater monitoring wells labeled V_N 1 through V_N 8. River Science installed V_N wells 1, 2, 3, 4, 7, and 8.

Table G1: V_N Well's with listed distance to the nearest channel of Oak Creek, the channel elevation, and the surface elevation at the well head.

V_N Well ID	Distance to Channel (ft)	Channel Elevation (ft)	Well Ground Elevation (ft)
1	35	5745.3	5752.0
2	97	5745.3	5757.3
3	65	5760.3	5770.9
4	10	5783.7	5786.2
5	81	5806.8	5814.1
6	220	5806.8	5819.5
7	45	5828.2	5833.5
8	123	5828.2	5839.4
9	113	5883.1	5893.6
10	303	5887.3	5911.8
11	142	5878.1	5887.9

Table G2: Groundwater data collected since April 2022 with relative water level compared to the channel elevation (i.e. negative water levels indicate that water is below the channel) and the same time period's presence or absence of surface water in that channel. Data for the month of May was lost.

	Relative Water Level (Well Water Elevation - Channel Bed Elevation) (ft)					Surface Water Presence				
V_N Well ID	April 22'	May 22'	June 22'	July 22'	Aug 22'	April 22'	May 22'	June 22'	July 22'	Aug 22'
1	NA		NA	NA	NA	Wet	Wet	Wet	Wet	Dry
2	NA		NA	4.1	4.1	Wet	Wet	Wet	Wet	Dry
3	-0.2		-0.7	-1.4	-2.0	Wet	Wet	Wet	Wet	Wet
4	0.4		0.4	-0.8	NA	Wet	Wet	Wet	Wet	Dry
7	NA		NA	-1.1	-1.1	Wet	Wet	Wet	Wet	Dry
8	-1.7		-3.4	-5.1	-6.6	Wet	Wet	Wet	Wet	Dry

Appendix H: Treatment Design

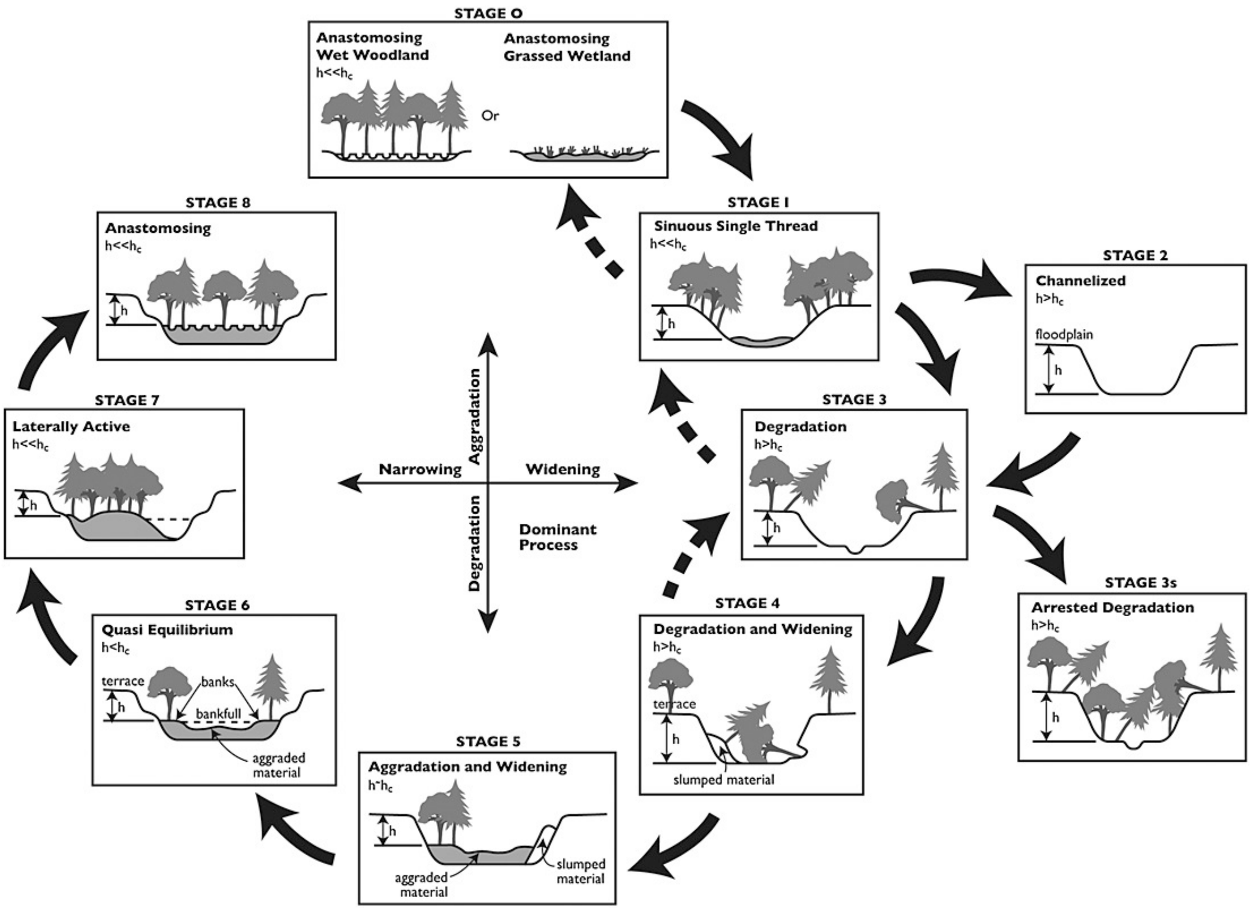


Figure H1: Stream evolution model depicting pre-disturbance conditions (Stage 0) taken from Cluer and Thorne (2014). This illustration depicts the target for restoration characterized by a physically complex valley bottom that has improved channel and floodplain connectivity.

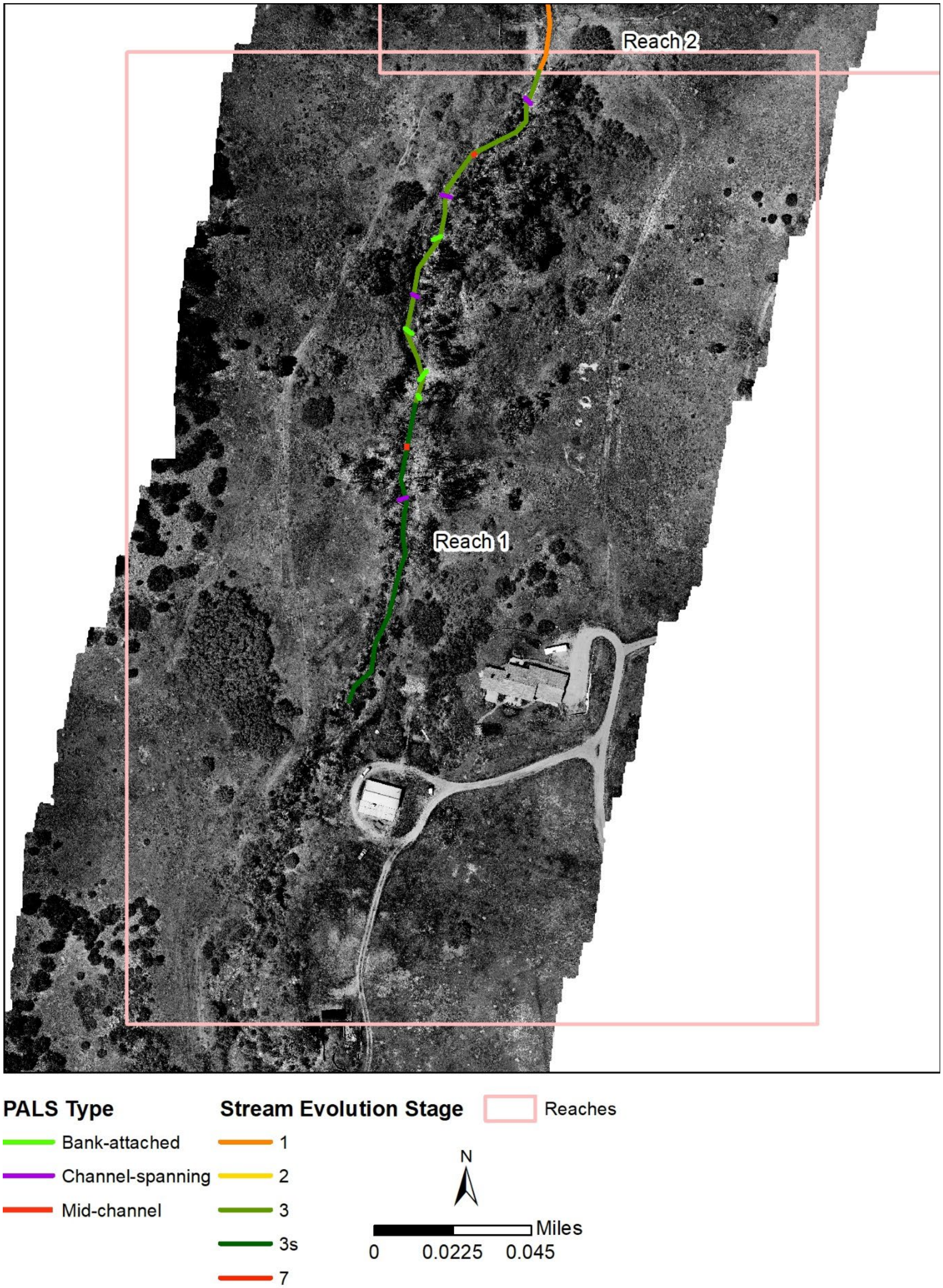


Figure H2: Reach 2 of Van Norman Project Restoration current stream evolution stage and proposed treatments using post assisted log structures (PALS) to induce river processes to induce channel widening and aggrading; thus advance the Stage to improved floodplain connectivity.

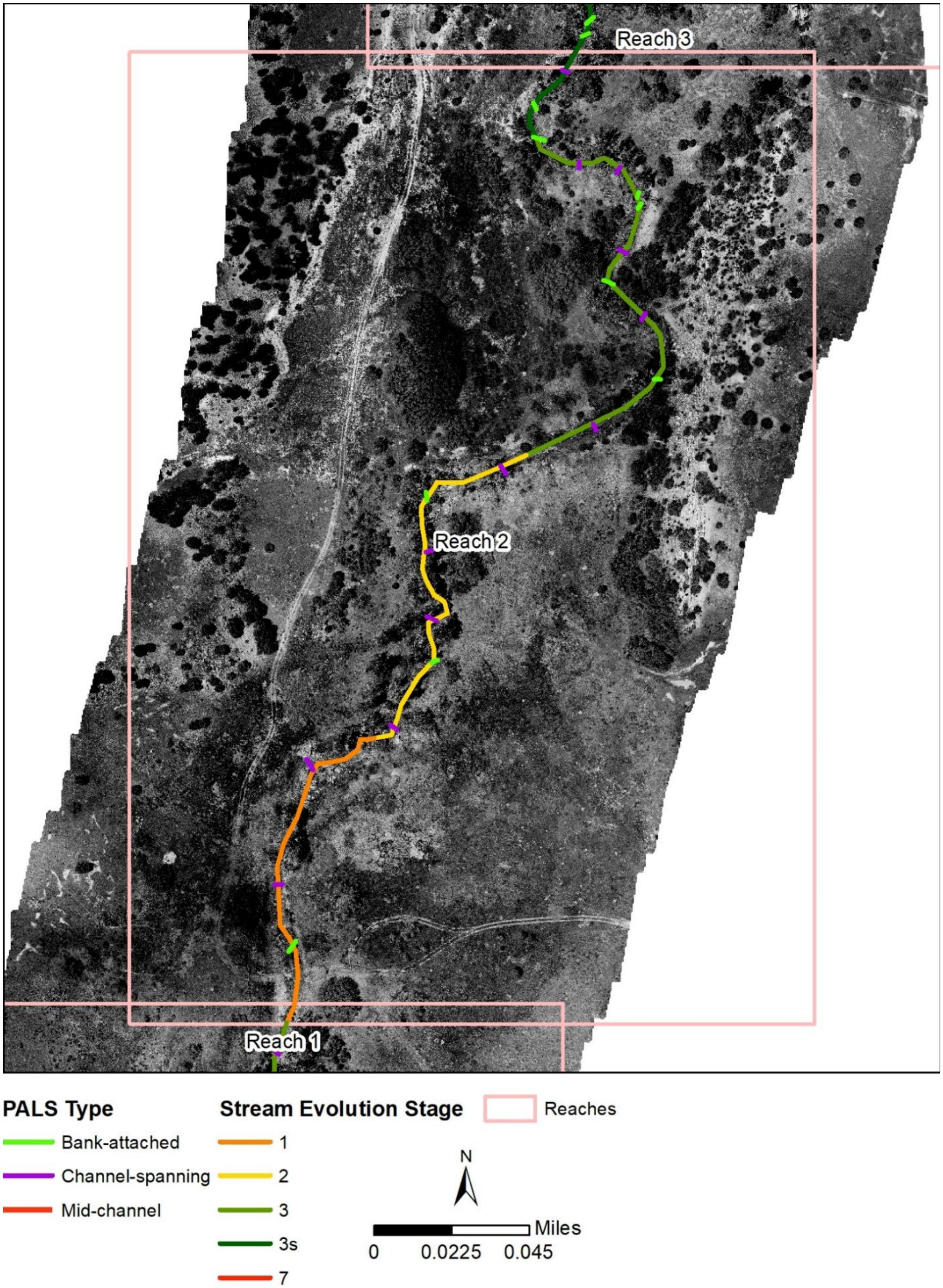


Figure H3: Reach 3 of Van Norman Project Restoration current stream evolution stage and proposed treatments using post assisted log structures (PALS) to induce river processes to induce channel widening and aggrading; thus advance the Stage to improved floodplain connectivity.

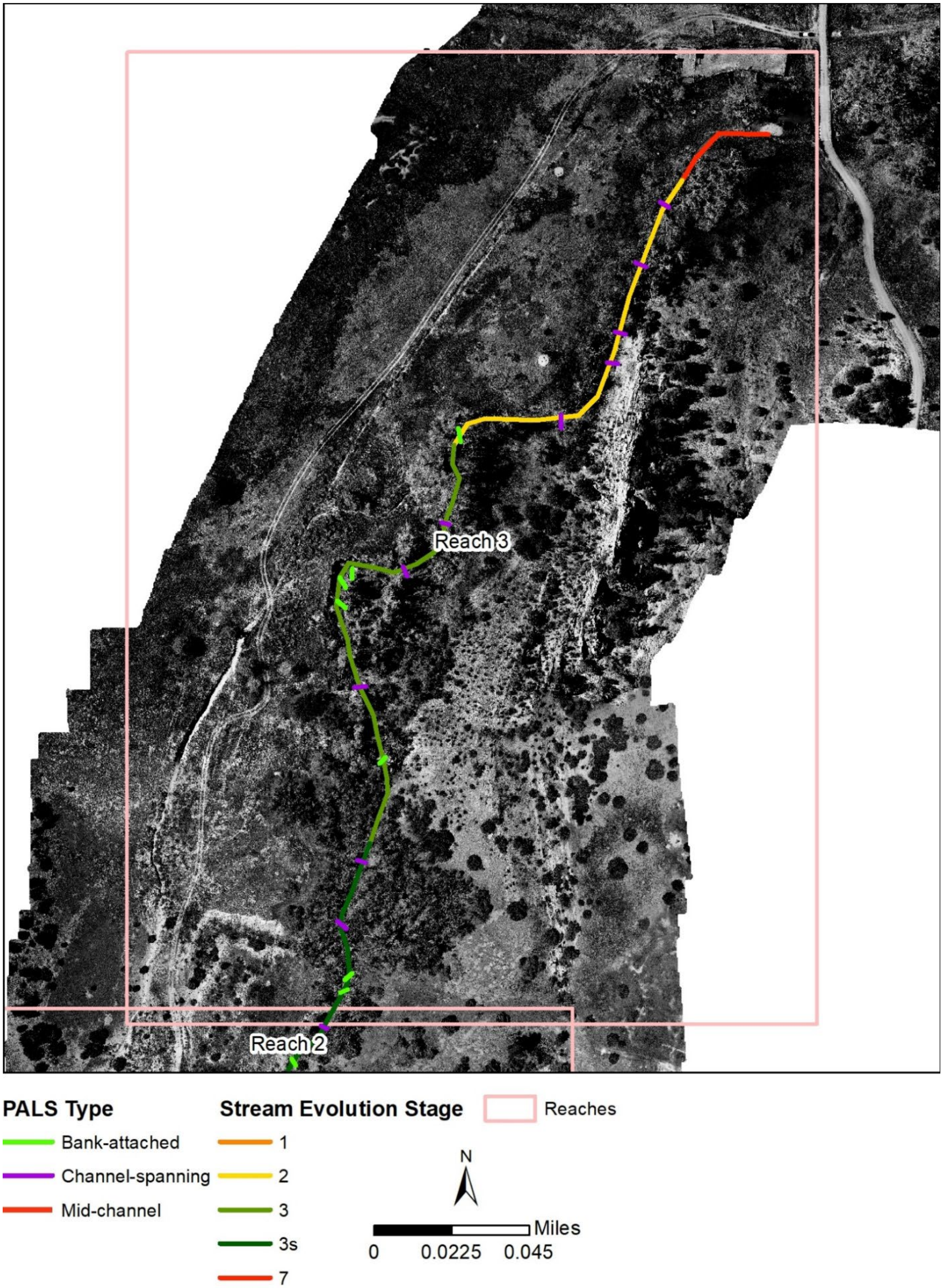


Figure H4: Reach 4 of Van Norman Project Restoration current stream evolution stage and proposed treatments using post assisted log structures (PALS) to induce river processes to induce channel widening and aggrading; thus advance the Stage to improved floodplain connectivity.

Appendix I: USACE 404 Permit

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
1970 E 3RD AVENUE, SUITE 109
DURANGO CO 81301-5025

August 2, 2022

Regulatory Division

SUBJECT: Nationwide Permit Verification (SPA-2022-00142)

Uviation World Water Inc./River Science
Attn: Luke Javernick
430 Main Street
Canyon City, CO 81212
luke@river.science.com

Dear Mr. Javernick,

The U.S. Army Corps of Engineers (Corps), Albuquerque District, is responding to your preconstruction notification (PCN), dated April 5, 2022, submitted to us for verification of authorization under Nationwide Permit (NWP) 27 for the *V_N Ranch* project. The project site is located at approximately latitude 38.3375, longitude -105.20833, in Fremont County, Colorado.

Based on the information provided, we have determined that the *V_N Ranch* project involves the discharge of dredged and fill material into waters of the United States, subject to Section 404 of the Clean Water Act. The specific activity that requires Corps authorization is the introduction of large woody debris in the form of post-assisted log structures (approximately 47). The project will permanently impact approximately 0.7 acre and will be conducted as described in the referenced PCN.

The Corps has determined that activities associated with the project are authorized by 2021 Nationwide Permit (NWP) 27 - *Aquatic Habitat Restoration, Enhancement, and Establishment Activities*. A summary of this NWP and the 2021 Colorado Regional Conditions are available on our website at www.spa.usace.army.mil/reg/nwp. Failure to comply with all terms and conditions of this NWP may result in the suspension or revocation of this authorization. As required by General Condition 30, you shall sign the enclosed Compliance Certification (Enclosure 1) and return it to this office within 30 days after completion of the authorized work. For specific information regarding compliance with water quality certification (WQC) requirements, please refer to our website at www.spa.usace.army.mil/reg/wqc. In addition, the work must comply with the following **special condition:**

1. Special Condition 1: In accordance with Colorado Regional Condition 7(d), you shall submit a complete set of as-built drawings to the Corps within 90 days following completion of the activities authorized by this verification. The drawings shall include the following:

References

Cluer, B. and Thorne, C., 2014. A stream evolution model integrating habitat and ecosystem benefits. River Research and Applications, 30(2): 135-154