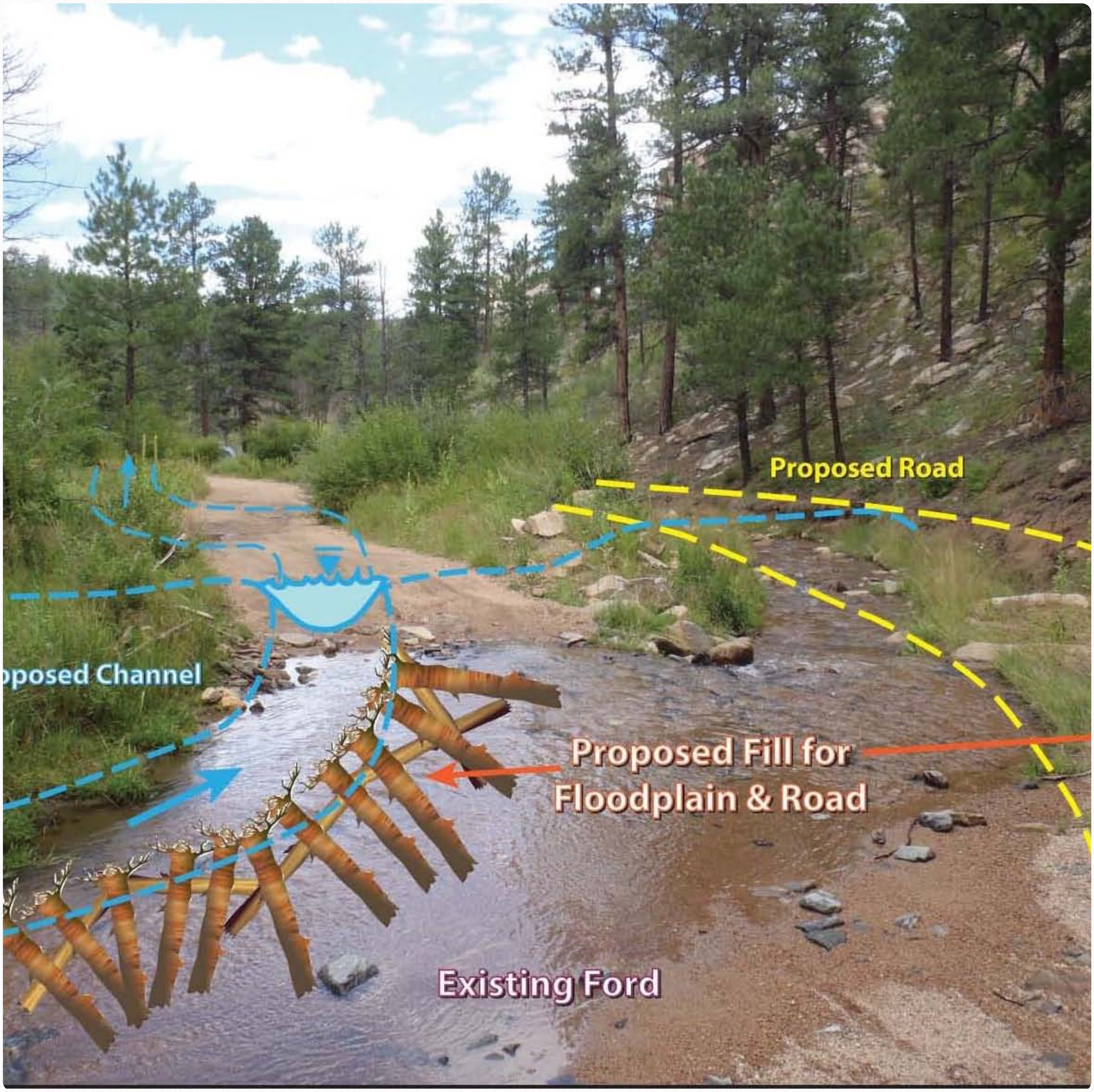
Trail Creek Restoration

Final Report

April 30, 2015



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Overview

"The whole state is on fire."
– Governor Bill Owens

Governor Bill Owens talking to volunteers at Colorado Cares Day, Hayman event, August 8, 2002

The Hayman Fire

The Hayman Fire, June 12, 2002

The morning of Sunday, June 8, 2002, broke with blue skies and dry winds. An ongoing drought had left the mountains of Colorado, particularly the area west of the Front Range, parched. Standing trees, or **1,000-hour** fuels[1] as they are called by wildland firefighers, had fuel moisture levels of about 4%; less than half the typical value of kiln-dried lumber. An upper atmosphere low-pressure system, stretching from Washington State to the plains, brought increasing wind speeds as the day progressed.

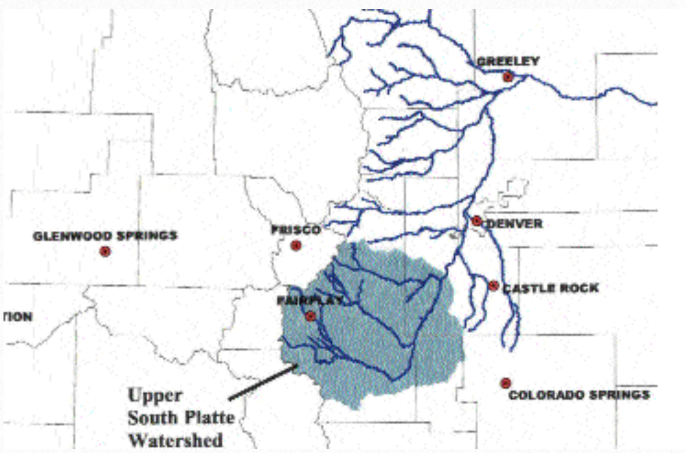
The counter clockwise winds circulating around this massive low-pressure system aligned perfectly with the topography of the South Platte River Corridor, and with gusts in this region at times reaching 60 mph, and sustained winds of 15-30 mph, conditions by mid-afternoon were perfect to drive a fire.

At 4:55 P.M. a fire was reported just south of Tarryall Creek and west of Highway 77 near Lake George, CO. Named for a

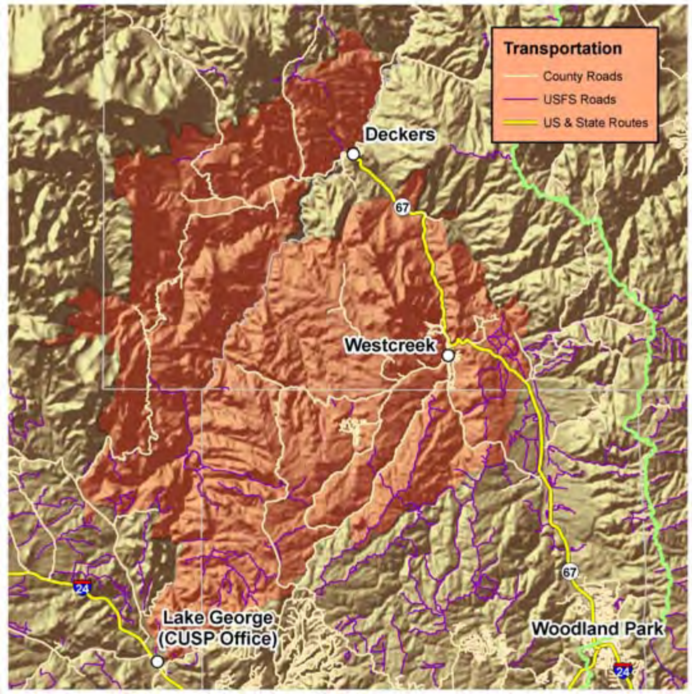
1. Defined as "the time needed for fuel moisture to come into equilibrium with the environment,"

mining-era ghost town nearby, the Hayman Fire went on to become the largest fire in modern Colorado history, scorching 60,000 acres in the first day, and ultimately burning over 137,000 acres, much of it at high intensity.

The entire Hayman Fire was contained within the bounds of the Upper South Platte Watershed. The fire burned along the South Platte River corridor between Lake George and Deckers, with 50-70% of the burn classified as moderate to high severity.



Location: Upper South Platte Watershed



Fire perimeter

The fire destroyed 132 residences, and over 400 other structures, or $24 million worth of real estate, in communities within the Upper South Platte Watershed. The fire also curtailed summer tourism in an area that depends on this revenue for much of the community's annual economic activity. Post-fire flooding and erosion quickly damaged infrastructure and property in and around the burn scar, and continued causing damage more than a decade later. The affected communities will continue to experience post-fire impacts for many years to come.

The area around Trail Creek was significantly degraded by the fire, with much of the watershed burned. Post-fire impacts in

Trail Creek included detrimental flooding, impaired aquatic habitat, and unsustainable sediment movement.

Recognizing these problems and seizing an opportunity to implement system-wide change, a coalition of partners including the the Pike National Forest (USFS), National Forest Foundation (NFF), the Coalition for the Upper South Platte (CUSP), Vail Resorts, Coca Cola, Aurora Water, the Colorado Department of Public Health & Environment (CDPHE), the Gates Foundation, Rocky Mountain Field Institute, the Mile High Youth Corp, Volunteers for Outdoors Colorado, and others joined together under the NFF's *Treasured Landscapes, Unforgettable Experiences* campaign to restore Trail Creek.

This multi-million dollar project, which took several years to complete and serves as a model of successful public-private collaboration, achieved landscape-scale restoration based on the concepts of natural-channel design as developed by Dave Rosgen, Wildland Hydrology Consultants. The project identified a variety of concerns, including:

Stream Health

Streams flowing through the burn area experienced water chemistry changes following the fire. Impacts included increased stream temperature, altered chemical composition, and increased turbidity.

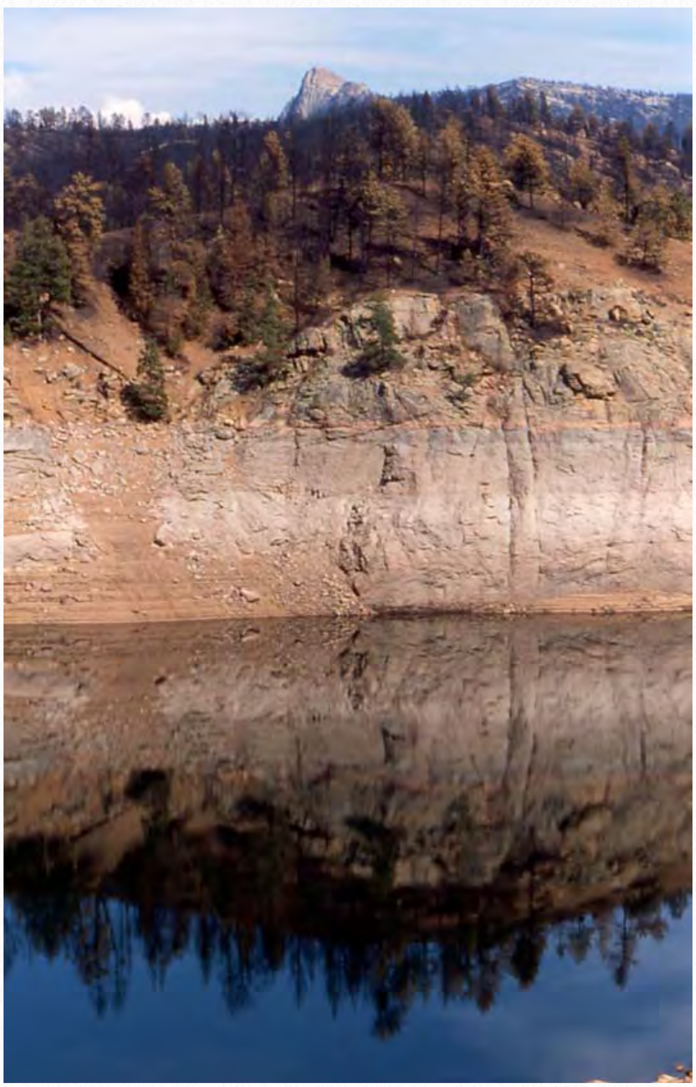
Ecology

Aquatic invertebrates, the foundation for aquatic ecology, decreased 60% to 80% shortly following the fire. Diminished diversity of aquatic species was also observed in the year following the Hayman Fire, with more species rebounding by the second year.

Stonefly, a benthic macroinvertebrate that trout and other fish depend on for their food supply.

Water Supplies

Water quality was negatively impacted, but continued to meet and exceed federal drinking water standards following the fire. However, rain events led to high erosion rates and massive sediment flows into Denver and Aurora Waters' reservoirs and intake systems. These municipalities have spent millions of dollars to mitigate damage and remove sediment from their systems, an effort that continues to this day.



Cheesman Reservoir, post-Hayman

Invasive Species

Non-native plant species were quick to take hold in burn areas following the fire. The higher the burn severity, the more apt invasive plant species were to establish and displace native plants.

CUSP's Jeff Ravage holds up a giant musk thistle

Recreational Trail & Road Issues

The area is heavily used for motorized recreation, and criss-crossed by many trails and forest roads. These roads and trails were damaged during the fire and post-fire flooding, contributed to sedimentation, and were often unsafe. The main Trail

Creek Road had XX live-stream crossings that were used to replace culverts immediately after the fire.

Learn more about the Hayman in the Hayman Case Study:
http://www.fs.fed.us/rm/pubs/rmrs_gtr114.pdf

The Fire's Impacts to Trail Creek

USFS, CUSP, and Teller County staff inspecting damage to Trail Creek Road, 2009

The 2002 Hayman Fire grossly affected Trail Creek, a tributary to the South Platte River, with a concomitant increase of sediment yield, increases in significant flood events, and reduced habitat quality.

At nearly 11,000 acres, the Trail Creek Basin was historically a forested landscape comprised primarily of Ponderosa pine and mixed conifer forests with varied hillslopes of up to 25% steepness. The dominant geology is a noncalcareous granite that forms relatively unconsolidated and highly erodible soils. Also known as decomposed granite, or DG, this soil type, combined with the steep canyons, and a local climate that is influenced considerably by quick-moving high-intensity storm events in the late spring through early fall months, naturally exacerbates erosion potential. CUSP staff refer to the DG as ball-bearings: the particles are just waiting to run down hill. In the photo above, the DG that has come down hill has completely obliterated Trail Creek Road (photo 2009).

Erosion and sediment yields increased in Trail Creek from 1,250 tons/year before the fire to 20,838 tons/year in the average year following the fire, with estimated yields in excess of 60,000 tons per year from some of the flood flows. Each rain event in the area contributed to sediment movement, resulting in more channel incising and stream instability.

The annual water yield of the Trail Creek watershed prior to the Hayman Fire was calculated to average 3,689 acre-ft/year. That nearly doubled to 6,560 acre-ft/year following the fire. In prime conditions for the hydrologic processes of a forested watershed, 75% of the ground is covered by vegetation, soils, and other forest clutter. The Hayman Fire destroyed these conditions by burning away the top layer of material and vegetation, exposing the soil to rainfall and creating water-repellant conditions. Regrowth of vegetation was difficult, as gullies and rills often eroded away soil down to the bedrock.

Pre-fire, the Trail Creek Basin had been home to a healthy population of wild beavers, whose dams influenced the hydrology of the area. Beaver ponds usually trap and store sediment, but the fire drove away the beavers. Without them maintaining their dams, and higher floods and debris flows in the basin, the dams eventually broke down. These dam failures increased water flow, led to even further accelerated bank erosion, and altered the channels.

Trail Creek before the Hayman Fire *(top)*
Trail Creek after the Hayman Fire *(bottom)*

Flooding

The stream's water discharge increased by orders of magnitude after the fire. For example the average annual discharge in cubic feet per second (CFS) based on 100 years of records was ~65 cubic feet per second (CFS). This soared to 1,235 CFS during a July 2003, one-inch rainfall event.

Flooding in Trail Creek, 2006

Highway 67 following post-fire flooding

This event caused all of the beaver ponds as well as a man-made pond to fail. This in turn caused the Trail Creek channel and riparian habitat to fail. Another storm event in July 2006 resulted in flood flows along West Creek exceeding 2,670 CFS, and destroying ~3 miles of State Highway 67. The highway remained closed for three months as the state repaired it.

Ecology

Hillslope and upland vegetation was slow to return in the Trail Creek basin, resulting in reduced habitat quality for upland species. Increased sediment movement from storm events and decreased water quality altered the aquatic habitat and impacted fish populations in the area.

Post-fire Efforts Immediately After Fire

Immediately following the fire, the Pike National Forest utilized its Burned Area Emergency Response, or BAER protocols. Treatments included aerial seeding and mulching, but due to the intensity of the fire and the steep terrain, problems continued, so Douglas County applied for and received an Environmental Protection Agency (EPA) Section 319 Nonpoint Source grant to address some of the issues in Trail Creek. Funds from this grant were awarded to CUSP to do restoration work in Trail Creek. CUSP used the funding to plant willows to restore riparian habitats, carry out volunteer projects, and work with Douglas County staff to stabilize and re-open Trail Creek Road. This work helped somewhat, but because it was limited to the immediate river corridor, it did little to correct underlying flood and debris-flow problems.

Roads and trails in the Trail Creek drainage were completely closed for years after the fire. In 2009, Douglas and Teller Counties joined together to patch the main Trail Creek Road together to such an extent that the area could be reopened.

Adapted from:

- http://coloradoforestrestoration.org/CFRIpdfs/2012_HaymanFireResearchSummary.pdf
- http://www.fs.fed.us/rm/pubs/rmrs_gtr114.html

Additional Resources:

- Trail Creek Maps; Trail Creek Master Plan; Horse Creek Watershed RLA: http://cusp.ws/reports/
- http://coloradoriparian.org/post-fire-watershed-recovery-trail-creek-case-study/
- http://uppersouthplatte.org/search/wp-content/uploads/2011/08/EH_Trail-Creek-Sediment-Yield-Report.pdf
- http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5361902.pdf
- http://www.fs.fed.us/rm/pubs/rmrs_gtr114.pdf

Treasured Landscapes, Unforgettable Experiences

Dave Rosgen explaining the project plan to stakeholders, 2010

The NFF launched their Treasured Landscapes, Unforgettable Experiences Campaign program in 2009 to implement large-scale restoration in priority areas by fostering collaboration between public and private partners. The goals of this campaign included:

- Implement stewardship projects that nurture more resilient forest ecosystems.
- Restore landscapes damaged by wildfire, insects, disease and natural disasters to provide scenic, watershed, wildlife and carbon sequestration benefits.
- Invest in the strength of communities of interest and communities of place, helping people convert their passion for forests into meaningful and sustainable conservation actions.
- Help the American public to fully understand, savor and appreciate all that our National Forests have to offer building lasting connections with the lands that

give us clean air and water, diversity of life, and fulfilling outdoor recreation opportunities.

In addition to ensuring each campaign project meets the above goals, NFF considers restoration needs, community capacity for investment, biodiversity, and the potential to raise funds for the project.

For projects that meet these criteria, NFF leverages resources by working with a large coalition of partners for each project. Private dollars raised by NFF are matched dollar for dollar by the US Forest Service as part of the *Treasured Landscapes, Unforgettable Experiences* agreement. This funding mechanism allows for ample investment by both public and private stakeholders in eligible projects.

National Forest Foundation Mission

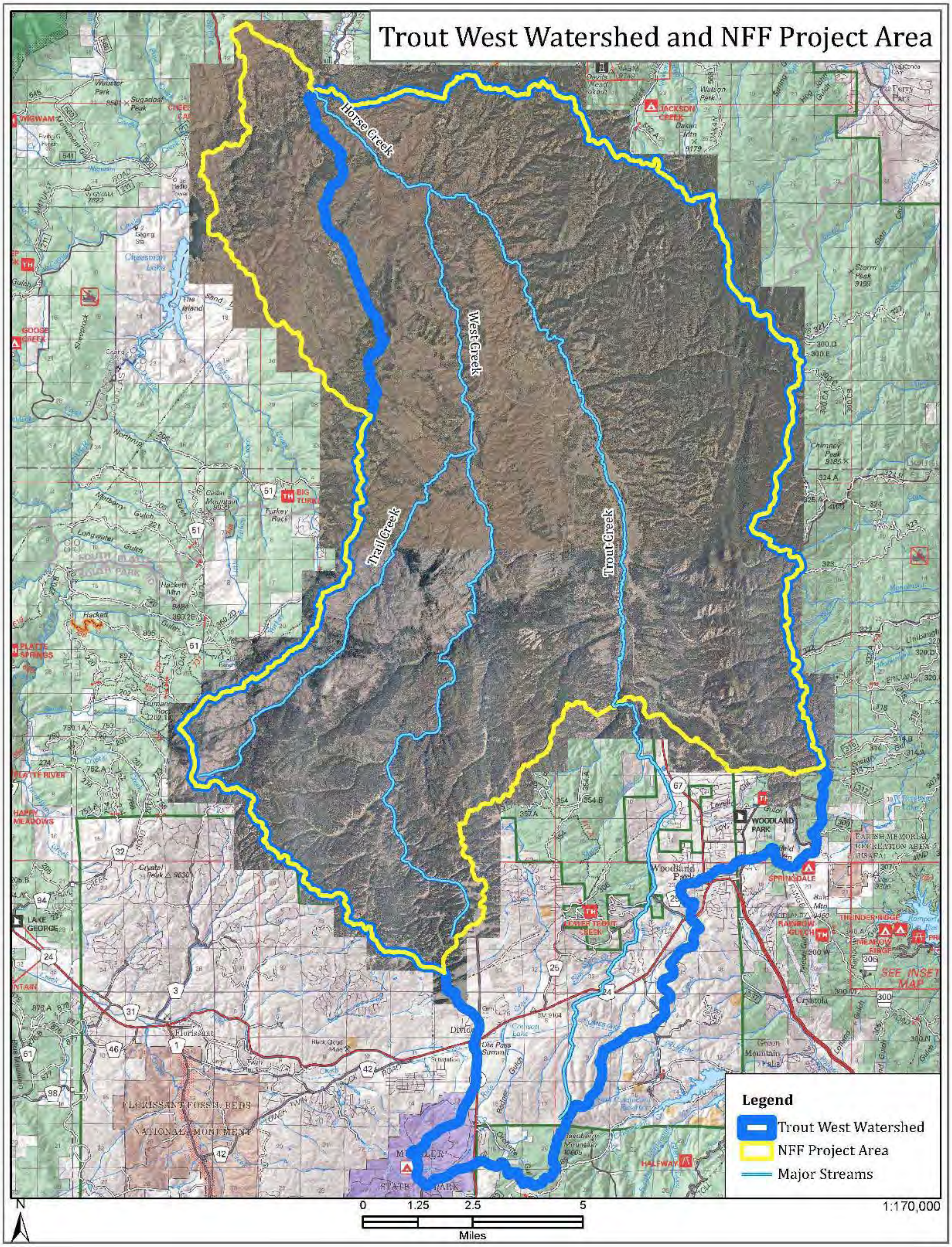
The National Forest Foundation, chartered by Congress, engages Americans in community-based and national programs that promote the health and public enjoyment of the 193-million-acre National Forest System, and administers private gifts of funds and land for the benefit of the National Forests.

Trail Creek was selected as a *Treasured Landscapes, Unforgettable Experiences* campaign site in 2009, in part based on NFF's existing partnership with the Pike National Forest and CUSP to address Hayman Fire recovery efforts; NFF first provided funding to CUSP in 2002 to help manage the Hayman Recovery Assistance Center, and provided additional funds over several more years following the fire.

Dubbed the HAYMAN RESTORATION PROJECT, the campaign was intended to raise millions of dollars for reducing impacts of the Hayman on downstream values at risk, including state highways, municipal water supplies, critical habitat, and high-value recreation areas.

The team pulling the partnership together identified Dave Rosgen of Wildland Hydrology, a world renowned hydrologist and former USFS employee who "wrote the book" on natural channel design to come on board as lead consultant. NFF Colorado Director at the time, Kim Langmaid, said "Mr. Rosgen's expertise is unmatched. By pulling our resources together within the framework of this partnership the U.S. Forest Service and the Coalition for the Upper South Platte are able to apply these internationally-recognized techniques to a particularly problematic section of this watershed."

As the technical team of USFS, CUSP, and Wildland Hydrology staff began working on


Trout West Watershed and NFF Project Area
Horse Creek
West Creek
Trail Creek
Trout Creek
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the planning phase, NFF recruited additional funding partners: The first to step up was Vail Resorts. As Beth Ganz, VP of Public Affairs and Sustainability for Vail said at the time, they were excited, "to help fund work that will have a dramatic and immediate impact here in Colorado while changing how wildfire restoration is approached across the country."

Within a short time, NFF added a variety of additional funding partners, including Aurora Water, whose downstream water infrastructure was being negatively impacted by sediment and debris flows; the Gates Family Foundation, a Colorado-based foundation that had long supported capital campaigns to address natural resource problems; and Coca-Cola, whose sustainability program at a national level was focused on water sustainability in regions where they have bottling facilities (Denver).

NFF further reached out to other nonprofit partners to increase on-the-ground capacity, bringing in the Rocky Mountain Field Institute, Mile High Youth Corp, and Volunteers for Outdoor Colorado to partner with CUSP on carrying out volunteer projects over the three years of the implementation.

CUSP also sought additional funds, partnering with the Colorado Department of Public Health & Environment's 319-Nonpoint Source grant program, the Colorado Water Conservation Board's Watershed Program, Douglas County, and other smaller donors to provide additional dollars to leverage federal contributions.

The Hayman Fire had profound impacts on South Platte River tributaries

Prioritizing the Project Area

Shortly after NFF initiated discussions with the Pike and CUSP about possible projects that would be suitable for a *Treasured Landscapes, Unforgettable Experiences* campaign, the group identified the Horse Creek Watershed as its highest priority based on long-term problems that continued to impact not only the drainage itself, but downstream values in unburned areas, including Strontia Springs Reservoir, a primary water supply reservoir for the Denver Metro area.

"Trail Creek made sense as an area we could tackle" - Dana Butler, USFS Hydrologist

In 2009/2010, NFF, with matching funds from Vail Resorts, provided funding to initiate a first phase of the Watershed Assessment for River Stability and Sediment Supply (aka WARSSS assessment) on the greater Horse Creek Watershed.

The WARSSS is a process developed by Dave Rosgen for the Environmental Protection Agency (EPA), and is EPA's preferred methodology for understanding sediment and bank instability issues.

Phase 1, also known as the Reconnaissance Level Assessment, or RLA, looked at the entire 186 square-mile Horse Creek Watershed. The RLA subdivided the watershed into 53 third- and fourth-order sub-watersheds. This process quickly identified the Trail Creek sub-watershed as the most problematic area.

Reference: NFF - Treasured Landscapes, Unforgettable Experiences
https://www.nationalforests.org/assets/pdfs/Hayman-Final-Report_8_29_14_design.pdf

Project Goals

Emanating from the collaborative planning and WARSSS processes, the following restoration objectives were established in the 2011 Trail Creek Watershed Master Plan for Stream Restoration & Sediment Reduction:

1. Reduce sediment supply from disproportionate sources identified by erosional process, land use and specific locations within the watershed

2. Quantify the sediment supply reduction by proposed restoration

3. Develop restoration scenarios that address the cause of impairment

4. Improve fish habitat, diversity and function

5. Stabilize streambanks and streambeds

6. Utilize a natural-channel-design methodology that results in a natural appearance (aesthetics)

7. Accelerate the recovery processes from the Hayman Fire

8. Re-establish a functional riparian corridor

9. Reduce road and trail maintenance and contributions to sediment

10. Provide for improved recreational opportunities

11. Provide ecological restoration (including birds, fish, mammals, and amphibians)

12. Reduce flood stage

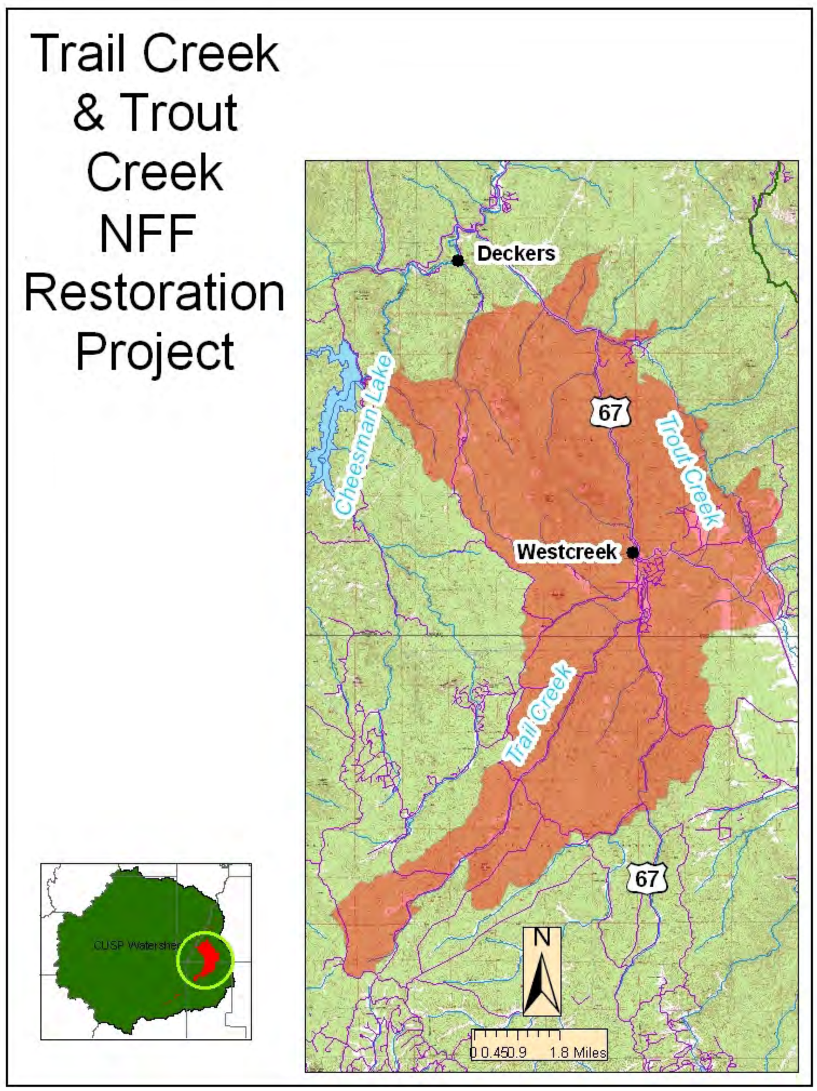
13. Accommodate floods and reduce flooding impacts on adjacent road

14. Create cost-effective and low-risk restoration solutions

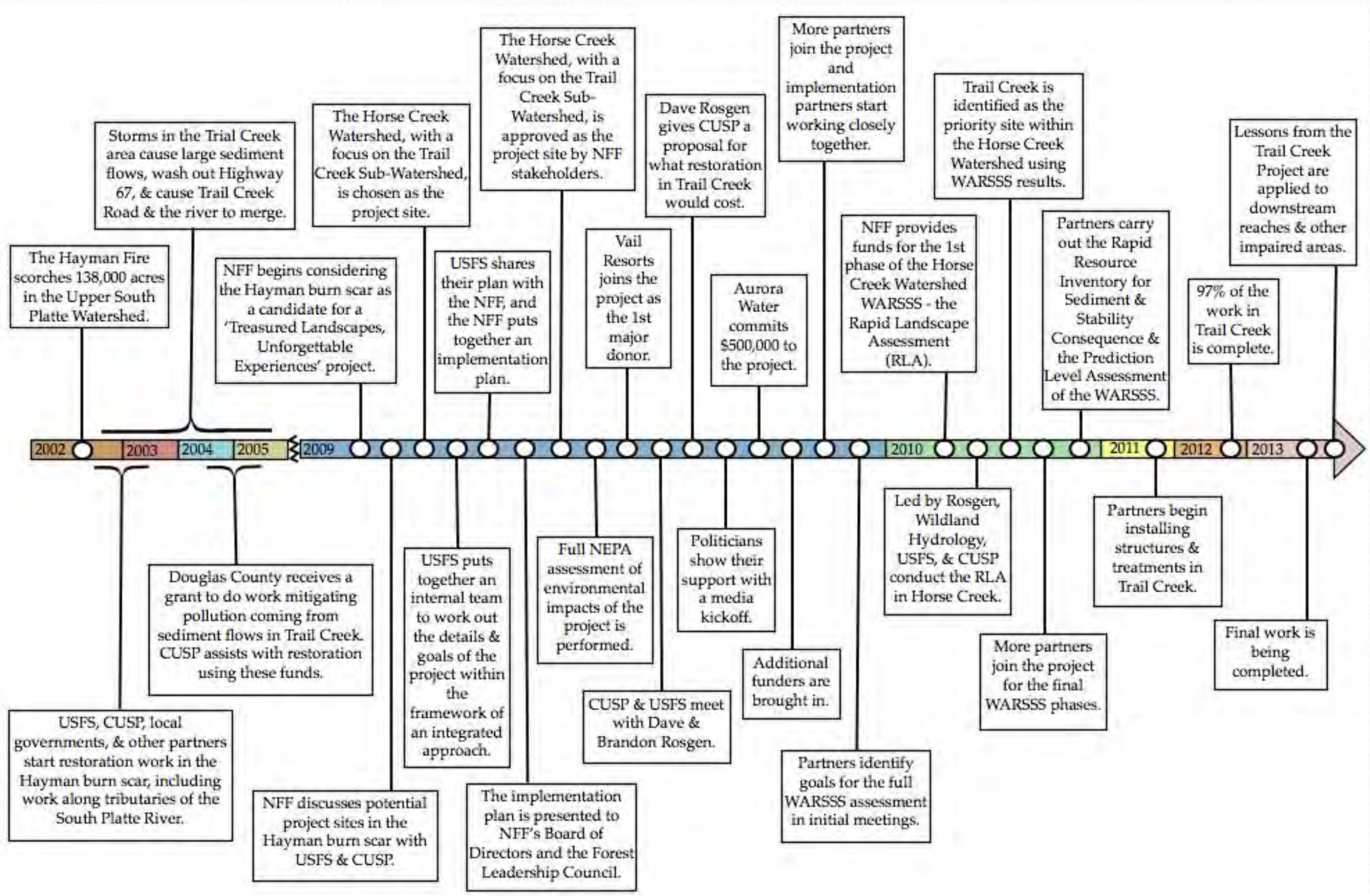
15. Be complimentary to the central tendency of natural systems

16. Provide a demonstration reach for extrapolation of similar applications

17. Provide an opportunity for research and restoration monitoring



Timeline



Timeline

June 8, 2002 - Hayman Fire starts

July 2, 2002 - Hayman contained

July 8, 2002 - Forest Service transitions to Burned Area Emergency Response mode [aka, the BAER Process]. Work includes seeding, mulching, sandbagging, stabilizing roads, etc.

July 22, 2002 - First flood within Hayman scar (flooding continues through 2014 as this report is being developed)

October 15, 2002 - CUSP begins managing the Hayman Recovery Assistance Center (HayRAC) through a memorandum of understanding (MOU) with the USFS.

November 12, 2002 - NFF provides CUSP with the first grant to assist with Hayman recovery.

2004 – Douglas County got the first 319 Nonpoint Source grant from the Colorado Department of Public Health & Environment to do work to mitigate the pollution coming from sediment flows in Trail Creek. CUSP began initial restoration work in Trail Creek with these funds.

July 7, 2006 - Storms in the Trail Creek area caused large sediment flows and washed out highway 67. Cost to state to rebuild: $7 million.

2009 - NFF sat down with the Forest Service and CUSP and chose a site on the landscape that fit with Forest Service priorities, fit with NFF priorities, and NFF was confident they could raise money to restore.

The Forest Service put an internal team together to come up with the details and goals of the project within the framework of an integrated approach (number of acres to be treated, restoration of butterfly habitat, sub-watersheds to focus on, number of acres to be seeded, areas to focus the replanting of trees, etc.)

The Forest Service plan was sent to the NFF, and the NFF put together an implementation plan, with a target audience of donors.

The implementation plan was presented to NFF's board of directors and the Forest Leadership Council, and the site was approved.

Full NEPA assessment of environmental impacts began.

Vail Resorts was brought in as the first major donor.

Dave Rosgen was contacted and CUSP and the Forest Service met with Dave and Brandon Rosgen and looked at the site.

Rosgen gave CUSP a proposal for what the restoration work would cost.

Media kickoff with public political support.

Aurora Water committed $500,000.

Goals for the full WARSSS assessment were identified by the original team in the first couple meetings.

2010 – NFF provided funds for the first phase of WARSSS, Rapid Landscape Assessment (RLA) in Horse Creek. Trail Creek was identified as the priority site.

RLA was done with the Rosgens, CUSP, and Forest Service staff.

RISCC and PLA assessment were performed and a full Trail Creek plan was generated

More partners were brought in as we moved to the next phase of the WARSSS assessment

2011 – Partners began putting in the first in-stream structures.

2012 - 97% of the Trail Creek work was completed

2013 & 2014 – Some final work was completed including both heavy equipment and hand crew projects.

2015 and beyond - Partners plans to use the experience from Trail Creek to continue moving down stream and implementing restoration projects in West Creek, Camp Creek, and Horse Creek among others.

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Lessons Learned

"We should not look back unless it is to derive useful lessons from past errors, and for the purpose of profiting by dearly bought experience."

– George Washington

A tree planted by volunteers thrives in Trail Creek, 2012

Purpose & Introduction to Lessons Learned

The purpose of this Lessons Learned chapter is to tell the *story,* based on personal observations of stakeholders in the Trail Creek River Restoration Project, in order to provide others who are interested in participating in a large-scale, collaborative project a reference document for lessons on the funding, social, and technical implementation aspects of what we did.

From start to finish, the Trail Creek Project was highly collaborative. To achieve the kind of holistic, landscape-scale vision the initial partners (the National Forest Foundation, Pike National Forest, and Coalition for the Upper South Platte) had for restoration work in Trail Creek, a much larger coalition of different partners with different funding mechanisms and expertise were brought together. By working cooperatively on such a large project, partnering organizations from all sectors were able to use resources more effectively, accomplish project goals efficiently, and learn a great deal from one another. Restoring an extensive stretch of channel and watershed successfully could not have been accomplished without this high level of collaboration.

Lessons: Funding

Early on, NFF, the Pike National Forest, and CUSP conceptualized the Trail Creek Project as a landscape-scale project that would be driven by a holistic view of river restoration. The planned project was more in depth and multifaceted than any of the grant programs NFF had managed in the past, and therefore needed a larger base of funding in order to fully implement. A requirement of the *Treasured Landscapes, Unforgettable Experiences* campaign was to have private funds raised by the NFF matched dollar for dollar by the Forest Service as part of the public-private collaboration model. Through this model, 2 million dollars were raised and matched for a total of 4 million dollars used to support the work in Trail Creek.

Vail Resorts Becomes the First Major Funder

From the beginning, the NFF was the backbone of the fundraising effort, and brought in the first major funder, Vail Resorts. The NFF initially approached Vail Resorts because the two organizations had collaborated successfully on a previous project and Vail Resorts' CEO, Rob Katz, was on NFF's Board of Directors when NFF started thinking about doing a large-scale project in the Hayman burn scar. According to Mary Mitsos, Executive Vice President of Programs for NFF, they specifically asked Vail Resorts about their interest in funding restoration work in the Hayman burn area because Vail Resorts' funding position and interests seemed to align well with an ambitious project in the burn scar. At the time, Vail Resorts was just wrapping up some carbon offset work and was looking to invest in a large-scale project that could positively impact Colorado's environment and would be meaningful for Colorado residents.

> *"This project allowed Vail employees to connect in a very real way to the Hayman and something that was so important in the community" - Nicky DeFord, Senior Manager of Charitable Contributions, Vail Resorts*

Vail Resorts met with Forest Service and The Nature Conservancy staff several times to discuss available projects throughout the state, and which were most critical. Both the Forest Service and The Nature Conservancy stressed the need for considerable work to be done in the Hayman burn scar; the Forest Service told Vail Resorts the Hayman burn was their number one priority, and without the help of outside entities this area would never be restored. This feedback paired with the opportunity to partner with NFF through the *Treasured Landscapes, Unforgettable Experiences* campaign convinced Vail Resorts to work with NFF to fund a large project in the Hayman burn scar.

Other factors that Vail Resorts considered important in making its investment included:

- Vail Resorts wanted to be very hands-on and involved in the project they invested in. It was important to them to participate in project meetings and give their staff the opportunity to become engaged through volunteering at the worksite. Vail Resorts therefore wanted a project located close enough that significant involvement was feasible.

- Vail Resorts' corporate headquarters is in the Denver metro area and much of their clientele lives in Denver and along the Front Range. With this strong connection to Denver and the Front Range, protecting the source water for this area made for a good investment.

- With their ski area and real estate holdings surrounded by forest, Vail Resorts

Vail Resorts volunteers in Trail Creek

could potentially suffer great economic, environmental, and social losses if a catastrophic wildfire struck the Vail area. By investing in a landscape-scale restoration project in a burn scar, Vail Resorts could proactively learn lessons about addressing post-fire impacts and readily apply these lessons in the case of a large wildfire in their region.

- In 2006, Vail Resorts had partnered with the NFF to support the NFF Ski Conservation Fund. From this experience, Vail Resorts felt the NFF was highly committed and had the right partnerships in place. Vail Resorts was therefore comfortable collaborating with the NFF on such a large project in the Hayman burn scar.

- As the state's largest wildfire, the Hayman Fire was recognizable and remembered, so Vail Resorts felt a project in the burn area would be very meaningful for residents along the Front Range and throughout the state as well as for other partners such as the Forest Service and Denver Water.

Vail Resorts committed $750,000 over 3 years and provided ongoing staff volunteer support for the Trial Creek Project. These funds became the seed money for the project, and the NFF and other partners were able to leverage this money as matching funds to involve additional funders over the course of the project.

Take Home Message

When seeking funds from business donors, understand that they are making an investment, and a project has to fit their corporate interests and cultural values.

The City of Aurora Invests in the Project

The City of Aurora became another major investor in the Trail Creek Project. Aurora receives 85% of its water from the South Platte River Basin, either as natural flows to the basin, or transmountain diversion flows from the Colorado and Arkansas Rivers. The Hayman Fire and post-fire flooding and debris flows directly impacted Aurora's water supply. With this in mind, the Forest Service and NFF approached Aurora to ask them to consider Hayman restoration for some of the money they had earmarked for forest restoration and watershed protection.

> *"We would consider doing a large-scale project like this again based on our experience with Trail Creek" - Mike McHugh, Environmental Permitting Coordinator, Aurora Water*

When the Forest Service and NFF approached them, Aurora was already aware of the project through staff involvement on the South Platte Enhancement Board and CUSP Board of Directors. Through further discussions, several factors helped convince Aurora to commit significant funding to the project:

- The core group of partners had a clear plan for the direction of the project.
- Vail Resorts and others had already committed funds, making Aurora feel more confident in doing so as well.
- Aurora was in the midst of contending with the effects of another fire, the Buffalo Creek Fire of 1996, on their water supply. Aurora had committed a significant amount of resources to dredge one of their reservoirs, Strontia Springs Reservoir, because large sediment flows coming off the burn area had degraded the reservoir. The Aurora City Council and committees involved in funding decisions for the Trial Creek Project were therefore very anxious to prevent similar impacts from the Hayman Fire and considered Trail Creek restoration a good investment.
- Aurora's contribution would be matched by money from the Forest Service through the NFF, so Aurora would get more from their investment.

The city of Aurora gave $500,000 over 2 years, which along with Vail Resorts' contribution catalyzed more giving from a variety of partners.

Take Home Message

As with business donors, government entities are often making an investment, with the intent of reducing costs or future regulatory burdens.

Bringing in Additional Funders

After the core group of funders was established, momentum for funding the project began to build. In 2009, NFF hosted a media event at the Denver Center for the Arts to kick off the project. The guests included Colorado Governor Bill Ritter, Denver Mayor John Hickenlooper, Senator Mark Udall, and other political figures. While the project would have gone forward without public political support, the media event helped spread the word about the project, especially in the foundation community, and was beneficial for Vail Resorts.

"Having the core group of funders committed created a ripple effect through all of the organizations to seek and secure more funds for the project" - Randy Hickenbottom, USFS Ranger

As awareness about the project grew and potential funders became more confident the project would progress thanks to Vail Resorts' commitment, more grants and donations began to come in. Funders were interested in being involved and attaching their name to what promised to be a very high-caliber project. This became particularly true when the initial phase of the assessment was funded and completed.

The NFF brought in the majority of funding, which was matched dollar for dollar by the Forest Service. Some of the funding was channeled through CUSP and provided matching funding CUSP could leverage when seeking additional grants. Using this to their advantage, CUSP brought in an additional $300,000 in funding for the project. These additional grants became very important because some of NFF's funds stipulated money was to be used exclusively on federal lands. Since work on private lands was essential for the landscape-scale project, these non-specific funds were crucial to the success of the project.

Challenges – Partnering with Funders

The NFF will not raise funds for some work-site necessities, such as parking lots, because they most often cannot get donations for these project necessities. Funding for these items had to therefore be secured elsewhere.

A challenge throughout the process was helping Vail Resorts' local communities and employees understand why Vail Resorts was working in a different part of the state rather than focusing on environmental needs directly in their communities. Vail Resorts had to communicate why the Trail Creek Project was critical for the state of Colorado and why Vail Resorts needed to be a part of it to their community and employees on a regular basis throughout the project.

As a corporation coming in as a funder, it was initially frustrating for Vail Resorts to adjust to a slower timeframe than they were used to. Vail Resorts was used to moving at a faster pace, but for Trail Creek, things moved more slowly to accommodate the steps needing to take place per federal government requirements. However, this project helped Vail Resorts understand how to be more thoughtful and take the time to ensure the right people and resources were involved to do the work in the most constructive way.

Funding was very complex. Different funds had different stipulations attached and different dates they would become available. Therefore, it was very difficult to keep everyone involved up to date on project funding at all times.

Highlights – Partnering with Funders

Bringing in a major donor - Vail Resorts in this case - helped speed things along; it would have been much harder to raise $2 million to get the work done without having this initial commitment.

The momentum created helped to continuously bring in funders.

The Trail Creek project demonstrated to Vail Resorts that public-private partnerships can be really effective, and these collaborative projects can find a lot of success by involving on-the-ground local nonprofits. Vail Resorts has therefore continued to work with NFF on projects in Eagle County, Summit County, and the White River National Forest following their involvement with the Trail Creek project.

This project allowed Vail Resorts employees to connect in a very real way to the Hayman burn scar and be involved with a project that was extremely important for the state.

Vail Resorts learned funding projects through a public-private framework in partnership with nonprofits and the federal government results in a much greater impact.

Rather than funding a project and walking away from it, it is more rewarding to continue involvement, through employee volunteer workdays and the like, throughout the project. Vail Resorts has brought this model of continued engagement to their other partnerships.

Based on the outcomes seen thus far, the city of Aurora, including the mayor, has been pleased with Aurora's involvement in the project.

Compared to more typical Forest Service projects, this project was much less limited by funds.

Having the ability to join funds together was more cost effective and eased financial burden on individual parties.

Lessons Learned – Partnering with Funders

Having existing relationships with possible donors can help convince them to step up with major funding commitments for a project.

Matching project goals of a potential project with a funder's goals for giving is and important initial step.

Having a major funder commit early can help bring other funders to the table.

Building awareness of a potential project through many different avenues can help secure funding.

Laying out a clear plan of action can help convince funders to get involved.

Prior experience with the consequences of similar situations can help convince potential funders to get involved.

Those planning the project should be aware of what funders will and will not cover, so excluded items can be built into budget planning.

Fundraising is more effective and can lead to a more successful project when multiple organizations are fundraising and leveraging seed money.

For a major donor, it is important not only to give money but also to get employees involved through volunteer workdays and on-the-ground engagement so employees can have a personal experience with the work being funded in the community.

Securing Forest Service Funding

As a requirement of the *Treasured Landscapes, Unforgettable Experiences* campaign, the Forest Service pledged to match any private funds raised by the NFF dollar for dollar. In early discussions between the Forest Service and NFF, the amount of funds the NFF would be able to raise for the project was unclear. Although a dollar amount was not established at the onset, an initial commitment to participate was made at the national level by the act-ing Forest Service Chief. In 2009, when the Forest Service Chief was replaced, there was quite a bit of uncertainty about the future direction of the Trail Creek Project and whether or not the Forest Service's agreement to participate and provide funding would be upheld. Dedicating what ended up amounting to 2 million dollars in matching funds for just one project was seen as a big risk in the climate of shrinking federal budgets.

In order to move the project forward and have the federal level of the Forest Service fulfill the initial commitment, Forest Service staff at the local level had to work to convince upper level staff the Trail Creek Project would be worth investing significant resources into. A major strategy used to demonstrate the necessity of the project was to bring regional and national level Forest Service personnel out to the site to see for themselves the severity of the degradation and the far-reaching consequences of inaction. Local staff was indispensable for providing on-the-ground expertise and making the case for substantial Forest Service support. After much consideration and many discussions, the Forest Service followed through with the original commitment and provided 2 million dollars in matching funds for the Trail Creek Project.

Challenges - Securing Forest Service Funding

Declining government budgets made securing $2 million for one project very difficult.

Getting a solid commitment for funding from higher-level Forest Service staff proved challenging, especially as leadership was changing.

Limits on how certain federal funds could be used and changing requirements made finding enough money in the Forest Service budget difficult.

More money was at risk because the scale of the Trail Creek Project was larger than most Forest Service projects in terms of both size of the watershed and the amount of money needed. The higher level of risk made Forest Service leadership more uncertain about committing the necessary funds.

Highlights – Securing Forest Service Funding

Having existing personal relationships with regional and national staff was helpful for those at the local level working to secure the funding.

The Forest Service has been able to use lessons learned from funding the Trial Creek Project to find funding for restoration in areas affected by another devastating Colorado fire, the Waldo Canyon Fire of 2012.

Lessons Learned – Forest Servicing Funding

Agreement is needed at all levels of the Forest Service to secure funding; personal relationships can help facilitate staff in different offices coming to an agreement.

Written funding agreements, signed by the correct leadership, should be in place at the beginning of the process.

The Forest Service may not be able to fund individual projects at this level in the future because regional offices usually do not have millions of dollars available in discretionary funds. Partners may therefore need to move away from the expectation that the Forest Service can match funds for multi-million dollar projects.

Forest Service staff should understand there are ways to get projects done that do not involve funds coming through the Forest Service.

Managing the Flow of Funds

Funds were dedicated to the Trail Creek Project from many different sources, so coordinating and managing the money for the project was a huge task. Point people from each of the 3 organizations involved in the project from the onset – NFF, the Forest Service, and CUSP – coordinated closely to ensure the funds were managed properly. Because the Forest Service must carry out a competitive bidding process for any contracts they fund and are restricted in how federal funding can be spent, it was critical to have money flow through CUSP. By feeding funds from federal, state, and local agencies through CUSP, the funding mechanism for work in Trail Creek became more adaptable and responsive to what was needed on the ground. CUSP contracted with the NFF, the Colorado Department of Public Health and Environment, other government agencies, and private contractors over the course of the project.

Lessons: Implementation

Just as important as having funding partners committed to the project was bringing in the right cadre of partners for project implementation. Some implementation partners became involved before funding was established; others joined after as the project progressed and evolved through the early planning stages.

"The Forest Service was very excited about the prospect of working with the National Forest Foundation on a Treasured Landscapes project" - Brian Banks, USFS GIS Systems Specialist

Initial investment from the NFF and Vail Resorts was an important driver for getting a variety of organizations with different skills and expertise involved, and once major funding was committed, the primary core of partners was able to focus on working with potential implementation partners to bring them onboard.

Through existing relationships and previous partnerships, the NFF, Forest Service, and CUSP were able to identify other partners that could contribute to the success of the project. Once approached, other partners were generally eager to participate in such a new and exciting project. Because very little controversy surrounded the project – the general consensus in the community and organizations across different sectors was that work in Trail Creek was necessary and would be highly beneficial – initial partners did not need to spend very much time or effort convincing others to get involved. The one major uncertainty was whether or not the project could reduce sediment by the significant amounts initially proposed.

"NFF was the catalyst for the Trail Creek Project" - Dana Butler, USFS Hydrologist

Nonprofit Organization Participation

Having high-capacity, local nonprofits with different skill sets involved in the project was essential for the attainment of project goals. Nonprofits that contributed to the project included:

- CUSP acted as the lead on the project and handled the flow of funding as well as the contracts with NFF, Colorado Department of Public Health and Environment, county governments, the Forest Service, private companies, and other entities.
- Rocky Mountain Field Institute (RMFI) came in as a third party to assist with monitoring, and ultimately also provided boots-on-the-ground field crew workers to implement projects and bring volunteers to the project.
- The Mile High Youth Corps (MHYC) helped with on-the-ground work and implementation. Youth Corps funds positions for young people through seasonal jobs. The MHYC and CUSP had worked together for years, and so CUSP helped direct the MHYC teams' efforts at assisting with project implementation
- Wild Connections, a small local nonprofit worked on smaller, complimentary programs during the first year of the pro-

Mile High Youth Corps employees stabilize a headcut in Trail Creek ject, bringing several volunteer groups out.

- Volunteers for Outdoor Colorado (VOC) assisted with on-the-ground work by coordinating several VOC-led volunteer projects during the project.

As the two nonprofit organizations with the biggest roles in the project, CUSP and RMFI decided to draft and sign a two-page Memorandum of Understanding (MOU) to clarify each organization's role and make the process smoother. The MOU was signed shortly after it became clear both organizations were interested in the project. The document established:

- Why the organizations wanted to work together
- What each organization's role would be
- How the organizations would communicate with each other
- What each organization hoped to gain from the experience
- What each organization would like to see happen over the course of the project

> *"Bringing in Rosgen was a game-changer" - Denny Bohon, USFS Fish and Wildlife Biologist*

Involving Wildland Hydrology

As the core group of partners began considering the skills and knowledge needed to complete a holistic, landscape-scale project to address sediment flow and degradation in Trail Creek, all involved realized the expertise required was above and beyond the capacity of the group. Through conversations between the Forest Service and CUSP, it was decided Dave Rosgen, renowned hydrologist and creator of the Watershed Assessment of River Stability and Sediment Supply (WARSSS) methodology, should be contacted for input.

At the time, several local Forest Service employees were taking Rosgen's Wildland Hydrology course and brought in pictures of the destructive sediment movement in Trail Creek. The Forest Service encouraged Rosgen to come look at the site and get involved. In 2009, CUSP called Wildland Hydrology, Rosgen's consulting company, to check on his availability to develop a WARSSS analysis for the Horse Creek Watershed. Although Rosgen had not worked with CUSP before, he agreed to come out to Trail Creek with his son and consulting partner, Brandon, and discuss possible solutions with CUSP and the Forest Service. The Rosgens recommended performing a Reconnaissance Level Assessment (RLA), the first and most generalized phase of the WARSSS, to identify areas in the Horse Creek Watershed that were contributing excess sediment to the system. This would help pinpoint the area most in need of restoration work and give a scientific basis for proceeding with the project.

"I saw all this great effort and people working toward a common goal to make a difference and wanted to be part of that" - Dave Rosgen, Hydrology Expert, Wildland Hydrology

After seeing the project area and discussing the project further with the Forest Service and CUSP, Wildland Hydrology agreed to become involved. CUSP and Wildland Hydrology drafted a contract for Wildland Hydrology's work, and the NFF provided funding for a RLA of Horse Creek in 2010. Project partners could normally not afford to hire Wildland Hydrology because Dave Rosgen is the leading expert in river restoration, but he came down in price and worked out lower rates for his subcontractors because he was interested in the project.

The Rosgens were motivated to work on the project, and commit their time for a lower rate because they:

- Wanted to set an example of how the restoration community can go about restoring disturbed areas
- Wanted to provide an example of what should be considered for post-fire rehabilitation and restoration in a representative reach of an affected watershed
- Saw this project as a great platform to run a WARSSS analysis while doing something that would have a positive impact on the burn area
- Were excited about the collaboration between federal, state, and local agencies; private funding partners; nonprofit organizations; residents; and volunteers
- Wanted to train the other partners, particularly the Forest Service staff, on how to carry out a WARSSS assessment and plan and implement a large-scale restoration so project partners could use these methods for future river restorations
- Wanted to influence the Forest Service Burned Area Emergency Response (BAER) process in the long run. BAER traditionally has focused primarily on

sedimentation from hillslopes, but a major source of sediment is often water channels. Rosgen's WARSSS method captures information about both sources, and the Rosgens believe this method would be more valuable for the BAER program than current assessment processes.

Challenges – Bringing in Implementation Partners

Some partners were initially skeptical that sediment could be reduced so significantly.

Some nonprofits could not commit until they were sure sufficient funding was in place.

The nonprofits had to learn how to collaborate with each other on a much closer level than they ever had before, and they all had to recognize the strengths and cultural differences between their different organizations.

Highlights – Bringing in Implementation Partners

The lack of contentious issues surrounding the project made bringing partners together much easier.

The coalition of partners came together quite naturally because many partners had worked together before and everyone involved was excited about the project.

The initial project catalyst, NFF, had already been working in Colorado, so the other partners did not feel that NFF came in and took over.

The establishment of a MOU between CUSP and RMFI early on allowed for the relationship to be clear and the work to be completed more efficiently.

Contracting with Wildland Hydrology was pivotal for the project's success and expedited project completion. Having a nationally recognized expert on board helped allay fears and encouraged external agencies, such as the Army Corp of Engineers, to embrace such a large-scale endeavor.

The Rosgens taught Forest Service staff, CUSP staff, and others involved in the project how to plan and implement comprehensive river restoration using the WARSSS methodology. This knowledge and skill set continues to benefit the local community.

Lessons Learned – Bringing in Implementation Partners

Recognizing the skills and expertise needed and which organizations and individuals should be involved in the project early in the process is critical to successfully completing the project in a timely manner.

Having a facilitating organization that is established in the project area is important for bringing partners together.

Making each partner's role in the project clear from the onset makes collaboration and work more effective.

Having a nonprofit organization – CUSP in this case – negotiate with contractors greatly increases the likelihood of signing with the preferred contractor – Wildland Hydrology in this case. The Forest Service does not have the same flexibility in hiring preferred contractors because of strict government contracting restrictions.

Large collaborative projects provide a great opportunity for the spread of knowledge, skills, and techniques among partnering organizations that can be used in future projects.

Coordinating Stakeholders

"We must use this collaborative approach when working on complex projects because it's the right way to do them" - Denny Bohon, USFS Fish and Wildlife Biologist

Once all of the partners interested in the project were brought on board, communication and coordination became paramount. Working with federal entities, state government, two counties, several nonprofit organizations, contractors, and private citizens required collaboration between many groups with different interests. Achieving project goals with so many organizations involved required clear and constant internal and external communication. Trust, respect, and positive working relationships among partners were essential for cooperation and solving issues that arose throughout the project. The project was successful in large part because stakeholders communicated effectively with one another.

Coordinating Council

As part of the design of *Treasured Landscapes, Unforgettable Experiences* initiative, the NFF put together a coordinating council to think through communication and fundraising issues. Council members were recruited by the NFF based on the NFF's identification of stakeholders interested in the process. The council met a few times per year as the project progressed, and helped plan the 2012 Hayman Science Symposium to share information and research done on the Hayman Fire.

Organizations involved in the council included:

- Aurora Water
- Coalition for the Upper South Platte
- Colorado Division of Wildlife
- Colorado State University
- Denver Water Department
- National Forest Foundation
- The Nature Conservancy
- Rocky Mountain Field Institute
- Rocky Mountain Research Station
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- Vail Resorts

Project Facilitation

As the coalition of partners came together and began delving into the project, it became clear a primary facilitator was needed to ensure all project efforts were coordinated, the project stayed on track, project steps were completed in the correct sequence, and communication stayed open between the different entities involved. Carol Ekarius, CUSP's executive director, assumed the role of the primary facilitator early on. Having a facilitating point person from a local nonprofit that had negotiated government contracts, worked with various funders, was known and respected in the community, was involved in the project from the onset, and had collaborated with nonprofit and government partners previously, helped move the project along in a more coordinated fashion. The coordination between CUSP and the Forest Service was particularly important. CUSP and the Forest Service had developed a certain level of trust and respect after working together for over 10 years on various projects prior to the Trail Creek Project. This long-term relationship and

"We cannot do this type of project without high capacity nonprofits at the table"
- Mary Mitsos, NFF Vice President of Conservation Programs

CUSP's experience and accomplishment working with the Forest Service on projects were essential because so much of the project occurred on Forest Service lands and both CUSP and the Forest Service were critical stakeholders throughout the process. Bringing someone in from outside of the local area that was not familiar with the region, was not known in the community, and had not worked closely with other local partners would not have worked nearly as well.

"Having CUSP in particular, not just any nonprofit, was extremely important" - Denny Bohon, USFS Fish and Wildlife Biologist

As the central coordinating organization, CUSP acted as the intermediary between all the other partners. CUSP facilitated procurement of special permits required by the counties in which work occurred, obtained waivers for permit fees, handled paperwork for the project, ran interference when problems arose, ensured everyone was moving forward with the work, and helped hold the coalition together. Information was fed through CUSP and communicated to the rest of the partners through one central entity rather than uncoordinated cross-communication between multiple organizations. This structure enabled all partners to be well informed, which helped smooth the way for everyone to work together effectively. Having one organization take the facilitation role for the project also expedited the process because it freed up other partners to focus more completely on the on-the-ground work. Wildland Hydrology, in particular, was able to concentrate on the scientific assessment of the watershed and the strategies for restoring the area because the usual requirements of contractors, such as securing permits, filling out paperwork, and coordinating among partners, were taken care of by CUSP.

Effective Communication

The Trail Creek Project was organized differently than much of the work partnering organizations had done previously. Typically, two organizations would work together, with one entity providing funding and the other carrying out the work. However, for this project, there was not just one leading agency, but many agencies were able to take on leading roles, with money coming in from multiple organizations. Due to the nature of the project, people with many different expertise were able to get involved, and the success of the project hinged on bringing together these many sources of knowledge and funding. With such a large and varied group of partners, effective communication was essential to moving the project forward.

“Good relationships are essential to making these types of projects work” - Denny Bohon, USFS Fish and Wildlife Biologist

A great advantage for the coalition was that many of the partners involved in the project had worked together before. Personal relationships had formed through years of previous collaborations between partnering organizations, and made open communication much easier. The established ease of communication between organizations that knew each other well also helped facilitate bringing new partners into the group. The full coalition of partners quickly became comfortable communicating with one another and solving problems together, which ultimately made this nontraditional project model effective. A critical element of the coalition’s communication strategy was regular meetings between the on-the-ground group of partners. These face-to-face meetings helped the implementation process run much more smoothly. In addition to open communication, the energy of the individuals involved in the project and the desire to get something important done in the watershed helped strengthen partnerships and accelerate progress.

Carol Ekarius, CUSP Executive Director, leading a tour in Trail Creek

Communication throughout the project went fairly well, but could have been improved. Some project goals and organizational roles were not clear from the beginning of the project, which created some tension between project partners during the course of the project. Very high expectations of what could be accomplished in the allotted timeframe by some partners also strained relations to some extent. As with any highly collaborative process, much time and effort was committed to communicating with partners and sharing knowledge, which at times slowed progress. Additionally, with so many decision-makers, there were a few instances of one person or organization making a decision that created unforeseen consequences for the rest of the group. For example, a decision to expand the project area resulted in extra work to get the additional clearances necessary to spend federal government money. However, nothing rose to be a critical issue because partners were able to work together effectively to resolve problems.

Working with Private Landowners

The Trail Creek sub-watershed spans public and private land. With a goal of completing a continuous and comprehensive landscape-scale project in the sub-watershed, it was necessary to work with private landowners along Trail Creek and gain permission to operate on their land. The majority of the work needed was to take place on Forest Service land, but a few key stretches of stream were located on private land and needed to be accessed in order to get the hydrology to work throughout the system. Having suffered from the Hayman Fire and its after effects, landowners were already disconcerted and were initially not interested in the government working on their land for this project. Additionally, the Forest Service lacks the flexibility to do much work with private landowners and are restricted to only working on federal lands, so it was critical that another partner take the role of working with private landowners and facilitating work on private land. CUSP was a natural fit for this role.

> *"Being a nonprofit gave CUSP leverage. We were able to give an earnest appeal because this work was central to our mission and we weren't in it for any other reason"*
> *- Carol Ekarius, CUSP Executive Director*

CUSP had been involved in the Trail Creek area doing Hayman restoration since shortly after the fire. Through this work, the local community became familiar with CUSP and recognized CUSP was committed to doing good work to mitigate post-fire impacts. CUSP established relationships with the landowners through their early restoration work, and this credibility with citizens became critical to getting two key landowners to agree to have work done on their land. Having Dave Rosgen talk with the landowners to explain the aim and methods of the work also helped build trust and further smoothed the way for cooperation with the community.

> *"Internal coordination within an organization like the Forest Service is very important and should start from the beginning"*
> *- Sara Mayben, USFS Renewable Resources Staff Officer*

Role of the Forest Service

When local Forest Service districts first started discussing the possibility of working with the NFF on a *Treasured Landscapes, Unforgettable Experi-*

ences project, they knew this was a chance to do something very different from any project they had previously worked on. The Forest Service typically works on smaller-scale projects with fewer partners, and previous burn area emergency response efforts had primarily focused on just reducing the post-fire threats to life and property. Shifting from focusing on one road, one trail, or a short stretch of stream to embarking on a holistic watershed-scale project that tackled so many aspects of restoration required a considerable change in how this project was thought of and managed from the Forest Service's perspective. Initially, the Forest Service was uncertain about how large of a project was feasible and what role they would play. As preliminary talks progressed, the Forest Service helped define the scope of the project and how the districts and other partners would be involved.

"Having various people take on leading roles at different times was a testament to the ability of partners to work together and coordinate efficiently" - Randy Hickenbottom, USFS Ranger

Forest Service personnel were heavily involved in planning and oversight, with less time spent doing on-the-ground implementation. Significant planning by the Forest Service in the initial stages of the project enabled the project to progress once additional partners committed to participating. The same set of major partners worked on both design and implementation, making the project a more complete package than typical Forest Service projects. Having very strong relationships between partnering organizations and highly committed people involved enabled this unique approach to project planning and completion to work well.

"The Forest Service was able to accomplish way more using this process. We were part of a full-blown restoration that will stand the test of time" - Dana Butler, USFS Hydrologist

The NFF specified early on that the project be completed in 2 to 3 years to coincide with the 10th anniversary of the Hayman Fire. In some cases, this shorter window of time meant altering the sequence in which clearances, required processes such as NEPA, and the work were completed. The speed of the project and the Forest Service's commitment to other project partners also heightened the agency's focus on the Trail Creek Project. With the amplified logistical challenges of having so many people involved and a shorter time frame for project completion, the Forest Service found they needed to be very flexible throughout the process, be comfortable with some uncertainty, and accept they would not have the same amount of control as they would during a typical project.

> *"This project would not have worked if brand new partners that had never worked with the Forest Service before were brought in" - Mary Mitsos, NFF Vice President of Conservation Programs*

Taking on a large, multifaceted project required much internal coordination among Forest Service employees in addition to external communication with partners. The District Ranger position for the Pikes Peak Ranger District, where most of the Trail Creek work was planned, was vacant at the start of the project. This vacancy made Forest Service coordination more difficult. The District Ranger from the South Platte Ranger District, who was more removed from the project physically, had to step into the leading role as the deciding official for the agency. The Forest Service manager in charge of coordinating externally with partners was also based out of the South Platte Ranger District. Having representatives from the Forest Service to serve as point people and spearhead coordination was essential for project management, but because those in charge of coordination were geographically more distant from the project and were coordinating between two offices - the Pikes Peak Ranger District and the South Platte Ranger District – the process was more arduous.

In addition to coordination of the project itself, the Forest Service also had a major role in spreading knowledge and skills learned over the course of the project. In addition to hosting Dave Rosgen's hydrology design class, which was offered free of charge to participants in the project with the help of Wildland, a nonprofit organization, the local Forest Service staff have been instrumental in sharing knowledge with other Forest Service districts and at the national level.

Challenges – Coordinating Stakeholders

Communicating and coordinating among so many different partners was difficult and very time consuming at times, but also very necessary.

Ensuring all the right entities were involved and aware of the project was challenging.

Some challenges arose with timing contracts appropriately to have all the pieces in place and in the correct order.

Working across two different counties with different permitting processes made obtaining the necessary permits more challenging, but having worked with county personnel on previous projects eased the burden somewhat.

Many small complications added up to be challenging, but no major setbacks arose.

Coordinating and carrying out the project between two Ranger Districts because the District Ranger position at the Pikes Peak Ranger District was vacant was more difficult than if the project would have been primarily concentrated in one Ranger District.

Some partners had very high expectations coming in, making it more difficult for the coalition to come together and decide what would be reasonable to achieve.

Too many decisions were made externally for some of the project goals, which hindered progress.

One decision by one person or partnering organization can create many, sometimes unforeseeable, consequences for the rest of the partners.

Highlights – Coordinating Stakeholders

Coordinating among many partners was made much easier because the Trail Creek project was not a contentious issue.

Having a primary point person from a local nonprofit that had negotiated government contracts, had worked with various funders, was known and respected in the community, and had collaborated with nonprofit partners helped move the project along in a more coordinated fashion.

Those involved were able to pull together government entities, nonprofit organizations, and private property owners to make a truly remarkable project come to fruition.

All involved at the local level were committed and enthusiastic about the project, which helped motivate people to keep working together.

By pulling together a large number of partners with different areas of expertise, the coalition brought together different sources of knowledge, which was crucial for the success of the project.

The structure of the project provided everyone involved with a unique learning opportunity.

By working together, everyone was able to achieve much more than any individual organization could have achieved on its own.

Involved organizations had a high level of trust and respect for one another and were excited to engage with each other on such a large project.

With such a high level of collaboration, the coalition was able to do better work and focus on proactive solutions rather than reactive fixes.

Those involved experienced much personal growth through meeting new people and making new partnerships. This proved to be a very enjoyable part of the process.

With this type of collaboration, partners have the chance to communicate and share this approach and information with others.

On the whole, all entities were well informed and worked well together.

Everyone involved stepped up and brought something to the project.

The project was more meaningful because a highly collaborative, holistic approach was taken.

So many entities were able to come together and work productively because partners developed positive working relationships early on.

Partners were able to be very flexible during the project to figure out and use the approaches that worked the fastest, best, and were most cost-effective.

Partners were able to resolve issues that arose, so nothing came to be a critical issue.

Good communication with the community was achieved.

The same set of people was involved from design through implementation, making the Trail Creek Project a more cohesive project.

Everyone involved was excited about working on the project and committed to its completion, so work was completed in a timely manner even without the usual supervision structure in place.

Lessons Learned – Coordinating Stakeholders

It is important to build excitement around a project to keep partners engaged and moving forward.

When coordinating multiple partners, the facilitator should already be established in the area, be familiar with the partners involved in the project, and be involved from the onset.

Face to face meetings should be held frequently from the onset of the project.

The coalition should decide on a deadline for when decisions must be made, so that fewer mid-course changes that slow the process are made.

Roles and responsibilities of each organization should be clearly defined at the beginning of the project.

Partners should expect that these projects take time to maintain the level of communication needed to keep all parties up-to-date.

Partners need to be comfortable with some uncertainty because there is always some ambiguity involved in these types of projects.

Everyone must be flexible, especially with timelines and specificity.

All involved need to be able to adjust and be comfortable letting others take the lead at different times.

Bringing in organizations that are familiar with each other and have worked together before makes cross-collaboration much easier.

The whole coalition must work together and believe in the project for it to be successful.

Pulling in multiple partners with different expertise and funding sources is important for making large, holistic projects work.

Partners must trust each other.

This collaborative framework is transferable to other complex projects.

Good communication with the community is a must. This is often best done through an entity (like a local nonprofit) the community is familiar with and trusts.

Forest Service

Internal coordination within an organization like the Forest Service is very important and should start from the beginning.

For this type of project, there must be willing Forest Service partners that want to work on a project under a different framework with multiple partners.

The Forest Service needs a leader internally that can coordinate across the board.

Working within one Forest Service District on a large project is easier than working across two offices.

Forest Service staff need to accept that, unlike when all the funds flow through the Forest Service, they will not be able to control all the contracts or all the people working on the contracts with these large-scale highly collaborative projects

Leveraging Resources

Having multiple organizations involved in the Trail Creek Project enabled the project to move forward with enough funding and resources without straining any one entity beyond capacity. By pooling resources, expertise, and funds, each organization's time and resources went further toward achieving project goals.

"The project impacted Forest Service resources significantly because so many staff were involved, but the final product far outweighs what we sacrificed" - Dana Butler, USFS Hydrologist

National Forest Foundation

The NFF committed significant resources to the Trail Creek Project. The NFF was able to leverage these resources and make this project a Treasured Landscapes, Unforgettable Experiences site because the area met all the necessary criteria for the designation. The Hayman Fire's notoriety and wide-reaching impacts garnered community interest and allowed the NFF to raise considerable funding for the project.

Coalition for the Upper South Platte

NFF's initial investment along with funds committed by other entities, such as Vail Resorts and the Forest Service, enabled CUSP to get involved in the project. As more funding became available, CUSP was able to commit more staff time and resources to the project. However, CUSP, like the other organizations involved in the project, did not halt all other activities to focus solely on Trail Creek. Through the multi-organizational partnerships, each entity used resources from other partners to compliment what each organization was contributing to the project. For example, contractors owned or rented the heavy equipment needed, thus freeing up CUSP to use available funds for other project necessities. This collaborative framework created less strain on time and money for all involved, and enabled CUSP to leverage funds from the various donors to use as matching funds for additional grants.

Forest Service

From a resource point of view, it made good sense for the Forest Service to commit heavily to the Trail Creek Project. The

Forest Service had always wanted to do more in the Trail Creek area, and with the Treasured Landscapes, Unforgettable Experiences project, NFF provided the opportunity and level of funding needed to make significant progress in Trail Creek. The blend of public and private funds for the project created more opportunities than would have been available if the Forest Service was the only or primary funder. Forest Service personnel, from the forest supervisor on down, were therefore quick to take advantage of the opportunity. Once the project was underway and began getting attention from other agencies, non-profits, and the larger community, the Forest Service wanted to ensure this very public project went well and accomplished what partners set out to do – make changes at a landscape scale. In order to learn as much as possible from this project and do it the right way using the best available science, the Forest Service committed to allocating the necessary resources and staff time to the project. The attention from the hydrologic community and the Forest Service at the national level motivated the forest supervisor to prioritize the project, put resources towards it, and allow staff the time to do the project well.

The local Forest Service made the project the number one priority once the forest districts committed to participating. Since the project was designated as a priority, it received priority time and resources and staff with specific skill sets were made available to work on the project. Ample resources and the ability to work with other partners helped expedite the process and utilize resources in the most constructive fashion. Although the Forest Service saw the project as a good investment, the significant amount of resources committed to this single project did strain budgets and reduce funding and time for other projects.

Challenges – Leveraging Resources

Coordinating so many resources with so many partners involved was stressful at times.

The project demanded a significant amount of staff time from many organizations involved.

Convincing higher level Forest Service staff to allow local personnel to commit so much time to one project was initially challenging.

The level of resources required by the Trail Creek Project impacted other Forest Service projects and services.

The unconventional manner in which resources were combined meant organizations had to become comfortable with less control over the finances of the project.

Highlights – Leveraging Resources

The project's designation as a *Treasured Landscapes, Unforgettable Experiences* site enabled organizations to pool and leverage resources in a more effective way.

Partnerships allowed each organization to use resources from other entities to compliment what they brought to the project.

Individual organizations' time and funds were less strained because of the collaborative process.

Combining resources and doing much of the contracting through a nonprofit partner - CUSP in this case - opens up many different possibilities and allows for more flexibility than having the federal government do the contracting.

Pooling funds enabled existing funding to be leveraged as matching funding for additional grants, which made the money go further.

By working together, the entities involved in the project were more productive and the project was completed more efficiently.

Lessons Learned – Leveraging Resources

Having trust in other partners is essential when combining resources.

Significant investment of resources can pay off for large, collaborative projects.

Working collaboratively can reduce the burden on any one organization and expedite projects.

Project funds can be used more effectively when leveraged as matching funds for additional grants.

Planning & Assessment

The success of the project stemmed from thorough planning and scientific assessment of the Trail Creek Watershed. The systematic method used to understand the movement of sediment in the watershed resulted in actionable objectives partners used to guide the implementation phase of the project.

Project Planning

Project partners worked on planning for two year before implementation could begin. Because the project was addressing problems on a watershed scale, much time was needed to ensure well thought out plans were developed, necessary permits were secured, and required assessments were completed. The Forest Service was required to carry out assessments analyzing the environmental impacts of the project in compliance with the National Environmental Policy Act (NEPA), assessments to determine biological impacts, and assessments to examine cultural impacts as part of the planning process. In addition to required assessments to determine potential project impacts, the coalition also carried out a systematic process to figure out what the best treatment options were in the impaired watershed. This careful planning and assessment phase allowed partners to identify problems and solutions that ultimately led to successful implementation.

"Lots of folks wanted to look at hillslope processes, but it takes 60 to 80 years for hillslopes to recover; Dave [Rosgen] pointed out many of the channel processes were what we needed to address"
- Dana Butler, USFS Hydrologist

WARSSS Process

The Watershed Assessment of River Stability and Sediment Supply (WARSSS) process was used to prioritize treatment areas and determine which structures would be most effective in addressing the problems in Trial Creek. Dave Rosgen, expert hydrologist and lead contractor on the project, developed the WARSSS methodology and guided other project partners through the process.

Overview of WARSSS

WARSSS looks at the entire watershed and predicts and quantifies the amount of sediment movement as a result of a fire or other disturbance. WARSSS gauges the movement of sediment through two main processes, channel and surface erosion. Channel erosion includes streambank erosion and the influence of riparian vegetation on sediment movement. Surface erosion includes hillslope erosion and sediment from roads, trails, and other sources.

The WARSSS process allowed partners to look at the causes and consequences of river impairment due to fire by analyzing three levels of assessment:

Reconnaissance Level Assessment (RLA): The first phase takes approximately one week and is the most general of the three phases. The RLA looks at fire intensity, landforms, geology, and broad landscape characterizations to see where the major sediment supply and channel stability problems are in the area of interest.

Channel degradation and streambank erosion in Horse Creek

Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC): The second phase is more detailed than the RLA and takes approximately three or four weeks to complete. The RRISSC phase looks at specific watersheds and uses a risk rating systems to determine land use, landscape and channel erosion potential, and how possible sediment sources may interact with hillslope, hydrologic, and channel processes.

Prediction Level Assessment (PLA): The third WARSSS phase is the most detailed of the three phases. The PLA more specifically identifies erosion and sediment processes and quantifies sedimentation by process and location.

From the very first meetings between the initial project partners and Wildland Hydrology, Rosgen recommended carrying out a WARSSS to assess and more specifically prioritize the project area. Prior to Rosgen's involvement, project partners were unsure of the best way to tackle such a large, multi-faceted problem, and many assumed excess sediment was coming from surface erosion when in fact most sedimentation was a result of channel processes. The WARSSS method helped implementation partners take a very complex problem and begin to visualize the processes responsible for impairment and how to address these problems. Everyone came together to understand how to reduce erosion and identify sources of impairment with the long-term goal of sustainability.

For many implementation partners, the Trail Creek Project was their first experience with WARSSS. The coalition agreed early on that involving local partners in the assessment was important for strengthening local knowledge and skills that could be applied to future projects. Not only was the collaborative WARSSS process an opportunity for local partners to learn first hand how to perform more detailed analyses and learn new techniques, but the ex-

Sediment Source	Annual Sediment Supply
Hillslope Processes	
Roads & Trails	848 tons/yr
Surface Erosion	2,542 tons/yr
Hydrology	
Pre-Fire Water Yield: Trail Creek watershed	3,689 acre-ft/yr
Post-Fire Water Yield: Trail Creek watershed	6,560 acre-ft/yr
Pre-Fire Flow-related Sediment: Trail Creek Watershed	1,250 tons/yr
Post-Fire Flow-related Sediment: Trail Creek Watershed	20,838 tons/yr
Post-Fire Flow-related Sediment Increase: Trail Creek watershed	19,588 tons/yr
Channel Processes	
Streambank Erosion	18,118 tons/yr

Summary of the total annual sediment supply by sediment source related to hillslope, hydrology, and channel processes

Table from the Trail Creek Watershed Master Plan for StreamRestoration & Sediment Reduction

pertise of these partners also enriched and improved the WARSSS process. For example, the mapping capabilities for the assessment were improved by the introduction of geographic information systems (GIS) into the process for the first time with the help of partnering organizations. The process was therefore a great learning experience for all parties involved.

In order to assess how the hydrology of the area had changed following the Hayman Fire and identify problems, the group, led by Dave Rosgen, performed the RLA across the entire Horse Creek Watershed in 2010 with funding procured through the NFF. The RLA identified several areas within the Horse Creek Watershed as high risk. These areas – including the Trail Creek Watershed and the mainstem streams of Horse Creek, West Creek, Trout Creek, and Trail Creek – were flagged for further analysis in the second phase, the RRISSC. This more detailed assessment revealed what many had already suspected; the Trail Creek Watershed was severely impaired, was experiencing disproportionate sediment supply, and was classified as the highest priority for restoration through the WARSSS. The PLA was therefore focused on the Trail Creek Watershed and was used to pinpoint where and why erosion and unsustainable sediment processes were occurring within this sub-watershed of the Horse Creek Watershed. By analyzing the 157 miles of stream and 67 sub-watersheds within the Trail Creek Watershed, Rosgen was able to develop a restoration design looking at all of the processes involved in Trail Creek's impairment. With a conceptual master restoration plan based on a thorough and systematic assessment, the group secured a 404 permit (under Clean Water Act requirements) for implementation of all the restoration scenarios outlined in the design over a 20-year period.

More information about the WARSSS process in the Horse Creek and Trail Creek Watersheds can be found in Wildland Hydrology's Horse Creek Watershed RLA and RRISSC Assessments and The Trail Creek Watershed Master Plan for Stream Restoration & Sediment Reduction.

Technical Implementation

In-depth planning and thoughtful implementation were critical for the project's success. Scientific assessment and collaborative problem solving guided the project's design and implementation, and ultimately made the project successful in reducing sediment movement and restoring the stream.

Challenges – Planning & Assessment

The District Ranger position for the Pikes Peak Ranger District was vacant for much of the project, which made the coordination of planning and assessments on the Forest Service side more difficult.

Clearly defining the final product and measures of success in order to get everyone involved focused on the same priorities and objectives was challenging.

Highlights – Planning & Assessment

The WARSSS method is straightforward and streamlined the watershed assessment phase of the project.

Partners were able to see where the problems were because of the planning process.

The collaborative approach improved the WARSSS process, and ensured everyone involved learned something new.

Many local partners learned the WARSSS method and participated in trainings, spreading knowledge and skills that are applicable to other projects.

Learning the WARSSS process was very exciting for project partners, and provided a great opportunity for all involved to develop professionally.

Working with different organizations on the WARSSS was fun and allowed project partners to reconnect and develop new relationships.

The WARSSS methodology is being applied to other local projects, including those in Bear Creek and the Waldo Canyon Fire burn scar.

Local Forest Service personnel believe the WARSSS process is highly effective for planning Forest Service projects. The Trial Creek Project has demonstrated the utility of the process in a Forest Service setting, and now much more serious discussions of using WARSSS for a wide variety of future Forest Service projects are underway.

Lessons Learned – Planning & Assessment

Comprehensive assessments are necessary to ensure project treatments are developed from scientific data rather than assumptions about the source of the problem.

It is important to have people involved that can articulate why such a long planning process is necessary to implement these large-scale projects correctly.

Project objectives, products, and measures of success need to be unambiguously defined so a clear plan can be crafted and all partners can focus on the same priorities.

The planning process is necessary to ensure structures installed during the implementation phase work.

River Restoration

After the assessment of the watershed was complete and the design plan for restoration in Trial Creek finalized, partners began the implementation phase of the project. Construction began in the fall of 2011 and was largely completed in 2012. Most of the work was completed in Trail Creek, with a small portion of West Creek, the stream Trail Creek feeds into, addressed as well.

"It is always important to make sure the structures you're building are not fighting nature, but emulating what nature would be doing" - Brandon Rosgen, Hydrology Expert, Wildland Hydrology

Implementing a restoration plan on the scale of an entire watershed was unprecedented. This holistic approach allowed the coalition to address multiple major erosional processes contributing sediment disproportionately and impairing Trail Creek.

Implementation Partners

Dave Rosgen was the field supervisor and directed construction based on his restoration design. Led by Rosgen, Wildland Hydrology and Finup Habitat Consultants Inc. did much of the construction work. Nonprofits including CUSP, RMFI, Mile High Youth Corps, and Wild Connections supplemented this work and assisted with volunteer projects. The Forest Service was less involved with on-the-ground work than planning and coordination, but Forest Service personnel were able to participate in some aspects of construction and helped ensure the process was moving forward.

"This type of project gives people experience dealing with restoration and ecosystems, which helps us develop and carry out best management practices" - Gifford Martinez, USFS Engineer

Much of the work required for the Trial Creek restoration was highly technical and the work needed to be done consistently and correctly to be effective. Some partners and volunteers were therefore unable to become deeply involved in the construction phase of the project because they lacked formal training. Rosgen did conduct a training on how to construct the structures called for in the design plan, but more comprehensive trainings could have made such a large workforce more productive and ensured everyone was on the same page. Many partners not directly involved in construction were, however, able to learn and better understand the design methods through observation and site visits.

The Approach

Although partners were working in a unique environment on an unusually large-scale project, the work was approached similarly to restoration work in any other environment. Led by Wildland Hydrology, the partners focused on what the disturbances were leading to stream impairment and how sediment was moving in the watershed. More variables did, however, need to be considered as construction progressed because the group was addressing problems throughout a large area in a post-fire environment. The coalition aimed to emulate nature as they worked to address multiple processes in many regions throughout the watershed. A Natural Channel Design methodology was used to guide technical implementation.

In-Stream Restoration

Before (above) and after (below) in-stream restoration

The WARSSS revealed many processes, including those of the creek, the channel, and side drainage instability, were contributed to unsustainable sedimentation in Trail Creek. To address these sources, the group focused much of their efforts on in-stream construction. This involved changing the path of the channel, the elevation of the riverbed, and the flow of water and sediment.

> *"The Forest Service needed to provide 3,000 trees; this ended up looking like a lot more once we were in the implementation phase" - Carol Ekarius, Coalition for the Upper South Platte Executive Director*

Normally, it is advisable to start on the upper end of the watershed and work down, cleaning construction sites as the crew moves from top to bottom. Moving down the watershed allows the integrity of the design at each stage to remain intact as more construction is completed in other reaches further down. If moving downstream to upstream, a design implemented on the lower end can be impacted by a design completed later on the upper end through increased sedimentation during construction, with a tendency to fill in some of the pools and disturb other design features already created. Due to a problem with fish migration caused by a culvert, it was necessary for the coalition to start at the bottom and work upstream for this project. As expected, this approach created more difficulty than working upstream to downstream.

In-stream structures were installed to achieve a number of objectives built into the design of the restoration project. Objectives for structure implementation included reducing streambank erosion, providing grade control, dissipating excess energy, preventing headcutting, buying time for riparian vegetation, providing fish habitat enhancement, maintaining floodplain connectivity, protecting road fills from erosion, and generally reducing sediment supply (Trail Creek Watershed Master Plan for Stream Restoration & Sediment Reduction). The structures implemented were designed specifically for the stream type crews were working in and included:

- Rock Vane, J-Hook
- Root Wad, Log Vane, J-Hook
- Rock Cross-Vane
- Toe Wood Structure
- "Rock & Roll" Log Structure
- Rock Step-Pool Structure
- Converging Rock Clusters

"Rock & Roll" log structure

J-hook construction

Building the structures involved harvesting many green trees and gathering boulders from the area. More trees and rocks were needed than estimated, which added to the time required and cost of heavy equipment rental. Harvesting so many unburned trees in an area where very few trees escaped the Hayman Fire was disconcerting to many residents. This concern dissipated, however, as residents learned more about the project and began seeing its positive effects. The positive effects of the structures were only fully realized after rain events hit the area. Even with all the planning and technical evaluation, the group could not be completely sure of the effectiveness of the structures until rainstorms that would have previously caused flooding and significant sediment movement controlled the flow and worked as intended.

"Seeing the change, the restoration, as it happened was exciting" - Denny Bohon, USFS Fish and Wildlife Biologist

More technical information about the design and function of the in-stream structures can be found in the Trail Creek Watershed Master Plan for Stream Restoration & Sediment Reduction.

Streambank Restoration

Stabilizing the streambanks and establishing healthy riparian systems was another crucial part of the Trail Creek Project. Streambank stabilization for this project presented some unique challenges. The lower Trail Creek area is home to the Preble's Meadow Jumping Mouse, a species federally protected under the Endangered Species Act. This protection meant project partners had to comply with increased constraints during the implementation phase. Over the course of the project, construction could not adversely affect the mouse's habitat, meaning project partners had to redeem a net gain of willows in areas disturbed by excavation work. Working with heavy equipment tends to destroy vegetation, so partners needed to devise a system to maintain the riparian habitat while implementing structures. The implementation team decided to transplant the vegetation that would normally be destroyed by heavy equipment work to areas where structures had already been installed. This approach allowed partners to prevent a loss of wilzlows in the Preble's Meadow Jumping Mouse's habitat and restore riparian areas critical to the success of the project.

Volunteers help plant willows to stabilize streambanks

Another challenge to stabilizing streambanks was working in a post-fire environment in which highly erosive granite soils dominate. These soils produce high sediment loads because the soil is highly erodible. With these erosion-prone soil, project partners had to add in more requirements than normal as part of restoration and stabilization. This meant altering methods for riparian planting and changing how the stream design was carried out.

"The magnitude of the fire and the erodible nature of the soil made this environment unique" - Dave Rosgen, Expert Hydrologist, Wildland Hydrology

Much of the vegetation along the streambanks was shallow-rooted in granite, and because this soil type has little cohesion, roots would often become exposed. Project partners therefore had to use a greater number of sod mats and make much deeper depressions in the receiving areas for willow transplants. Working in the summer during a period of drought also caused problems because the granite soil retains very little moisture. To combat the willow transplants' high moisture stress, the crew had to ensure riparian vegetation was receiving enough moisture from the stream. Partners used an approach involving portable pumps and irrigation systems for newly planted vegetation over the course of the construction phase.

The erosive granite also caused partners to rethink some of the stream designs. Throughout the restoration area, crews varied meandering stream with ripple habitat for fisheries. In order to support riparian vegetation along the streambanks with enough moisture, more log structures were installed to redirect the flows away from the pools and allow a longer length of stream. This allowed more time for the riparian vegetation to take hold. A storm that hit during the course of construction demonstrated lateral stream adjustments were also needed because of the erodibility of the soil.

Hillslope Restoration

Sediment coming off the hillsides surrounding Trail Creek was another cause for concern. Building up natural landforms and installing structures on the hillsides to address this issue complimented the work being done in-stream.

Erosion control structures on the land were designed to keep sediment from entering the stream and contributing to waterway impairment. After some trial and error, partners soon discovered erosion control fabric was needed when installing log erosion barriers – logs installed across slopes to slow water and sediment. The erosive granite soil in the area necessitated this extra step, a step that would likely be unneeded in areas with different soil types.

Installment of sediment retention ponds, rebuilding landforms, reestablishing alluvial fans, and building natural features back up were also integrated into the plan to address hillslope processes and prevent sediment from entering the stream system.

Roads & Trails

Although recreational trails and Trail Creek Road, which runs along Trail Creek, were not identified as

Erosion control fabric used for in-stream structures

Hillslope stabilization

Sod mats

Sill logs installed with erosion control fabric help reestablish alluvial fans

Volunteers help with road decommission

Heavy equipment use during river restoration

the major sources of sediment, these sources were contributing to the impairment of the stream as well. Roads and trails were identified early on as problem areas; with many in the group initially believing the road was the main source of increased sedimentation. After the WARSSS, the group had a more complete picture of sediment movement. To address road and trail issues, Rosgen included a plan to relocate the road and some of the trails in the project design. At first, some residents were upset with the planned work to change the road and trails because they enjoyed the challenge of recreating in areas that are not well maintained. Greater understanding of the larger goals of the project helped temper these concerns.

Working closely with the Forest Service, Rosgen directed the road and some trails to be moved from their original location near the streambed. The original placement made it impossible to keep sediment out of the waterway. The group worked on road maintenance and rebuilding the road in a new, more sustainable location over the course of the project. Some of the regulatory processes and stewardship measures the coalition was complying with, including NEPA, slowed the maintenance work somewhat throughout the process. The Forest Service decommissioned the original road by the end of 2013.

"Using the skills learned at the local level, we have more confidence going in and working in other watersheds, and we will get more efficient as time goes on." - Denny Bohon, USFS Fish and Wildlife Biologist

Use of Heavy Equipment

To successfully implement the structures, about a dozen pieces of heavy equipment were needed throughout construction. When that many pieces of large equipment enter any environment, there will be an immediate impact. The scope and scale of disturbance made some nervous, but by the end of the project everyone involved learned it is possible to clean up and restore the areas of disturbance.

With the significant use of heavy equipment, equipment operators were very involved with the restoration. The group found it was easier to have one person in charge on the ground working with the operators so they received consistent feedback. Getting consistent messages helped operators develop a solid foundation of understanding about the concept of the project and how the structures needed to be placed to be most effective. Paying operators hourly rather than for completion of the job also incentivized operators to diligently fix any problems and take the time to understand how structures should be placed.

Challenges – River Restoration

The magnitude of the fire made the work more challenging, and post-fire environments in general bring in more variables for consideration.

Addressing multiple processes on a watershed scale is more complex.

The erosive granite soils were a location-specific challenge. The soils made installing erosion control structures, designing in-stream structures, and transplanting riparian vegetation more complicated.

Waiting for the first large storm to see whether or not the structures worked as planned was distressing.

Finding enough rocks and trees for structure construction in the implementation phase was challenging. More natural materials than anticipated were needed, and the community did not like all the green trees being harvested because there were so few left in the area.

Ensuring everyone involved in on-the-ground implementation was communicating and coordinating was difficult.

Sediment is always moving downstream, so physically preventing the mobilization of sediment was an ongoing challenge.

Working from downstream to upstream because of the fish migration problems was difficult.

Bringing in heavy equipment and rerouting trails and the road was disconcerting to some in the community.

Getting the angles correct for the log rollers based on the valley slope was difficult.

Constructing sediment retention ponds and reconnecting them to the right flood plain feature proved challenging.

Getting the elevations correct when constructing flood plains and streams was challenging.

The initial level of disturbance from the heavy equipment work was disconcerting.

The available money went very quickly as implementation progressed.

The stewardship work needed to comply with regulations required more creative efforts and slowed the work to some degree. The constraints associated with the Preble's Meadow Jumping Mouse in particular made the work more challenging.

Without formal training, not everyone in the group was able to be involved with the implementation phase at the desired level.

Everyone involved was not well versed in the techniques of the work, so there was an education curve.

Highlights – River Restoration

People from various organizations involved were able to learn the river restoration techniques so they could apply them locally on future projects. The project was a great learning experience for everyone involved.

The large size and length of the project helped reinforce learning. Those involved were able to spend time learning the restoration techniques and had more flexibility to ensure they had a good understanding of what they were doing.

The project helped change how partners looked at restoration by helping those involved read more carefully what was happening in nature and emulate the natural processes.

Working on the project helped partners develop and carry out best management practices.

Even without formal training, those involved could learn through observation.

What the group thought would work was generally effective. This was largely due to taking the time to carefully plan the project.

The project addressed 90% of the issues in the Trail Creek Watershed, taking the watershed from a degraded to a more restored condition.

Working on the problem at a large, watershed scale was much more effective than chipping away at the problem with small projects, and adds more certainty to how effective the project will ultimately be.

The benefit of a holistic approach is starting to be realized by the Forest Service's federal offices as they see the success of Trail Creek.

The project can now be used as a demonstration area for stream, road, and trail restoration and logging management, which helps spread the lessons learned.

The Forest Service did a good job of documentation and data gathering, so the project techniques and success can be shared with others in detail.

The project the group set out to do was completed using the best available information and a holistic approach. This was one of the first, if not the first, instance of a watershed restoration of this magnitude.

The project received a high level of recognition in the community.

Having Dave Rosgen involved increased the prestige of the project.

Different stakeholders worked well together throughout the implementation process.

The group enjoyed leading tours of the project to show other agencies and interested people the results of what can happen in a relatively short period of time and how effective this approach can be to improve stability and decrease sedimentation. Having partners, such as CUSP, that could lead the tours as the work was ongoing was helpful so the project could keep moving forward quickly.

The project partners enjoyed working together and were excited to see the changes in the area as they happened.

Lessons Learned – River Restoration

Having a comprehensive plan and strategy for implementation will minimize problems that need to be corrected later.

Even with all the planning, partners must be prepared for some challenges because no one can account for everything.

Some trial and error is necessary to determine what will work best in a particular area.

As much as possible, partners need to ensure none of the pieces of the project are implemented externally without discussing with the entire implementation group.

Soil type can make an appreciable difference in the structures needed for restoration and the approach taken to implementing those structures.

Using erosion control fabric with each installed structure was necessary in this particular project because of the erosive granite soils.

Costs can add up quickly if heavy equipment rentals are needed, so it is best to harvest and bring back plenty of materials to the project site to minimize spending extra time bringing in more materials.

Addressing community concerns throughout the implementation phase is important for maintaining community support.

More experienced excavators should work with less experienced excavators.

Equipment operations should be paid hourly so they have an incentive to learn the proper techniques and go back and fix any problems that arise.

Work goes much smoother if one person is in charge on the ground.

Replanting vegetation in another project area where work had already been completed rather than destroying it as the implementation team was excavating was an effective way to maintain habitat for the Preble's Meadow Jumping Mouse.

Addressing high levels of stress among transplants early on is important. If dry conditions are a problem, portable pumps and more irrigation may be required for transplants to survive.

Post-fire river restoration should be approached in the same way as any other river restoration, but with the understanding that more variables are involved because of the post-fire environment.

Anyone involved in the project – organizations, volunteers, consulting firms, agencies – should participate in a general training that gives direction on how to carry out the techniques so the efforts of the groups and individuals are done correctly, are consistent, and result in the best possible outcomes.

Working from upstream to downstream is ideal so that structures in place downstream are not disturbed by construction upstream.

The structures being implemented should be made for the particular stream type where the work is being done.

Structures should not fight nature, but should emulate natural systems. Emulating natural systems is much more effective for long-term restoration.

Addressing the problems at a watershed scale is more effective than fixing minor problems one at a time.

Successful large-scale watershed restoration can be accomplished in a relatively short period of time when you have multiple partners working together.

Having local organizations involved in implementation work is important for building local capacity for future projects.

Trained supervision and a proper ratio of supervisors to volunteers are essential to getting a good product from volunteer work. This is a good role for nonprofit partners.

When looking at symbiotic projects in which multiple sources of pollutants need to be addressed, a holistic approach is necessary; considering the whole system rather than doing small projects that only address the most obvious problems was necessary to make a significant impact in Trail Creek.

Lessons from the Trail Creek project have been spreading regionally, including to Flagstaff, Arizona and for Waldo Canyon Fire restoration in Colorado.

Results and Next Steps

The majority of the Trail Creek Project was completed in 2012, with some final structure installation, willow planting, cleanup, and monitoring in 2013 and 2014. The project successfully reduced erosion for the long term in the Trail Creek Watershed and water systems downstream through a holistic approach to restoration. The complex nature of the project required a diverse coalition, including representatives from government, nonprofit, and private sectors and the community, to come together to fund, plan, and carry out the project successfully. The variety of skills and resources the different partners brought to the project were not only essential for completing the watershed-scale restoration in a relatively short time period, but also provided everyone involved an opportunity to learn

"I'm still amazed it came out as well as it did given all of the different people involved"
- Brian Banks, USFS GIS Systems Specialist

new techniques and develop relationships with other partners. The involvement of local entities ensured knowledge and skills gained from the project can be applied to ongoing and future projects in the area.

"I continue to be amazed at how quickly watersheds can recover with money and the right people on the ground " - Mary Mitsos, NFF Vice President of Conservation Programs

The use of Trail Creek as a demonstration site showing how the WARSSS and Natural Channel Design methodology can be used in a post-fire environment on a large scale has resulted in increased recognition of the utility of these methods and the benefits of large, collaborative efforts in restoring entire systems. More work using the techniques applied in Trail Creek is planned for downstream reaches in the Horse Creek Watershed. The lessons from Trail Creek are also being applied to restoration work in the Waldo Canyon Fire burn scar west of Colorado Springs, Colorado; work in the Bear Creek Watershed in Colorado; and post-fire recovery work in Flagstaff, Arizona. As this approach to restoration is practiced in more systems in the region and across the nation, the techniques, local knowledge, and multi-partner coordination will be further refined and strengthened for each locale.

Lessons: Conclusions & Recommendations

The lessons learned through the Trail Creek Project can help communities, organizations, and large agencies navigate large, holistic river restoration projects. While some of the challenges involved in a restoration project of this scale will be unique to the particular location, many of the lessons learned through this project will be common among different projects. Understanding the lessons learned about funding, multi-partner collaboration, and implementation from the Trail Creek Project is useful for organizations embarking on collaborative landscape-scale projects for the first time.

Lessons Learned

Involve the community from the onset

Involving local entities from the beginning ensures knowledge and techniques learned during the project can be used for future projects in the area

Private-public funding mechanisms in which funds can be leveraged for additional grants can maximize project funding

Multiple organizations working together is more effective than one or two organizations working on their own

Flexibility and willingness to learn are essential

Partners must be committed to the project

Communication is crucial

Emulating natural processes is more effective than working against natural processes

Large-scale restoration is more sustainable long term than small projects that only address one problem at a time

A successful watershed-scale project can be completed in a relatively short time period

Lessons Learned: Acknowledgements

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Brian Banks: *GIS Systems Specialist, U.S. Forest Service*

3

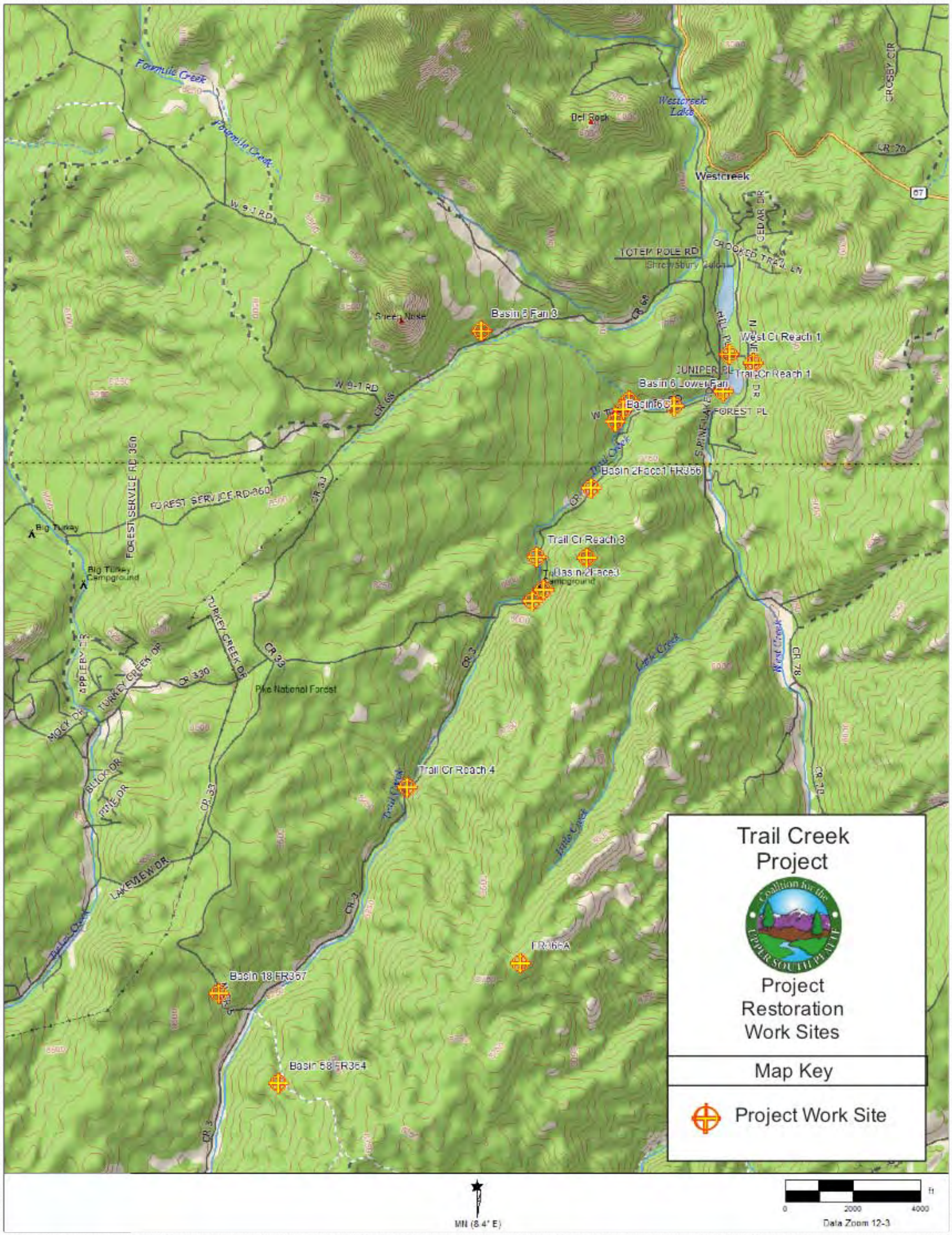
Implementation: Major Projects

> **“Leadership and learning are indispensable to each other”**
> *– John F. Kennedy*

Overview of Major Projects

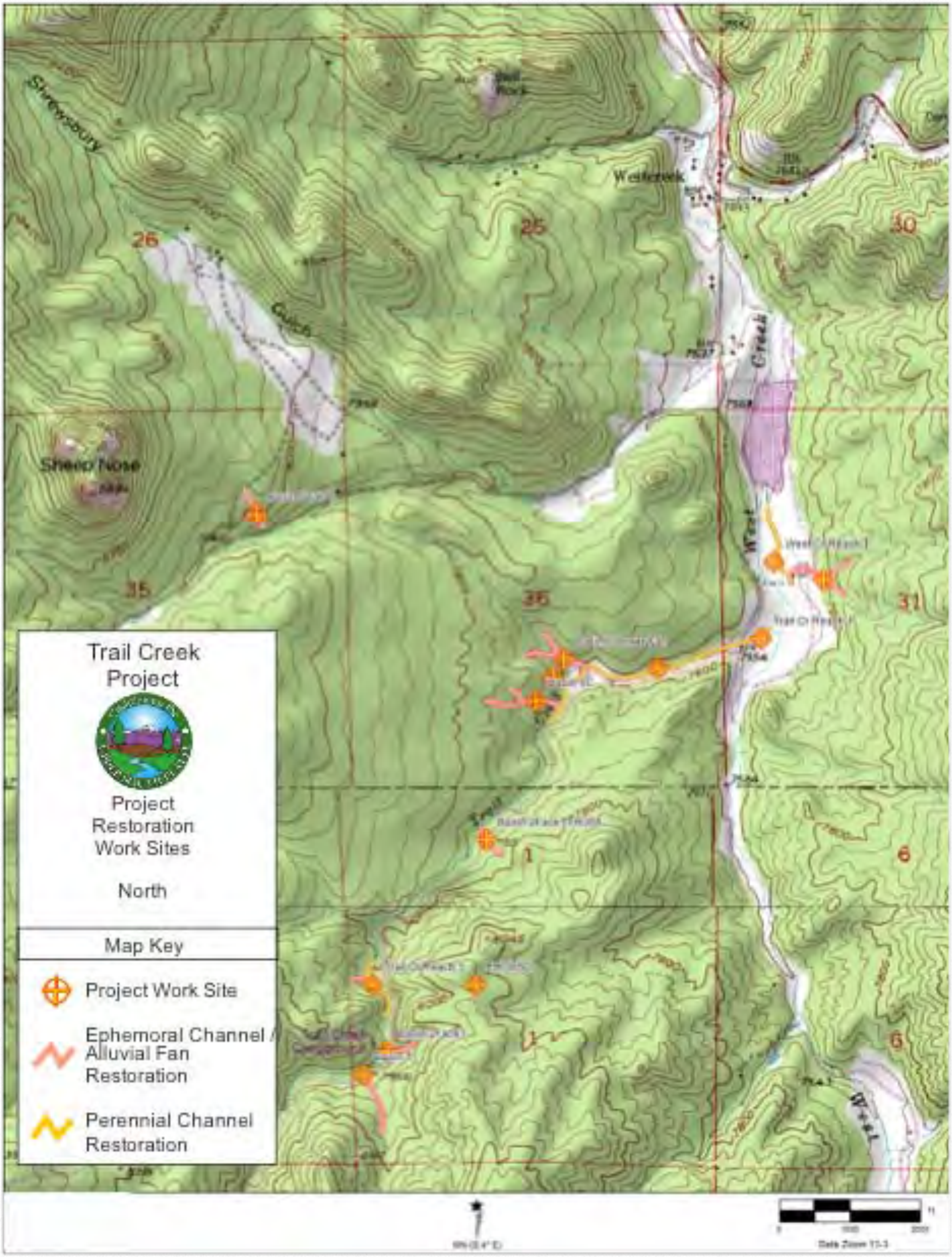
Twenty-two major sites were restored using heavy equipment during the 2011/2012 & 2014 field seasons.

Major work included complete reconstruction of 5 reaches of perennial stream, and restoration of 16 large ephemeral channels and associated alluvial fans. 6,700 feet of perennial stream channel and 14,395 feet of ephemeral channels were restored to improve sediment transport and aquatic habitat conditions in the Trail Creek and West Creek Watersheds. In the process of realigning several of the perennial channels, seven off channel ponds were constructed to provide fill material necessary for the project. The ponds, connected by small tributary channels to the main stem of the creeks, provide additional lentic habitat and rearing areas for resident brown and brook trout. Thirty sediment detention basins were constructed in 11 sub-basins of Trail and West Creeks to reduce sediment input into the perennial channel, and nine alluvial fans were restored to proper function.

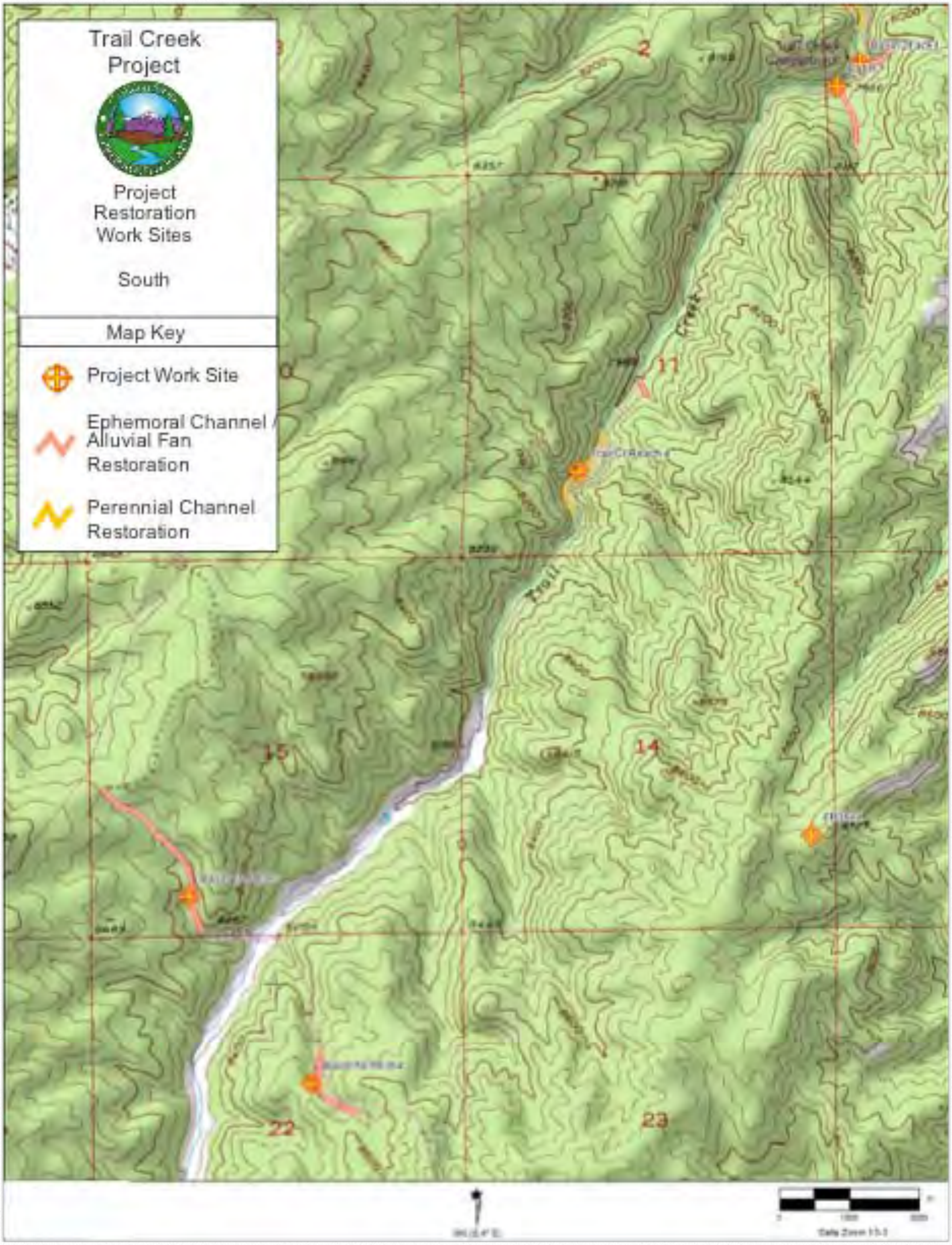


Large wood and boulders for the project were harvested from nearby sites on the National Forest. Over 3,500 pieces of large wood and approximately 3,000 yd^3 of granite boulders were used to construct 634 structures within the project reaches. Structures included “Rock & Roll” log vanes, J-hook vanes, cross vanes, boulder and/or wood drop structures, log sills, toe wood pool features, and riparian benches. Seven road and river crossings were eliminated in the project area, and the critical culvert crossing of Trail Creek at Douglas County Rd 73 was completely reconstructed.

11,383 feet of road and trail were obliterated during the period, and 1.6 miles of new road were constructed to replace the eliminated routes.



Major projects in the northern half of the project area.



Major projects in the southern half of the project area.

Perennial Channel Work

This section documents the work done at five perennial channel sites in 2011, 2012 and 2014.

The table below delineates perennial channel work sites, and lists the significant features constructed at each site.

Trail Creek Perennial Channels						
Project Site		***Length (ft)***	***# Str***	***Off Channel Ponds***	***Road/River X***	***Year***
West Creek Reach 1		1185	53	5	1	2012
Trail Creek Reach 1		504	12			2012
Trail Creek Reach 2		3300	104	2	1	2012
Trail Creek Reach 3		890	42		2	2012
Trail Creek Reach 4		820	40		4	2012
Totals		6699	251	7	6	

West Creek Reach 1

The boulder step pool structure at the top of West Creek Reach 1

The project reach extends from just upstream of Pine Lake to the bridge across West Creek at Old Dam Road, within the community of Westcreek, CO. The reach is located entirely on property owned by the Westcreek water utility. Prior to the Hayman Fire, the reach was extensively occupied by beaver, with no definable single thread channel. The reach is a natural deposition area, and post-fire flooding resulted in filling of many of the ponds with sediment, and gradual formation of a multi-threaded D channel through the reach as flood debris and sediment deposited from upstream. Work completed in the summer of 2012 included relocation of the river to the east side of the valley and restoration of the floodplain and Hill Place road to the west. 1,185 feet of new single thread C perennial stream channel was constructed in the project reach, creating 29 new pool habitats along this segment of West Creek. A large and complex boulder cross vane structure was constructed at the upstream boundary of the project reach, immediately downstream of the bridge, to maintain a large beaver pond immediately upstream of the bridge. Other in-channel features included numerous large wood J-Hook vanes and cross vanes, convergence boulder and log wood structures, toe wood riparian bank stabilization and extensive willow mat transplants. The floodplain on the west side of the creek was re-contoured, and five off-channel ponds were constructed to provide necessary fill material for the new channel construction, as well as material needed to raise Hill Place Road to an elevation

The complex boulder cross van near the upstream boundary of West Creek Reach 1 sufficiently above the flood plain to prevent frequent inundation of this important route to the local community.

See the monitoring results and As-Built drawings for West Creek Reach 1.

Trail Creek Reach 1

Trail Creek Reach 1 extends from just upstream of a large beaver pond on West Creek upstream of the bridge at Old Dam Road upstream to the concrete box culvert forming the Douglas County Road 72 crossing of Trail Creek. The reach is located entirely on private property. As was the case with the West Creek reach, Trail Creek Reach 1 is a natural deposition area, and post fire flooding has resulted in significant deposition of sediment, aggradation of the river channel, and increase in flooding risk to the adjacent properties. Previous flood mitigation efforts, including construction of a concrete block flood levy on the north side of the project reach further exacerbated flooding problems by significantly reducing the flood prone area and capacity in the reach.

Work on the reach was completed in August of 2012, and included removal of the concrete block levy, re-contouring and replanting of the floodplain, and construction of 504 feet of new single thread C perennial channel between the confluence with West Creek and the box culvert at CR72. Eleven new pools were created through the installation of 12 structures in the channel, including log J-Hook vanes, boulder cross vanes, and toe wood pool/riparian bank features. Work in the reach was complemented by the re-design and reconstruction of the box culvert crossing described in the next section.

Trail Creek Reach 1, looking downstream from CR 72

See the monitoring results and As-Built drawings for Trail Creek Reach 1.

Trail Creek - Douglas County Road 72 Box Culvert Reconstruction

Significant deposition of sediment and flood debris since the Hayman fire in 2002 had nearly buried the large concrete box culvert at the CR72 crossing of Trail Creek. Attempts by the county to raise the level of

Realigned/reconstructed Douglas County Road 72/Trail Creek crossing

the road and add additional steel culverts above the box culvert proved ineffective. During the course of the WARSSS assessment and restoration design process, it was determined this critical infrastructure would need to be completely redesigned and reconstructed. The new design called for raising the box culvert approximately four feet to match the grade of the newly constructed stream channels in Reach 1 and Reach 2. Five additional 24 inch steel culverts would be set at the bank full elevation on either side of the newly aligned box culvert to allow flood flows to pass the crossing without significant pooling upstream of the road. The culverts will also allow for periodic inundation of the newly constructed floodplain downstream of the crossing.

Construction of the new crossing was completed over a four week period in July and August of 2012. A temporary one lane road was constructed immediately downstream of the crossing, and the box culvert, consisting of three separate pieces, was removed from the channel utilizing a large crane. Underground utilities within the road corridor required relocation to a higher elevation before final grading of the crossing site and reinstallation of the box culverts could be completed. The new crossing functions as designed, eliminating a significant aquatic organism passage (AOP) bottleneck in the watershed, and greatly reducing the likelihood of flood flows overtopping this critical county road.

Trail Creek Reach 2

Trail Creek Reach 2 was the most complex and extensive project reach completed in 2012. The reach is located mostly on U.S. Forest Service lands, with the exception of a short segment of private property immediately upstream of the CR72 crossing. Douglas County Road 64 (Trail Creek Road) is immediately adjacent to, and parallels, the stream on the south side throughout the reach, encroaching at times on the available floodplain. The reach is 3,300 feet long, extending upstream from the CR72 crossing to a point where CR64 departs from the stream.

Prior to the Hayman Fire, the reach exhibited B and Cb channel forms, and was characterized by a narrow yet robust willow riparian community within the floodplain. The reach was occupied by beaver, with numerous in-channel beaver ponds present. Post-fire flooding resulted in significant channel alteration and catastrophic loss of usable aquatic habitat in the reach, with significant down cutting of the river channel in the upstream half of the reach, and subsequent deposition/aggradation of the stream channel in the lower half.

Work on Trail Creek Reach 2 was completed over a two month period in the summer of 2012. Extensive realignment and reconstruction of the river channel was required to complete the project reach. Two large off-channel oxbow ponds were dug in the upstream half of the project reach to provide the necessary fill material to elevate portions of the channel and adjacent floodplain that had down-cut in previous flood events. A completely new channel with additional meanders was constructed adjacent to these ox-bow ponds to increase the length of the channel and reduce slope through this segment. 104 in-channel structures and other features were constructed along the reach, creating 88 new pools for resident brook and brown trout. Log J-Hook structures and toe wood pool/riparian bank features were exten-

Channel reconstruction featuring new pool habitats formed by log J-Hook structures in Reach 2 sively used in the reach.

See the monitoring results and As-Built drawings for Trail Creek Reach 2.

Trail Creek Reach 3

Trail Creek Reach 3 was identified as a priority reach in the Trail Creek Watershed Master Plan for Stream Restoration and Sediment Reduction due to the two poorly functioning road/stream crossings in the segment. The reach is located entirely on U.S. Forest Service lands, and is located approximately one mile upstream of Trail Creek Reach 2. The reach is 890 feet long, and is characterized by a C4 channel in the upstream half of the reach and an incised G4 channel in the downstream half of the reach, where the stream has cut into an alluvial fan entering the river from Sub-Basin 4. The reach is for the most part confined on the east side by the Trail Creek Road.

Channel reconstruction featuring "Rock & Roll" logs formed pools and new road alignment in Reach 4

The restoration of Trail Creek Reach 3 was accomplished in September and October of 2012. The two low water crossings were eliminated, and a new road was constructed along the east side of the valley, closely following the route of the old stream channel. An entirely new C4 channel was constructed along the west side of the valley, and tied into the existing channel below the site of lower crossing, where the channel type changes to a B and G form. Several boulder cross vanes were installed at this point to provide grade control between the two channel forms. A total of 42 structures, mostly consisting of log J-Hook vanes and toe wood pool/riparian bank structures, were utilized to create 30 new pool habitats in the reach. Additional work to stabilize the toe of the alluvial fan (Sub-Basin 4) on the west side of the stream was accomplished, and is described in further detail in the description for Trail Creek Ephemeral Site #7.

See the monitoring results and As-Built drawings for Trail Creek

Reach 3.

Trail Creek Reach 4

Trail Creek Reach 4 was also identified as a priority reach in the Trail Creek Watershed Master Plan. The reach is approximately two miles upstream of Reach 3, and is located entirely on U.S. Forest Service lands. This segment of Trail Creek is confined and controlled by bedrock features on either side of the stream, as well as being encroached upon by the location of the Trail Creek Road immediately adjacent to the stream. Maintaining the road through this reach has been problematic since the Hayman Fire, with periodic floods wiping out the road and realigning the river meander. Before restoration, there were four poorly armored low water road crossings in this short 820 foot long reach. The stream channel had degraded to an F4b type, exhibiting high sediment supply and stream bank erosion.

The restoration of this segment included relocating the Trail Creek Road to the south and east side of the valley, and constructing a new B4 stream channel on the north and west side. Restoration work on Reach 4 was completed in September and October, 2012, concurrent with the efforts on Reach 3. Forty structures, consisting of log J-Hook vanes, boulder cross vanes, "Rock & Roll" log roller structures, and toe wood pool/riparian bank structures were utilized to create 31 new pool habitats in the reach. Additionally, numerous log sills were embedded perpendicular to the direction of flow along the south bank and floodplain to protect the toe of the newly constructed road fill slope adjacent to the creek.

See the monitoring results and As-Built drawings for Trail Creek Reach 4.

Ephemeral Channel and Alluvial Fan Work

This section documents the work done at seventeen ephemeral channel and alluvial fan sites in 2011, 2012 and 2014.

The table on the following page delineates ephemeral channel and alluvial fan work sites, and lists the significant features constructed at each site.

Trail Creek Ephemeral Channels						
Project Site	***Basin***	***Length (ft)***	***# Str.***	***# Detention Basins***	***Road Oblit.***	***Year***
West Creek Ephm Draw #1	N/A	845	9	5		2012
Trail Creek Basin 6 Lower Fan	6	3617	40	4		2011
TC Basin 6 (Stump Road) Fan #2	6	325	25	1		2014
TC Basin 6 (Stump Road) Fan #3	6	465	25	4		2012
TC Basin 6 (Stump Road) Fan #4	6	600	23	2		2014
Trail Creek Basin 6Face Fan	6Face	300	7	4		2011
Trail Creek Basin 6C Fan	6C	569	20	1		2012
Basin 2Face 1 FR366 Oblit.	2face1	1580	33	3	1580	2014
Trail Creek Basin 10Face Fan	4b	150	2	1		2012
Trail Creek Basin 2Face3 Fan	2face3	300	3	1		2012
Trail Creek Basin 1 Fan	1	700	8	1		2012
Trail Creek Basin 9 Fan	9	100	1			2012
TC Basin 60 & 62 (Huff) Fans	60	920	18	2		2014
TC Basin 58 FR364 Ephm Channel	58	945	66	1		2014
TC Basin 18 FR367 Road Oblit.	18	2979	103		1750	2014
FR366D Road Obliteration	N/A				1800	2014
FR 366A Road Obliteration	N/A				6253	2014
Totals		14395	383	30	11383	

West Creek Ephemeral Draw #1

West Creek Ephemeral Draw #1 is located in a large sub-basin immediately east of West Creek Reach 1, and joins the main stem of West Creek near the upstream boundary of Reach 1. West Creek Ephemeral Draw #1 exhibits characteristics typical of ephemeral channels and sub-basins in the project watershed, consisting of A and B channels in the steep headwaters of the basin draining onto a large alluvial fan formed at the point where the sub basin channel emerges onto the valley floor of the main stem of West Creek. Functioning alluvial fans are characterized by the absence of a defined channel through the feature, creating divergence of concentrated flows from the upper portions of the basin across the surface of the fan. This divergence results in deposition of sediment onto the fan before it can enter the main channel of the creek. In the case of the

Sediment detention pond and drop structure at the downstream boundary of West Creek Ephemeral Draw #1

West Creek Ephemeral Draw #1, a road traverses the lower third of the alluvial fan, and a culvert has concentrated flows into a single channel, resulting in a single thread incised channel both upstream and downstream of the road throughout the length of the fan. Although this fan was probably not functioning before the fire, subsequent flooding and increased sediment supply have combined to create a serious flood hazard that jeopardizes the integrity of the road and the West Creek water treatment building immediately adjacent to the channel. The sub-basin also provides a copious sediment supply to the upper end of West Creek Reach 1, and was identified as a priority treatment area for the project.

Restoration of this fan included construction of 5 sediment detention basins, beginning at the point where the channel emerges onto the top of the alluvial fan, and extending 845 feet downstream to near the confluence with West Creek. In between the sediment detention basins, the previously down-cut channel was filled with spoils excavated from the detention basins. These filled channels were further stabilized utilizing boulder cross vanes and numerous log sills. Due to the need to protect the water treatment building and move flood flows past the road, a single thread channel was maintained downstream of the fourth sediment detention pit. Work in the basin was completed in November 2012.

See the monitoring results and As-Built drawings for West Creek Ephemeral Draw #1.

Trail Creek Basin 6 Lower Fan

The Trail Creek Basin 6 lower fan was the first, and most extensive of the sub-basin ephemeral channel projects accomplished during the project, and was completed in November 2011. The project site is located on the large alluvial fan at the bot-

Looking upstream from the 1st basin in Basin 6 Lower Fan, 6 months following construction.

D channel rivulets between Sediment Basins 1 & 2

tom of Sub-Basin 6, the largest, and highest priority of the sub-basins identified in the Trail Creek watershed. The project area included work along 3,617 feet of ephemeral channel, including three tributaries at the upstream end of the reach.

Sub-Basin 6 is a significant contributor of sediment to Trail Creek, due to the large, combined sediment yields from roads, surface erosion, stream bank erosion, and both pre- and post-fire flood flows. The objective of the restoration effort at this site was to convert the existing down-cut F4b channel that had cut through the alluvial fan to a D4 stream type. At intervals along the new D4 channel, four large sediment detention basins were dug to provide the necessary fill material to fill the old F4b channel. The sediment detention basins are designed to store sediment before it can be delivered to the main stem of Trail Creek. These basins were lined with log sills, and log crib structures were constructed on the upstream side of the basins to eliminate the possibility of head cuts forming and advancing upstream through the newly constructed D channel. Multi-threaded divergent rivulets were carved into D channel surface to mimic natural braiding that typically occurs in this channel form, as well as to reduce accelerated stream bank erosion along the edges of the channel. The small islands formed by these carved rivulets were then hand planted with willow to provide further stability in the channel surface. Construction of the rivulets proved to be a daunting and time consuming challenge, requiring close monitoring of elevations to

Constructed B channel below Sediment Basin 1

Divergent channels on the D channel surface below Sediment Basin #2 in Basin 6.

assure sufficient divergence so that a single favored channel did not develop.

Downstream of the lowest sediment detention basin, a small (10 cfs) B channel was constructed across the eastern edge of the alluvial fan to convey higher flows to the main stem of Trail Creek. Log J-Hook vanes, toe wood, convergence boulders, and "Rock & Roll" logs were utilized to create twelve pools along the 250 foot constructed channel. Extensive re-contouring of the toe of the alluvial fan below the 1st sediment detention basin and the B channel was accomplished to assure that large flood flows would access the fan, as opposed to being focused into the small constructed channel. A buck-and-rail fence was added following construction to prevent motorized recreation use in the newly restored channel.

See the monitoring results and As-Built drawings for Trail Creek Basin 6 Lower Fan.

Trail Creek Basin 6 (Stump Road) Fan #2

Trail Creek Basin 6 (Stump Road) Fan #2 is located in the center Sub-Basin 6, approximately ¾ mile upstream of the Basin 6 lower fan site. The project site consists of a deep gully cutting through a natural fan along a small tributary in the basin draining the north and east side of the Sheep's Nose granite outcrop. The gully has formed as a result of a culvert on Douglas County Road 33 (Stump Road).

Log Rock & Roll structures on the stabilized channel through Basin 6 Fan #2

Restoration work at this site was completed in October 2014. The work focused on stabilizing the vertical profile of the gully and routing flood flows past the fan and into the main channel of Basin 6. One sediment detention basin was established near the bottom of the project reach. Log sills were installed on the upstream and downstream edges of the basin to prevent the formation of new head-cuts. In addition to the sills, a log crib structure (2013 design), backed by geo-textile fabric, was used on the upstream edge of the basin to ensure the elevation of the channel bed was maintained. A log "Rock & Roll" B channel was constructed between the sediment detention basin and the Stump Road, immediately upstream of the culvert to convey excess flow to the main stem of Sub-Basin 6.

See the As-Built drawings for Trail Creek Basin 6 (Stump Road) Fan #2.

Trail Creek Basin 6 (Stump Road) Fan #3

Trail Creek Basin 6 (Stump Road) Fan #3 is located mid-way up through Sub-Basin 6, approximately one stream mile upstream of the Basin 6 lower fan site. The project site consists of a large alluvial fan that has formed at the bottom of a small tributary in the basin draining the north and east side of the Sheep's Nose granite outcrop. Stump Road traverses the toe of the fan, immediately adjacent and parallel to the main stem of the Sub-Basin 6 channel. The road is cut into the toe of the fan, with an additional in-board ditch that drains approximately 1/2 mile of road upstream of the site. A 24 inch culvert conveys flows from the fan and the inboard ditch to the main channel, and may have contributed to the formation of a head cut that carved a deep F4b channel through the fan. The fill slope along the stream side of the road is quite steep, and has failed during several flood events. The fill slope is now armored with rip-rap, however, the most recent repair has the culvert "shot-gunned", or perched over the main channel, which is severely down-cut through this segment.

The "Rock & Roll" Channel

Restoration work at this site focused on re-establishing the function of the alluvial fan upstream of the road. Four large sediment detention basins were dug across the fan perpendicular to the direction of flow to provide the material necessary to completely fill the 20 foot wide and six foot deep F4b channel that had cut through the feature. Log sills were installed on the upstream and downstream edges of the basins to prevent the formation of new head-cuts. In addition to the sills, log cribbing, backed by geo-textile fabric, was used on the upstream edge of each basin to ensure that the elevation of the re-contoured alluvial fan upstream was maintained. A smaller incised channel was also filled on the eastern edge of the fan, and log-sills were utilized at intervals of 20 – 30 feet throughout the re-contoured fan to maintain grade. Log sills were also installed at the top of the cut slope along Stump Road to prevent head-cutting of any surface flows reaching the steeper cut slopes. To address the possibility of flows filling all of the basins, a log “Rock & Roll” B channel was constructed between the last basin and the Stump Road inboard ditch, immediately upstream of the culvert to convey any excess flow to the main stem of Sub-Basin 6.

Partially filled sediment detention basin following August 2014 rain event

In August of 2014, this site was subjected to a significant rain event equaling the design flow estimate. All four basins filled completely with run-off flow, and water flowed down the log Rock & Roll constructed channel. During this event, the upper most basin filled completely with sediment, and a few of the sills suffered minor damage. During the fall 2014 construction period, we were able to do minor maintenance of this site, digging out the upper basin, and repairing the damaged sills. Additionally, we did some additional work on the main channel immediately south of Douglas County Road 33 in this project reach, including the installation of twelve log “Rock & Roll” structures and four boulder gully plugs to maintain the channel bed profile.

See the monitoring results and As-Built drawings for Trail Creek Basin 6 (Stump Road) Fan #3.

Log “Rock & Roll” structures on the main stem of Basin 6 below Stump Road - Basin 6 Fan #4 Site

Trail Creek Basin 6 (Stump Road) Fan #4

Trail Creek Basin 6 (Stump Road) Fan #2 is located in the upper half of Sub-Basin 6, where the main stem channel of the basin crosses Douglas County Road 33, approximately ½ mile upstream of Basin 6 Fan #3. The project site includes a Forest Service designated parking area for hikers and climbers accessing the Sheep’s Nose rock formation to the north. The project site consists of a deep gully cutting through a natural fan along a small tributary draining the headwaters of the basin south of Douglas County Road 33. This gully is most likely the result of the main stem channel down-cutting below the culvert on Douglas County Road 33.

Constructing a log crib structure (2013 design) at the confluence of the two channels in Basin 6 Fan #4

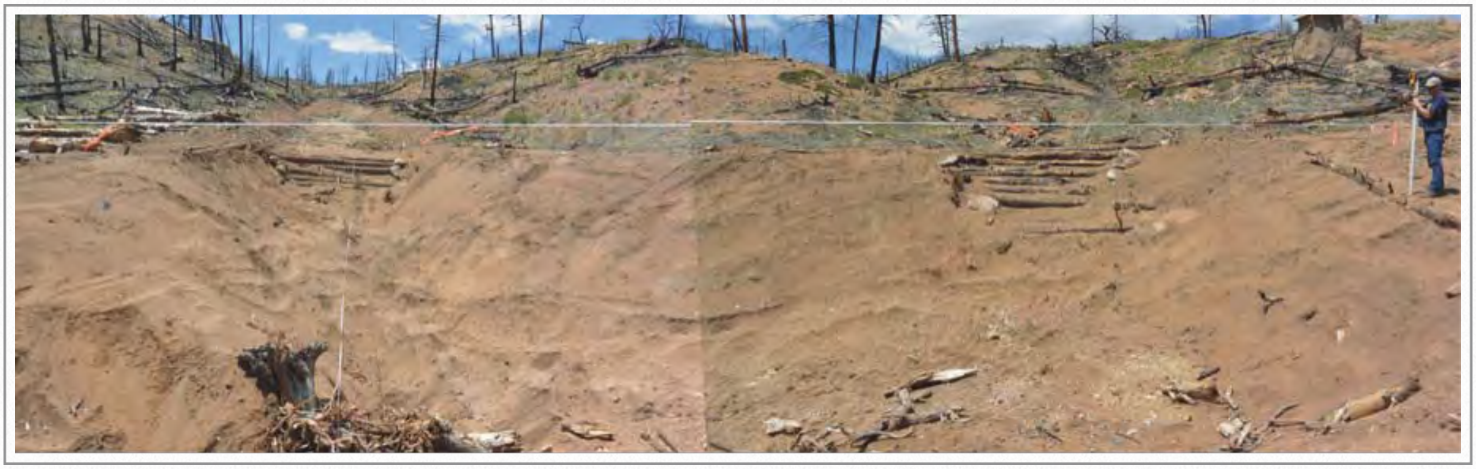
Restoration work at this site was completed in October 2014. The work focused on stabilizing the vertical profile of the gully and routing flood flows past the fan and into the main channel of Basin 6. Two large sediment detention basins were established. The first of these basins was constructed at the active head cut on the tributary channel. The second, larger basin was constructed at the confluence of the main stem and the tributary channel. Log sills were installed on the upstream and downstream edges of the basins to prevent the formation of new head-cuts. In addition to the sills, log crib structures (2013 design), backed by geo-textile fabric, were installed on the up-stream edge of each basin to ensure that the elevation of the channel bed was main-tained. A log "Rock & Roll" B channel was constructed between the lower sediment detention basin and the Stump Road cul-vert to convey flows through the project reach. Additionally, a log crib structure (2011 design) was utilized to maintain the toe elevation of another tributary fan enter-ing the project reach from the south.

See the monitoring results and As-Built drawings for Trail Creek Basin 6 (Stump Road) Fan #4.

Trail Creek Basin 6Face Fan

The Trail Creek Basin 6Face fan was the only other site restored in 2011. The pro-ject site is located at the downstream end of Sub-Basin 6Face, and is a relatively small alluvial fan through which a deeply incised F4 channel had cut through the lon-gitudinal axis of the fan. The channel was approximately 600 feet in length, reaching 6 feet deep in some segments, and contin-ued to be a significant source of sediment supply to Trail Creek Reach 2. The restora-tion treatment for this site was typical for alluvial fans in the project area, consisting of construction of sediment detention ba-sins at the top of the fan, and at intervals along the lon-gitudinal axis of the fan to provide necessary fill mate-rial to fill the incised channel between basins. In Trail Creek Basin 6Face, four small basins were required to generate the fill necessary to fill the F4 channel back to the grade of the original fan. Log crib structures were in-stalled along the upstream


Looking downstream towards Trail Creek from the uppermost basin in Trail Creek Basin 6Face



The large sediment basin at the top of the alluvial fan - Trail Creek Basin 6C worksite (Sub-Basin 6C)

side of each basin, and log sills were installed around the remaining edges. Additional log sills were added at intervals along the filled channel to ensure stability of the material until vegetation could become established.

See the monitoring results and As-Built drawings for Trail Creek Basin 6Face Fan.

Trail Creek Basin 6C Fan

The Trail Creek Basin 6C Fan is located on the west side of Trail Creek Reach 2, immediately upstream of Trail Creek Basin 6Face, at the bottom of Sub-Basin 6C. The restoration effort was similar to work in the other sub-basins, filling multiple incised channels that had cut through a compound alluvial fan at the bottom of the basin. 569 feet of ephemeral channel were treated and stabilized. The multiple channel threads were filled to an elevation matching the surrounding lobes of the compound fan. Log sills were placed perpendicular to the direction of flow every 25 – 30 feet along these filled channels to stabilize the fill materials. Additionally, several sills were installed across the entire fan for additional protection. A very large single sediment detention basin (approximately 1 acre) was dug at the top of the fan in lieu of multiple sediment detention basins being dug at intervals. This technique produced the necessary fill material with less

Sediment detention basin and restored alluvial fan at Trail Creek Basin 2Face3 work site.

time and effort due to the fewer log cribbing structures required. In all, twenty structures were needed to complete the stabilization work, which occurred in August 2012.

See the monitoring results for Trail Creek Basin 6C Fan.

Trail Creek Basin 2Face3

Trail Creek Basin 2Face3 is located ¼ mile upstream of Reach 3, on the east side of the Trail Creek Road. The project site consisted of an alluvial fan restoration and incised channel repair at the bottom of Sub-Basin 2Face3. The Trail Creek Road traverses the lower third of the fan, and has concentrated flows into a single thread below the road. Subsequent flooding created a head-cut, which migrated upstream through the fan to a bedrock control point in the channel above the top of the fan.

An F channel cutting through the fan in Basin #1 is filled, recontoured, silled, and covered in slash.

Work on the site was done following completion of Reach 3, in November 2012. A large sediment detention basin was constructed at the top of the alluvial fan, and the excavated material was used to fill the incised channel through the fan from the downstream edge of the basin to Trail Creek Road. The grade control structure in the channel upstream of the basin was constructed entirely of large boulders, which were available from a small cliff feature immediately north of the alluvial fan. Three hundred feet of ephemeral channel was treated, and three structures installed, including armoring the toe of the fill slope on the downstream edge of Trail Creek Road. The channel downstream of the road was not treated during this time.

See the As-Built drawings for Trail Creek Basin 2Face3.

Trail Creek Basin 1

Trail Creek Basin 1 is located ¼ mile upstream of Trail Creek Basin 2Face3, and immediately downstream of the former Trail Creek Campground (closed), on the south side of Trail Creek Road. The project site consisted of an alluvial fan restoration and incised channel repair at the bottom of Sub-Basin 1. Trail Creek Road traverses the lower edge of the fan, and a multiple-use motorized Forest Service Trail follows the longitudinal axis of the alluvial fan along the eastern edge of the feature. Post fire flooding in the basin created a head-cut, which migrated upstream to the top of the fan, creating a deep F channel. Following formation of the incised channel, flows were concentrated onto a short segment of Trail Creek Road, resulting in period failure of the road fill slope leading to the creek. Armoring the fill slope with riprap has been only partially effective in protecting the road.

Work on the site was done concurrent with Trail Creek Draw #4, in November 2012. A large sediment detention basin was constructed at the top of the alluvial fan, and the excavated material was used to fill the incised channel through the fan from the downstream edge of the basin to Trail Creek Road. Two log crib grade control structures and one boulder structure were constructed upstream of the sediment detention basin. Additional log “Rock & Roll” structures and a log J-Hook vane were added to the channel to further reduce energy as flows enter into the detention basin. Downstream of the basin, approximately 500 feet of down-cut channel was filled, silled, and covered with slash. The Forest Service motorized trail was closed and decommissioned, and a small transverse drainage ditch was cut across the fan to convey limited flows from the decommissioned trail onto the fan.

Incised channel filled with wood at Trail Creek Ephemeral Draw #6

See the As-Built drawings for Trail Creek Basin 1.

Trail Creek Basin 9

Trail Creek Basin 9 is located on the south side of the Trail Creek Road ½ mile downstream of Trail Creek Reach 4, and immediately upstream of the newly re-routed Forest Trail #717 crossing. The project site is the smallest of all of the sites described herein, consisted of an allu-

Treated fan toe and filled incised channel at Trail Creek Draw #7, adjacent to Reach 3

vial fan and incised channel repair at the bottom of Sub-Basin 9. Trail Creek Road traverses the upper edge of the fan. Post-fire flooding in the basin carved a G channel through the fan upstream of the road. 100 feet of the incised channel was filled with large woody debris to slow down flows and capture sediment before it could enter the creek.

Trail Creek Basin 10Face

Trail Creek Basin 10Face is located within Trail Creek Reach 3, previously described. An As-Built drawing of the work can be found in the section describing the work in Trail Creek Reach 3. Restoration work consisted of an incised channel repair and alluvial fan re-contour at the bottom of Sub-Basin 10Face, where it joins Trail Creek near the downstream boundary of Reach 3. Most of the fan in Sub-Basin 10Face is intact and functioning, however, a meander in the main stem of Trail Creek has eroded the toe of the fan, creating a significant source of sediment supply to the creek. A small incised channel/headcut has formed in a smaller tributary gully on the south side of the fan as well, and is also a contributor of sediment to the system. A small basin was dug at the top of the headcut, and the materials used to fill the incised channel, and to construct a small berm to direct the flow from the tributary away from the creek and onto the surface of the large alluvial fan forming the downstream boundary of Sub-Basin 10Face. Approximately 100 feet of channel was filled, with the addition of log sills and slash to reduce flow velocity and energy as it spread across the fan. Work on the toe of the alluvial fan included re-seeding with native grasses and erosion control matting approximately 100 feet of the slope above the toe of the fan. Slash and large wood was also spread along the surface of the fan following construction.

Trail Creek Basin 2Face 1 Forest Road 366 Closure, Re-Route and Fan Restoration

Forest Road 366 is a popular recreation route accessing the ridgeline separating

Layered log head cut stabilization structure in a small channel along the right edge of the fan

the Trail Creek and West Creek Watersheds. The northern most segment of the route, from the ridgeline down to Trail Creek Road is very steep, and for the most part is located in the ephemeral main stem channel of Sub-Basin 2face1 throughout its length. The Trail Creek Road traverses the center of the large alluvial fan that has formed at the bottom of Sub-Basin 2face1, and FR366 cuts through the longitudinal axis of the fan along the length of the left (east) edge of the feature. In the 2011 WARSSS Assessment, the segment of FR366 through Sub-Basin 2face1 was identified as a major source of sediment supply to the lower reaches of Trail Creek, and was recommended for closure. Due to the immense popularity of the route, the Forest Service elected to construct a new road to the east, from the ridgeline down to the Trail Creek Road, removing it entirely from Sub-Basin 2Face1. In the late fall, following completion of the re-route, the old road down through Sub-Basin 2Face1 was closed to all traffic. Tank trap berms and pits were dug on either side of closed segment, and in the course of this work, a small restoration was accomplished on the fan that forms the downstream boundary of the Sub-Basin.

Work on the fan included treatment of three headcuts and small incised channels that had cut through the fan, and construction of three water bars on the closed road

Filled down-cut channel in between the two sediment detention basins in Trail Creek Basin 60 along the left edge of the fan to disperse water over the surface. The head cuts were stabilized using layered wood cribbing placed parallel to the direction of flow in the channel to tie together the elevations upstream and downstream of the head cut. Downstream of Trail Creek Road, the deeply incised channel near the edge of Trail Creek was stabilized by constructing two large boulder cross vanes in the channel. The closed road was decommissioned and restored to a natural channel in the fall of 2014. This work included construction of three additional sediment detention basins and numerous boulder and log sills.

Log “Rock & Roll” channel along FR364

See the As-Built drawings for Trail Creek Basin 2Face1.

Trail Creek Basin 60 & 62

Trail Creek Basin 60 and Basin 62 are located in the middle of the Trail Creek watershed, near the northern property boundary of the Trail Creek Ranch. The project site consists of two large alluvial fans where the sub-basins empty into the main stem channel of Trail Creek. Teller County Road 3 crosses Trail Creek at two low-water crossings within the project area, and traverses the toe of both of these alluvial fans. A channel has down cut through the Basin 60 fan. The Basin 62 fan is in better condition, and is still spreading flows over most of the surface of the fan. Although the fans are both on private property, forest motorized recreation users have created social trails on the fans that are further destabilizing these features.

Restoration work at this site was completed in November 2014. The work focused on filling the down-cut channel in Basin 60 and restoring alluvial fan function. Two large sediment detention basins were established on the fan. The first of these basins was constructed near the top of the fan, at the active headcut channel. A second, smaller basin was constructed near the center of the fan. Log sills were installed on the upstream and downstream edges of the basins to prevent the formation of new headcuts. In addition to the sills, log crib structures (2013 design), backed by geo-textile fabric, were installed on the upstream edge of each basin to ensure that the elevation of the channel bed was maintained. The unauthorized motorized trails were closed off, and the Basin 62 fan was shaped and contoured to enhance flow divergence across the fan surface. All vehicle access points to the fans were blocked using boulder and large wood.

See the As-Built drawings for Trail Creek Basin 60 & 62.

Trail Creek Basin 58 - Forest Road 364 Improvements & Ephemeral Channel

Forest Road 364 is an important connector route between Manchester Creek and Trail Creek. The northern most 2 miles of the route, from the ridgeline down to the Trail Creek Road is very steep, and is located to the east of the ephemeral main stem channel of Sub-Basin 58. The road is immediately adjacent to the channel throughout its length and encroaches upon the channel, particularly in the upstream half of the basin. A dirt berm/levy was constructed at some time in the past along a seven hundred foot segment of the road in the upper half of the basin. Likely, the road followed the natural channel through this segment, and the berm was constructed to keep runoff from following the road corridor. The channel behind the berm is unnaturally straight and steep, and has down cut throughout its length. Downstream of this segment, the road drops steeply to the Trail Creek valley floor, and this segment exhibits significant down cutting of the channel, with several headcuts that have cut to bedrock. While there are frequent water bars constructed along the road in this segment, the fill slope from the water bar to the channel is extremely steep and consists of unstable decomposed granite. Near the bottom of the basin, immediately upstream of the top of the alluvial fan, the road crosses over a natural spring. The spring seasonally seeps across the road, creating a significant mud bog and adding additional sediment to the channel.

The 2011 WARSSS Assessment recommended this segment of FR364 for closure or re-route. Unfortunately, a suitable reroute has not yet been identified, and closure is likely not an option unless a suitable alternative route can be found. During the summer of 2012, the Forest Service conducted major maintenance of the road, including construction of a large cobble/boulder French drain to address the bog created by the natural spring. Many additional water bars were added to the steep section of the road above the spring. However, drainage on the fill slopes is still an issue, and will need to be addressed to fully contain sediment supply from this basin. Upstream, CUSP crews removed the dirt berm along the upper segment of the road, and constructed a new "Rock & Roll" B channel parallel to the road, utilizing over 70 trees harvested from the 9J road. Dirt from the berm was stockpiled off channel for use later to restore the alluvial fan at the bottom of the basin and to stabilize the fill slopes along the steeper segment of the road.

During the fall 2014 construction season, CUSP crews completed the work on the alluvial fan at the bottom of Basin 58. A small sediment detention basin was constructed at the top of the alluvial fan, and an additional rolling dip water bar was added to FR 364 between the French drain and the top of the fan to spread out run-off flow coming from the road.

See the As-Built drawings for Trail Creek Basin 58.

Trail Creek Basin 18 - Forest Road 367 Re-Route, Road Obliteration & B Channel Restoration

Forest Road 367 is an important connector route between Stump Road (Teller County 33) and the Trail Creek Road. The southernmost 3/4 mile of the route, from the ridgeline down to the Trail Creek Road, follows the ephemeral main stem channel of Sub-Basin 18. The road effectively functions as the channel throughout the length of the basin, with a few brief deviations to either side along the route. The 2011 WARSSS Assessment identified the basin as a principle source of sediment to Trail Creek, and recommended a re-routing of FR367 be undertaken to remove the road from the ephemeral stream channel. Most of Sub-Basin 18 is located on Forest Service land, with the exception of the very bottom, which is private property owned by the Trail Creek Ranch. The private property includes the large alluvial fan where the basin joins the main stem of Trail Creek.

Following the recommendation of the WARSSS Assessment, Forest Service engineers identified a suitable re-route of FR367, following a ridgeline on the southern edge of Sub-Basin 18. Construction of the new road was completed by the Forest

Service in May and June of 2012. Following construction of the new re-route, CUSP contractors obliterated and rehabilitated the old route. Because the old road followed the natural route of the ephemeral channel in the basin, regular road ripping and obliteration techniques were not appropriate, and could possibly increase sediment supply from the basin. It was determined that a B channel should be constructed along the length of the closed road, utilizing wood sills to create pools at intervals of 2 – 3 times the bank full width (20-30 ft.) along the longitudinal axis of the channel. Riffles between the pools would be constructed by embedding copious quantities of smaller woody debris into the channel bed to create additional roughness. Five relatively short segments of the reach exhibiting higher gradient required the installation of “Rock & Roll” log structures to create a step-pool channel form. 1,989 feet of B channel was constructed in August 2012. The new channel consisted of 33 silled pools, 34 woody debris riffles, and 34 “Rock & Roll” log structures. Headcuts in two small tributaries on the north side of the channel in the upper basin were also treated as part of the project, and CUSP hand crews re-seeded the entire reach following the heavy construction. In addition to the channel work, segments of the road outside of the channel were obliterated and reseeded.

Remaining work in the basin was completed in the fall of 2014, and included continuing the construction of the B channel through the private property down to the alluvial fan, utilizing “Rock & Roll” log structures. Excess excavated material from log roller construction, as well as from Basin 58, was used as fill to elevate the downcut section of FR 367 to match the surface elevation of the fan.

See the As-Built drawings for Trail Creek Basin 18.

Additional Road Obliteration & System Trail Work Completed in 2014

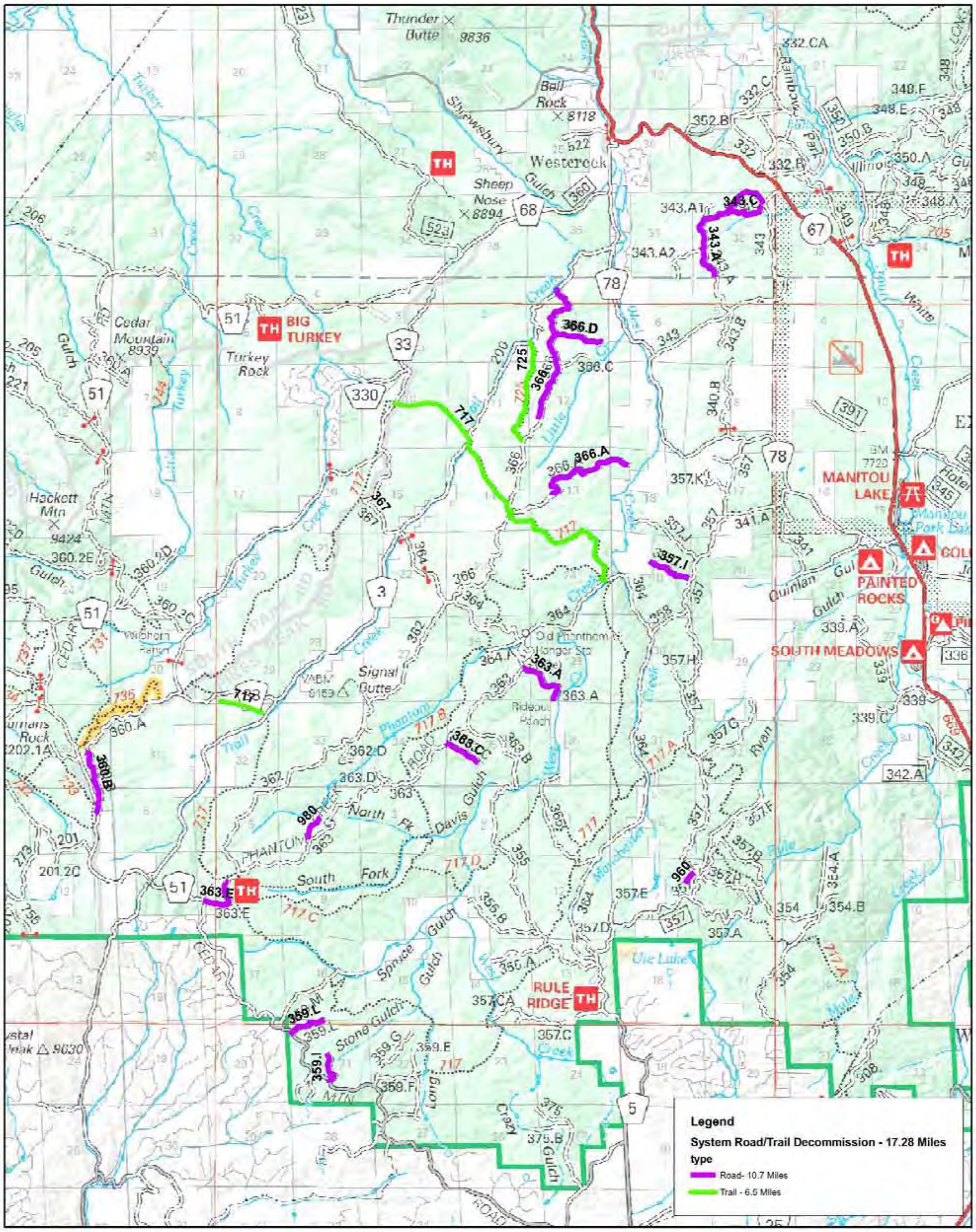
In addition to the work described in the previous sections, CUSP crews were able to complete additional road obliteration in the project area during the course of construction activities in October and November of 2014. While moving equipment from the FR366 road obliteration work in Basin 2Face1 to Basin 58 along FR 364, crews were able to obliterate a ½ mile segment of Forest Road 366A that had been overlooked during the main construction period in 2012.

Crews were also able to construct a new hardened water crossing at the point where the recently relocated National Forest System Trail 717 crosses Trail Creek, adjacent to Basin 9, utilizing large flat boulders left over from the construction in Trail Creek Reach 4.

SHEET	TOTAL SHEETS
2	7

No Scale

PROJECT LOCATION MAP
ROAD DECOMMISSIONING
Pikes Peak Ranger District



NFF 2012 Decommissioning

4

Implementation: Hand Work

> **"If everyone is moving forward together, then success takes care of itself"**
>
> *– Henry Ford*

Overview of Hand Work

Handwork done by project partner crews and volunteers complemented major project work. In addition to handwork done in first order ephemeral draws higher up in drainages above major project work, hand crews played a key role in erosion mitigation and restoring areas disturbed by heavy equipment and other impacts.

In 2011, project partner Rocky Mountain Field Institute undertook research focused on the effectiveness of restoration techniques to be used within the greater Trail Creek Basin (see Billmeyer et al, 2011). This research, along with extensive implementation in Trail Creek and other fire-affected areas, has informed the techniques represented in the following pages.

Handwork included:

- Seeding
- Planting & Transplanting
- Willow Planting
- Installing Erosion Control Blankets

- Installing Log Erosion Barriers
- Installing Sediment Control Logs/Wattles
- Installing Logfalls
- Installing Log Cross-Vanes
- Installing Reinforced Rock Berms
- Installing Check Dams

A more in-depth accounting of the restoration methods described in the following section can also be found in the Wildfire Restoration Handbook, a collaboration of the Coalition for the Upper South Platte, Volunteers for Outdoor Colorado, and the Rocky Mountain Field Institute.

Erosion Control

Erosion posed a major challenge in Trail Creek following the Hayman Fire. The naturally erosive decomposed granite soils in the area accelerated the rate at which sediment was moving downhill. Handwork was essential for reducing the impacts of this erosion in Trail Creek. Strategic re-vegetation efforts and installation of erosion control structures by partner crews and volunteers were critical for stabilizing the hillslopes and expediting recovery in this sub-watershed.

Re-vegetation

Promoting growth of native vegetation is crucial for restoring post-fire environments. Vegetation helps reduce erosion by stabilizing hillslopes, and is essential for reestablishing habitat and restoring ecosystem function. Reseeding denuded slopes is an important initial emergency stabilization step. Once native grasses are established from seed and are intercepting water, slowing it down and increasing absorption rates, burn scars are more amenable to other restoration efforts such as planting trees. Reforestation is only successful if the right trees are planted in the right conditions. Waiting to ensure areas are ready for saplings is critical for good survival rates and the promotion of healthy forest establishment.

Seeding

Ground cover is essential to ecosystem recovery. Seeding with native species is an economical and easy way to restore a disturbed ecosystem. Planting nurse crops such as triticale and sterile oats can serve as an effective method for establishing ground cover. Early seedling germination provides protection against raindrop and wind erosion, and as the ground cover becomes established, provides long-term stabilization of exposed soils and other ecosystem benefits.

Successful seeding is dependent upon proper technique and suitable weather conditions. Seeding during the proper time of year and with the correct technique can mean the difference between a successful and an unsuccessful restoration outcome. Both warm season species (start their growth when the weather warms up in late spring or early summer and produce seed by late summer or fall) and cool season species (grow primarily in the fall or spring when the weather is cooler and produce seed by mid-summer) can be seeded between late fall and early spring. Warm season species can also be seeded separately in the late spring or early summer. It is most important to ensure seeding occurs before moisture is present.

To reseed a disturbed area:

1. Use a native seed mix that takes into account:
    - The goals of the restoration project
    - Appropriate native vegetation for the ecosystem
    - Diversity of species, including growth

times and habitat benefits
- Ease of germination from seed and species' growth rates
- Species' ability to compete with invasive weeds
- Species' potential to control erosion
- Availability, quality, and cost of seed
- Approval of seed mixes by Federal land managers, if appropriate

2. Prepare the seedbed so the soil is loose enough for water and the seed's roots to penetrate the soil, but firm enough so the seed will be in contact with the soil and not easily washed or blown away.
- If appropriate, native topsoil may need to be spread to a depth of at least 6 inches. All disturbed areas should be loosened to a depth of 6 inches prior to spreading topsoil.
- Rake identified areas, ensuring the tines of the rake dig as deep as possible.
- Always rake on the contour of the hillslope. Never rake downhill! Raking downhill promotes erosion and will cause the seed to roll downhill.
- Re-contour any areas of disturbance such as equipment tracks or construction areas.
- Remove any weeds in the area.

3. Seed uniformly at the determined rate with the native seed mix, ensuring you

have enough seed to cover the entire pre-identified area.
- Lightly rake over the seed mix. Rake parallel to the contour (perpendicular to the slope). Never rake downhill!
- Lightly tamping the soil, which can be done by walking over raked and seeded areas, is also beneficial for promoting seed contact with the soil.

4. Add mulch to cover the seed.
- Various materials can be used for mulch. Weed-free straw or native wood mulch are often used.
- Mulch application rates will vary depending on the project.

5. Water the seeded area with buckets.

Other considerations when seeding:

- Consider species acceptability to the given site. Do not use a one size fits all approach, but rather consider ecological factors specific to the site (see above under native seed mix) when deciding on an appropriate seed mix.
- Consider approval of seed mixes. If the project is on Federal lands, all seeds must be certified weed free and the species must be pre-approved.
- Seeding on a windy day may be particularly challenging. Wind can carry seeds out of the work area, making seeding efforts futile and adding to the expense of the project. If you must seed on a windy day, apply the seed about 6-12 inches off the ground, and use the wind to help with distribution. If seed is being disbursed too far, wait until the wind calms down to continue seeding.
- Seeding in a rocky area also presents challenges, but can be successful. Start by breaking up soil compaction to a depth of at least 4 inches, and then smooth out the seeding area. Spread seed uniformly at the determined rate across the seeding area. Raking may not be available in these rocky areas.

Planting and Transplanting

Planting native plants in disturbed areas can accelerate recovery when plantings are done at an appropriate time and in the appropriate place. Planting large species, like trees, in a wildfire burn scar is only beneficial if the area to be planted has made a sufficient recovery first. In order to ensure high rates of survival, safe volunteer experiences, and the most effective reforestation, trees should only be planted after hillslope stabilization efforts, grass seeding, and hazardous tree felling operations have taken place. Planting methods will vary depending on the species and site.

General planting guidelines:

- Native species must be used. Seedlings must be derived from a source near the planting site to ensure the highest possible survival rates and the most benefit for long-term ecosystem health.
- Follow specific requirements detailing which species are suitable for different elevation gradients.
- Keep roots moist and protect exposed roots from direct sunlight.
- Summer months are typically too hot and dry to establish plants successfully. However, planting during summer in higher elevations may be feasible.
- Intense sun, extreme heat, and lack of precipitation are much harder on a transplant than a container plant.
- Learn to recognize native plants, weeds, and endangered or threatened species. Never disturb a federally listed or rare species unless specifically directed as part of the project.
- Avoid using weak or sickly plants.
- Amendments such as compost or other organic matter may need to be added to planting areas or individual planting holes.
- Learn about the desired microclimate of the species you are planting and match plantings to that microclimate.
- Within the planting area, try to place plants in spots where rainwater or runoff collects or passes by.
- Look for features such as small rocks or downed logs that will collect moisture and provide some shelter from intense sun and wind. These features should not be so large as to shade out newly planted seedlings. Seedlings should typically be planted on the east side of these structure or upslope when planting on steep slopes.

Willow Planting

Post-fire erosion and flooding have devastating effects on waterways and riparian areas. Planting willows along streambanks helps stabilize streambanks, improves habitat, reduces erosion, improves water quality, and enhances aesthetics. A basic understanding of what a riparian area is and looks like is needed for successful willow planting.

To plant willows in a riparian area:

1. Harvest willows in areas where they are abundant and healthy, creating a ‘bank’ of willow slips for transplant.
   - Prepared slips should be greater than 1 inch in diameter and 12-18 inches long,

cut diagonally on the bottom and flat on top.
- Willows slips can typically be stored up to 2 weeks if kept in a bucket of water in a shaded area.

2. Transplant slips with 60 inch rock bars, shovels, or in some cases, an auger.
- Plant willows only in areas where other willows naturally occur.
- Spacing depends on proximity to water, slope, and soils.
- Assess where the water table is and plant willow slips deep enough to be in contact with the subterranean water for a good amount of time. Typically, this means planting the pointed end of willow stake at least 6 inches deep with at least 4 inches remaining above the ground surface. Willow planting success rates increase greatly when stakes are planted deep enough to access a consistent water supply.
- Cut any split tops horizontally to create a crack-free surface.
- Watering with a bucket and the creek may be required.

Erosion Control Structures

Erosion is one of the most damaging longterm impacts following a wildfire. When high-intensity wildfires sweep through the forest, they leave behind areas of denuded slopes and scorched soils. The impact of erosive forces such as rain and wind are magnified in these exposed landscapes. Erosion robs the land of the fundamental building block of forests as soils slough off barren slopes. Erosion also threatens other values by impairing water quality as sediment enters downstream waterways, increasing the damage caused by post-fire flooding, disturbing and altering habitats, and threatening infra-

structure. Controlling erosion using a variety of proven techniques is a critical part of wildfire recovery.

Understanding Slope

Different types of slopes will require different types of protection from erosion. The land's slope is measured in percents, degrees, or described by a ratio of run:rise. For example, a rise in slope of one foot per ten feet of horizontal distance is described as a 10% slope (rise [1] divided by run [10] x 100 = 10%). Expressed as a ratio, it is 10:1. The degree of a slope is the angle of the slope. A 90° slope would be a vertical cliff face, 0° slope would be flat ground, and a 45° slope is in between the two. As the percent or degree increases, the slope gets steeper. As the slope gets steeper, the ratio decreases. For example, a 4:1 slope (=25% or 14º) is typically a gentle slope, compared to a 2:1 slope (=50% or 25º) that is fairly steep.

Generally, a slope equal to or steeper than 3:1 (33% or 18º) will require some type of mulch or erosion control on it. Also, areas that concentrate the flow of water during rainstorms or snow runoff, such as gullies or streambanks, may require extra reinforcement through the use of check dams, drainage control structures, and materials called erosion control blankets.

Erosion Control Blankets

Erosion control blankets are used on slopes, streambanks, or other areas of concentrated runoff to provide a protective cover for the soil from rain and runoff. These fibrous blankets can also act as mulch, holding moisture and shading germinating seeds.

Installing erosion control blankets:

1. A restoration professional will choose a blanket or mat appropriate for the site and goals of the project.
   - Mats or blankets should be made of 100% natural and biodegradable materials such as straw, coconut fiber, aspen shavings, jute, or combinations of such fibrous materials. Blankets made of plastic or other synthetic materials, even if photodegradable, will not completely degrade and can have negative effects on ecosystems.
   - Straw breaks down the quickest, so is suitable for relatively gentle slopes with no gullies, such as a 4:1 or 3:1 slope.
   - Woven coconut fiber blankets are hardier and are better for areas where erosion potential is very high, including stream banks, gullies, and other areas

where water velocity is concentrated and constant.

2. Seed and rake the soil in the designated area to promote germination of native seed appropriate for the project.

3. Smooth and moisten the soil area that will be below the erosion control blanket.

4. Establish a perimeter anchor trench at the outside perimeter of all blanket areas.
   - Dig a 6 inch deep trench across the top of the slope where the mat will start and place the excavated soil upslope of the trench.
   - Fold over the edge of the matting, and place it into the trench.
   - Anchor the erosion control blanket with wooden stakes, about every 2 feet.
   - Backfill the trench and tamp down the soil.

5. Install the blanket in full contact with the soil underneath.
   - Remove all large rocks and branches to ensure there are no gaps or voids between the blanket and the soil. If part of the blanket does not touch the ground, water may run underneath the blanket and erode away soil rather than running over the blanket, which protects soil underneath.
   - Unroll the matting down the slope, straightening any folds or kinks.

   - Position and pin the edges of the matting with staples every three feet in staggered rows.
   - At the lower edge of the mat, dig another 6 inch deep trench and secure the matting the same way as at the top.

6. Use joint anchor trenches to join rolls of blankets together.
   - Join the blankets longitudinally and transversely unless they are on a slope where concentrated flows are not present. In that case, the trenches will only need to be along the perimeter for all blankets except 100% straw, which may use an overlapping joint.
   - Overlap edges by 6 to 12 inches.
   - Anchor the erosion control blanket with wooden stakes every 2 feet.

Log Erosion Barriers

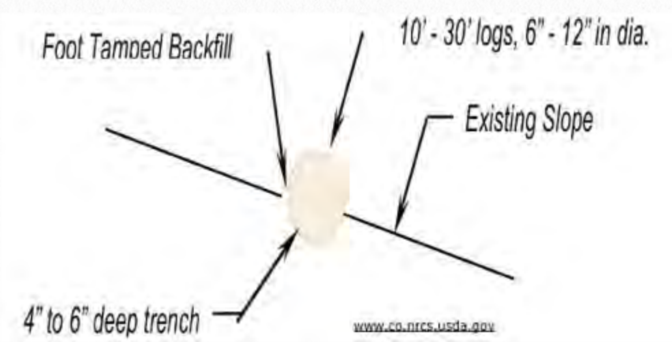
Log Erosion Barriers (LEBs) are used to intercept water running down a slope, trap sediment, and encourage native species reestablishment. The effectiveness of this treatment depends on the intensity of precipitation and correct installation. Felling of burned trees is very hazardous and should only be completed by trained sawyers. LEBs are used on moderately to severely burned slopes with steepness of 20% - 60%. Depending on the slope, availability of trees, and the burn severity, 60-120 trees per acre is recommended.

Installing Log Erosion Barriers:

1. Fell trees directionally on the contour.
   - Utilize trees no smaller than 6” and no larger than 12”
   - Fell trees to achieve a proper spacing.
   - Leave the stump high to help secure the tree.
2. Cut a shallow trench for the log to lay in when dropped.
3. With the tree on the ground, limb most branches, leaving any on the downhill slope that may help to stabilize the tree when placed.
   - Limbs that are cut and not used can be spread on the contour above the LEB. This coarseness helps to reduce the water’s velocity.
4. Cut branches at 2-4 foot lengths to use as stakes. One side should be cut flat and the other side should be cut with a spiked end.
5. Fill voids on the uphill side of the tree.

- In some instances (where soils are too rocky or the tree does not sit flat), you can utilize erosion control fabric to fill voids. Fabric should be dug in and attached to the log with small roofing nails.
- If fabric is not suited for the conditions or is not available, use native materials such as branches or rocks to fill any voids on the uphill side of the tree.

6. With voids filled, backfill with native soils excavated from the trenching. Tamp all soil, spread native seed and rake smooth.
   - You should not be able to see any sunlight or any gaps between the log and the existing grade.



Sediment Control Logs/Wattles

Sediment control logs, or wattles, are cylindrical bundles of excelsior, straw, compost, or coconut material designed to form a semi-porous filter and withstand overtopping. These logs trap sediment and reduce the velocity of water running downhill in the same manner as LEBs.

Installing Sediment Control Logs:

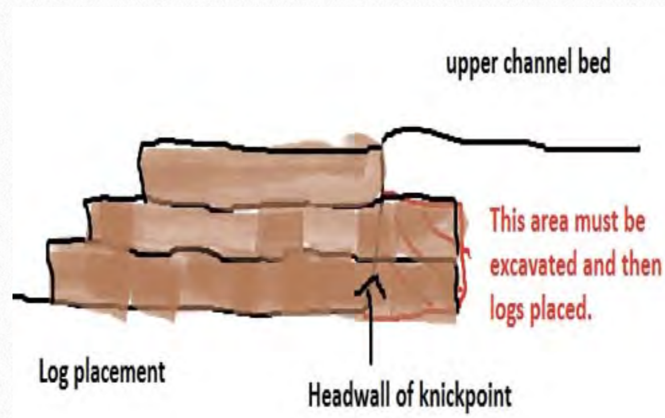
1. Place the log on the contour of the slope.
2. Trench the log into the ground at a minimum of 2 inches.
3. Stake the log securely into the ground with wooden stakes.
4. Fill voids on the uphill side of the tree.
5. With voids filled, backfill with native soils excavated from the trenching.

Logfalls

Logfalls help mitigate erosion by addressing headcuts and preventing them from continuing to migrate upwards. According to the Unites States Department of Agriculture, Agriculture Research Services, a "headcut is the sudden change in elevation or knickpoint at the leading edge of a gully. Headcuts can range from less than an inch to several feet in height, depending on several factors. These factors include soil properties, such as density, moisture content and erodibility, as well as factors affecting the flow hydraulics, such as flow rate, overfall height, and tailwater conditions can have a large impact on the headcut advance rate" (USDA, 2008).

Installing Logfalls:

1. Square up the headwall, sidewalls, and bottom of the channel. Eliminate the scour pool and any irregularities (rocks, roots, or indentations) in the channel bottom, sidewalls, or headwall.
2. Use a shovel, spade, Pick Mattock, or crowbar to shape the site. Save sod clumps, grasses, sedges and vegetation for use later.
3. After the headcut is "squared up," excavate underneath the far headcut wall to facilitate the installation of the first course of logs.
   - The excavation of the lower headwall of the knickpoint should be the width of the knickpoint and then cut back 8 to 10 inches. In the diagram below, we show only one headcut, however, for multi-step headcuts this should be done at step 1 and step 2 of the headcut to ensure that no undercutting or piping occurs.



4. Install logs. Utilize native materials cut to the proper length.
   - Always size the material appropriately with the logs increasing in size as they move farther from the headcut lip. The first course of logs should be of the greatest length and largest suitable diameter for the length of channel to be treated. All subsequent layers of logs should be shorter than the last and smaller in diameter so that a slope of 3 to 6 degrees can be created when the log structure is backfilled with topsoil.

5. Use excavated soil to fill the gaps and secure the first layer. Tamp all soils into place.

6. With the first layer complete, measure for the next course and size the logs larger than the first layer.
   - As the work continues downstream toward the main drainage, the logs should become increasingly larger in diameter and in length. Logs are set in place securely with smaller material used as chinking.

7. As the layers, moving from the top down, are finished, work to re-slope the walls to the angle of repose.

8. Tamp all completed work.

9. Cover all work.
   - Place sedge mats and native plants where appropriate and cut and re-slope wall angles.

Log Cross Vanes

Log cross-vanes "provide grade control upstream of the structure. Field observations indicate that the use of log cross-vanes is effective at providing bank stability and grade control within the project area" (Billmeyer et al, 2011).

Installing Log Cross Vanes:

1. Install two log vanes extending from the bank to meet at a 20° to 30° angle out from the streambank toward upstream.

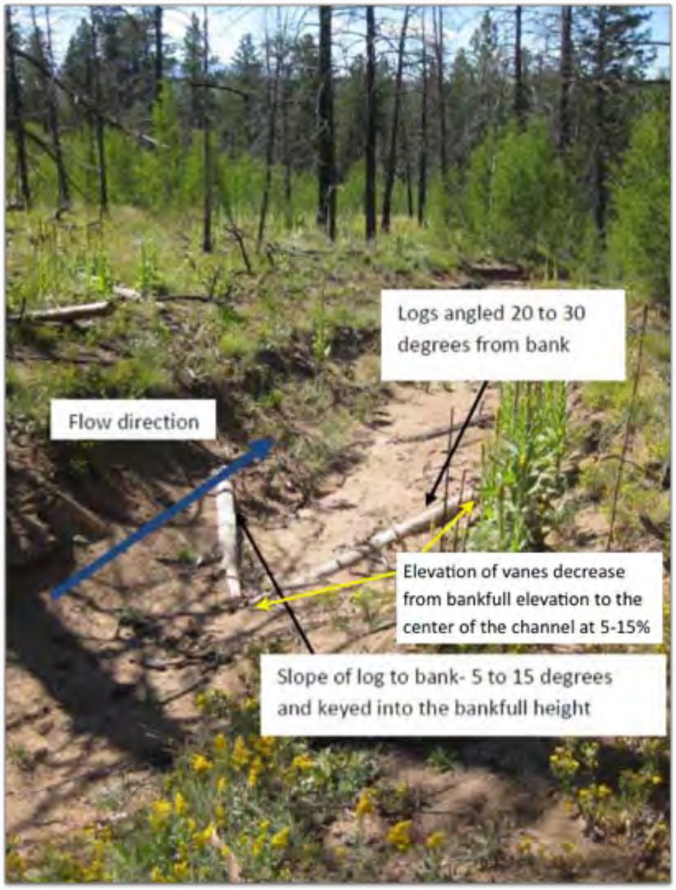
2. Ensure the top elevation of both vanes decreases from bankfull elevation toward the center of the channel at a slope of 5 to 15 percent.

3. Key the vanes into the bank 12-24 inches.
   - Rock may be used to provide additional support. Rock may also be used down-

Before
Headcut is causing increased erosion and will continue to migrate upslope.

After
Base has been hardened, land re-contoured & stabilized. Minimal disturbance of surrounding land.

stream of the V to prevent scour in steeper gradient streams (≥ 7°).



Reinforced Rock Berms

Reinforced rock berms are useful for protecting culverts by reducing sediment in runoff approaching the culvert.

Installing reinforced rock berms:

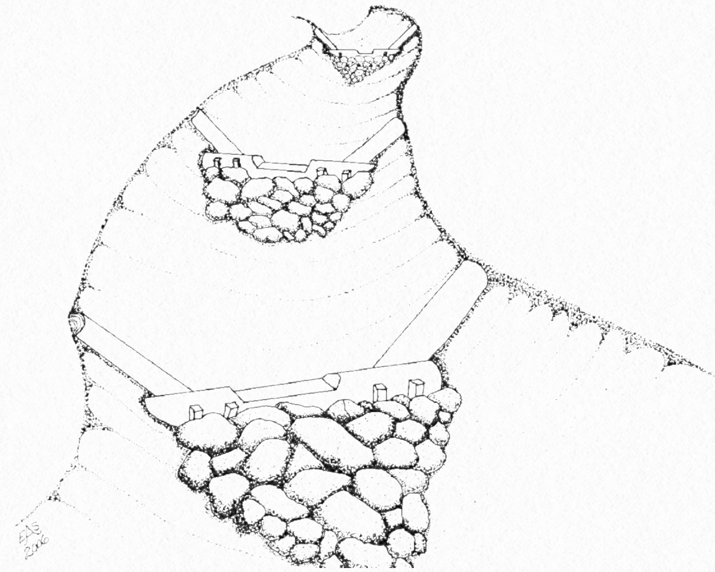
1. Ensure crushed rock is fractured face (all sides) and complies with gradation as required for drainage size and area.
   - Recycled concrete meeting the correct gradation may be used as well.
2. Secure ‘chicken wire’ (wire mesh made of 20 gauge wire with a maximum opening of 1 inch, with a roll width of 48 inches) using ‘hog rings’ or wire ties at 6-inch centers along all joints and at 2 inch centers on the ends of the berm.
   - For concentrated flow areas, ensure the ends of the reinforced rock berm is 12 inches higher than the center of the berm.

Reinforced rock berms will be inspected, repaired, and cleaned out as necessary.

Check Dams

Check dams are structures designed to span gullies and slow the erosive force of water. As the water slows down at the check dam, sediment will be deposited behind the dam, hence building up a terrace of soil behind the structure. In this way, gullies can be filled up, instead of continually deepening with each new rainstorm or snowmelt. At the same time, check dams allow water to seep into the soil instead of flowing over the land.

The materials and methods used to construct check dams will vary depending on access to the site and the availability of local materials. Structures can be made of locally collected rock or logs, or from purchased materials such as straw bales or straw wattles. Check dams are particularly useful for closing old eroded roads and trails, or on severely eroding hillsides.



The spacing between check dams is determined by the steepness of grade. In general, the steeper the slope, the closer together the check dams.

Installing a Log Check Dam:

1. Obtain a log roughly 18 to 24 inches longer than the area needing a check dam.
   - The diameter could vary from 6 inches to over 12 inches. Use larger diameter logs for areas with deeper gullies or steeper terrain, and smaller diameter logs for shallow gullies.
2. Dig a trench and gauge the depth based on the lowest point in the gully.
   - Gullies tend to be deeper in the middle, rather than flat across the bottom.
   - Dig slightly shallower and narrower than the length of the log. If the trench is too big, then water can easily flow around the ends, making the check dam useless, or possibly even accelerating erosion.
   - If the trench is too deep, then you will lose above-ground height of the check dam.
3. Extend the trench 9 to 12 inches into each bank of the gully.
4. Dig out the ends of the trench to match the depth of the middle of the gully. Be conservative when digging initially, and remember that it is better to dig more later than to try to fill it back in later.
5. Place the log tightly in the trench.
   - Install the logs as level as possible, perpendicular to the fall line. Otherwise, water will just flow to the low end of the check dam, reducing effectiveness and eroding the upslope edge along the check dam.
   - For large diameter logs in wide gullies, notch the logs at the center of the gully to direct water through the center of the check dam instead of around it. For larger check dams, also build an apron of rock around the outflow of the notch to prevent a plunge pool from forming at the outflow of the dam.

6. Secure the log check dam with small rocks wedged in on the downhill side.
   - Use logs or rocks to reinforce the gully banks at the sides of the log check dam to keep water from eroding around the dam.

7. On the uphill side of the log, backfill and tamp with loose dirt one quarter of the way up the log. Take care not to fill the entire uphill side of the log, as this is where sediment will be trapped in future runoff events.
   - For high water flow situations, add reinforcing logs on either side of the gully, upstream of the check dam, to prevent flow from cutting around the check dam.

Installing a Rock Check Dam:

1. Pick out a rock or rocks for the check dam.
   - Whenever feasible, use one large blocky rock with a flat edge to span the entire gully to eliminate the chance of water flow between rocks.
   - If a single rock is not available, use smaller blocky rocks (with a median stone size of 10 inches) with adjoining surfaces that match up as tightly as possible. Small gaps between rocks can be filled with small rocks and soil.

2. Dig a trench all the way across the gully to key in the rocks.
   - Plan to trench the rock(s) into the ground a minimum of 8 inches to 1 foot.
   - Try to dig the trench according to the rocks chosen.
   - Be conservative when digging initially.

3. Extend the trench 4 to 6 inches into each bank.
   - Ensure the ends of the check dam are a minimum of 6 inches to 1 foot higher than the center of the check dam.

4. Place the rock(s) tightly in the trench.
   - If using multiple rocks, match up rocks' adjoining surfaces as tightly as possible, and fill gaps with small rocks and soil.
   - Rocks can also be shingled or overlapped in the trench, much like tiles on a roof, to create a more impervious barrier.

5. Secure the rock check dam with small rocks wedged in on the downhill side. Fill in the uphill side with packed soil no more than 1/4 of the rock face.

The sediment that accumulates upstream of the check dam will be removed when the sediment depth reaches within half of the height of the crest of the check dam.

Installing a Straw Bale Check Dam:

1. Dig a trench and gauge the depth based on the lowest point in the gully.
   - Gullies tend to be deeper in the middle, rather than flat across the bottom.
2. Dig out a trench for the bales to lay in, about 6 inches deep.
   - Try to dig the trench with a low point at the channel centerline, so the bales can be set into the trench in a wide V formation (if looking at a cross section of the gully) to create a low-flow spillway.
3. Extend the edges of the trench at least to the high water mark, if it is noticeable.
4. Place bales in the trench in two rows. The first bale should be stood on its higher side. Place bales in the first row on end, width wide. Place bales in the secondary row, or the anchor row, directly behind the first row. Bales in this row are placed short side up and anchored. The secondary row should be approximately 406 inches lower than the first, front row.
5. Anchor the straw bales using 2”x2”x3” wood stakes.
   - Make sure the stakes go all the way through the bales and adequately into the soil for anchoring.
   - Up to 4 stakes can be used for each straw bale check dam, but less may be needed.
6. Create a rock apron by gathering any gravel or cobble-sized rock in the vicinity of the check dam and placing it on the downslope side of the dam.
   - This rock apron will protect against localized scour and should ideally extend across the 3-foot bottom width of the swale and approximately 1-foot downstream of the check dam.
7. If additional brush is available, place some brush on the upslope side of the dam.
   - The brush will help break up the force of major storm flows before they come in contact with the dam.

5

Monitoring

> **"When we try to pick out anything by itself, we find it hitched to everything else in the Universe"**
> *– John Muir*

Project Monitoring

Post-project monitoring of the project sites commenced immediately following construction, and was completed in 2014. In 2013, Coalition for the Upper South Platte and U.S. Forest Service field crews established permanent monitoring benchmarks, cross sections, and over 500 photo-points in the project reaches completed in 2011 and 2012. Additional monitoring was completed following construction activities in the fall of 2014. Crews collected geomorphic survey data of the dimension, pattern, and profile of the new channels and restored fans. In addition to the survey work, crews created sketches of the completed work to be used to develop the formal “As-Built” drawings for the project. The As-Built drawings can be found in the Appendix.

At a minimum, permanent geo-referenced photo-points were established and a field sketch created at each project site. Additionally, a detailed longitudinal profile and cross section surveys were collected on all of the perennial stream reaches, and on eight of the twelve ephemeral sites. CUSP field crews completed nearly 3 miles (15,429 ft.) of longitudinal profile survey, and established 42 cross sections in the project reaches.

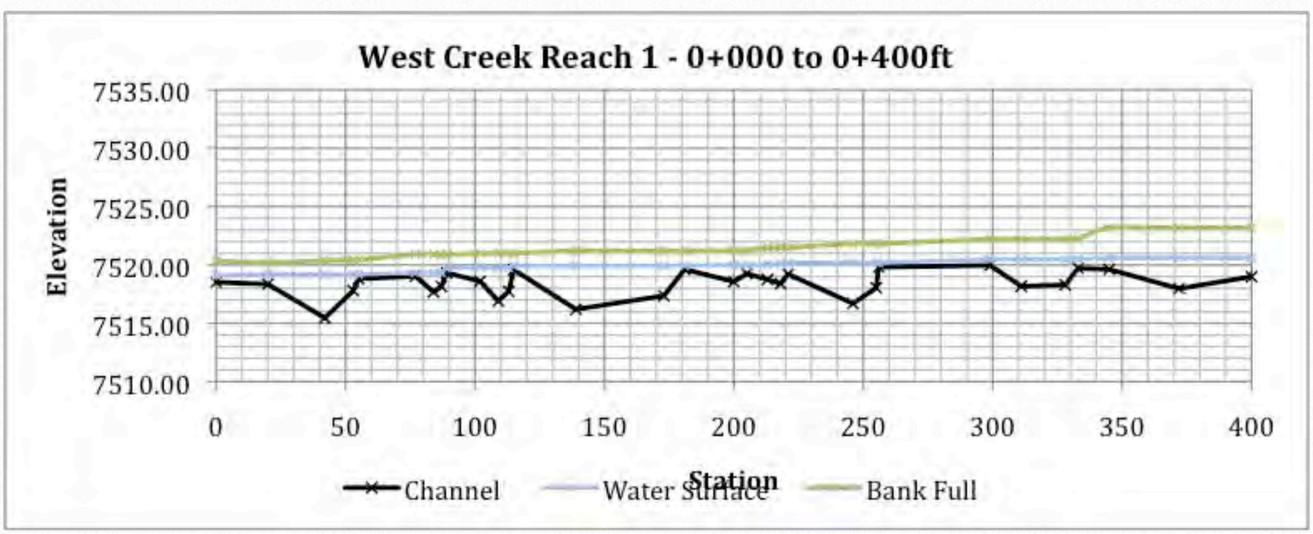
Future monitoring activity may include periodic repetition of established photo-points. Longitudinal profiles and cross section surveys will take place at two to three year intervals, or as necessary in the event of a significant event such as a major flood. The monitoring team anticipates conducting another WARSSS Assessment on a sub-set of the project reaches to validate the predicted reduction in sediment supply in the watershed. A post project WARSSS assessment will likely occur 3 to 5 years following completion of the overall project, depending of funding available for the analysis.

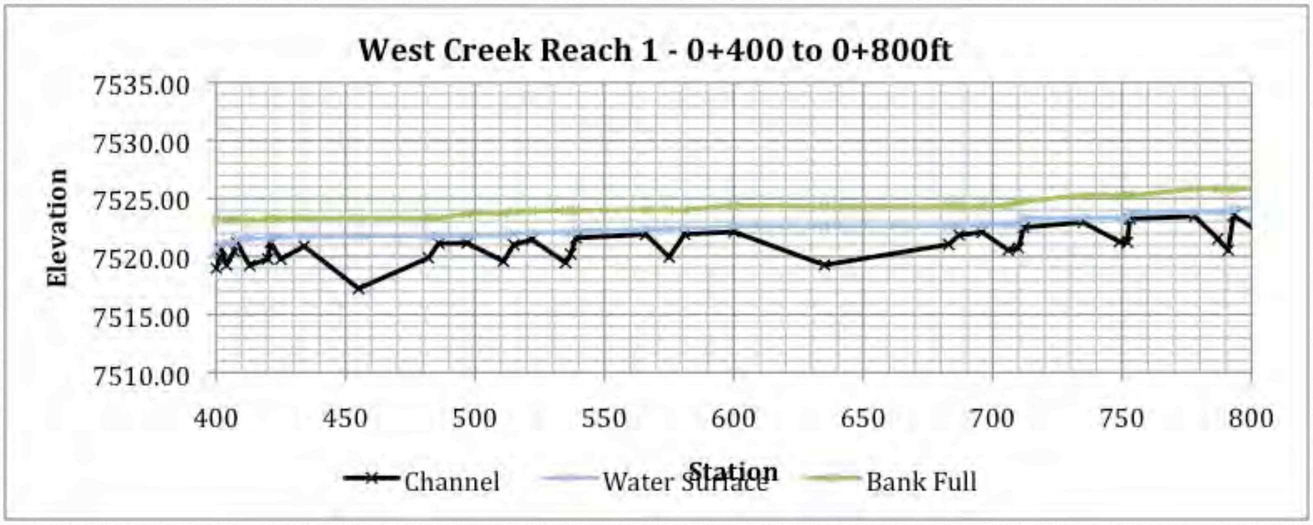
Perennial Channels

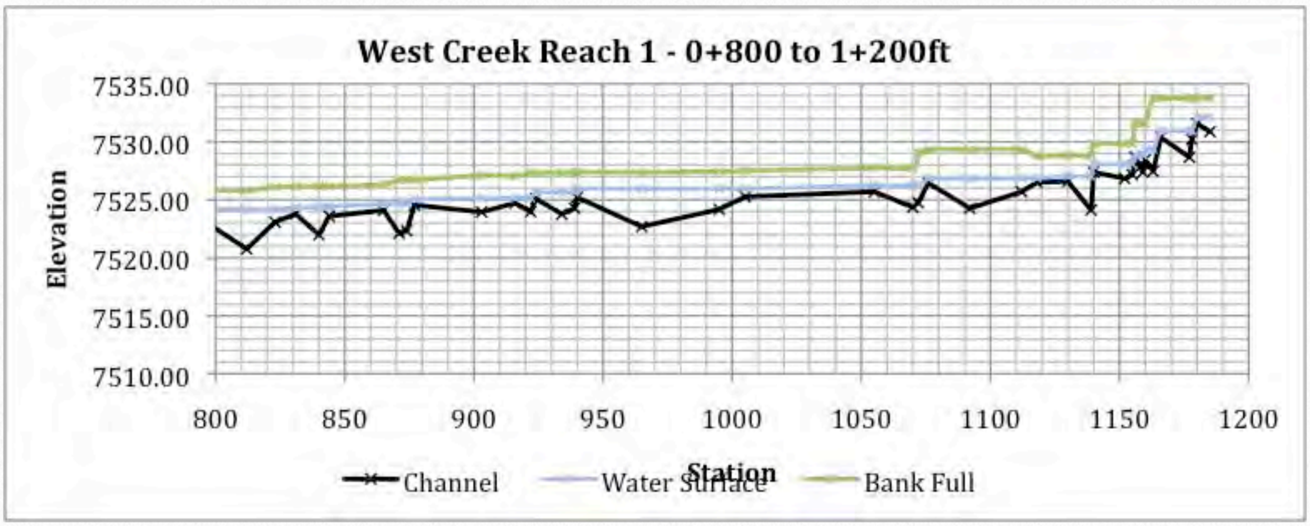
West Creek Reach 1

A longitudinal project and cross section survey was completed in the reach in 2013, and is plotted below. Channel slope in the reach was approximately 1%. Maximum pool depth at base flow within the reach ranged from 1.18 ft. to 3.74 ft., with an average of 2.28 ft. Residual pool depth ranged from ½ ft. to 3.4 ft., and averaged 1.77 ft.

Four channel cross sections were established on West Creek Reach 1, and the locations are shown in the As-Build drawings in the appendix. Bank full width, mean bank full depth, width/depth ratio, flood prone width, and entrenchment ratios for each of the cross sections are shown in the table below. Plots of the four cross sections are also presented here.

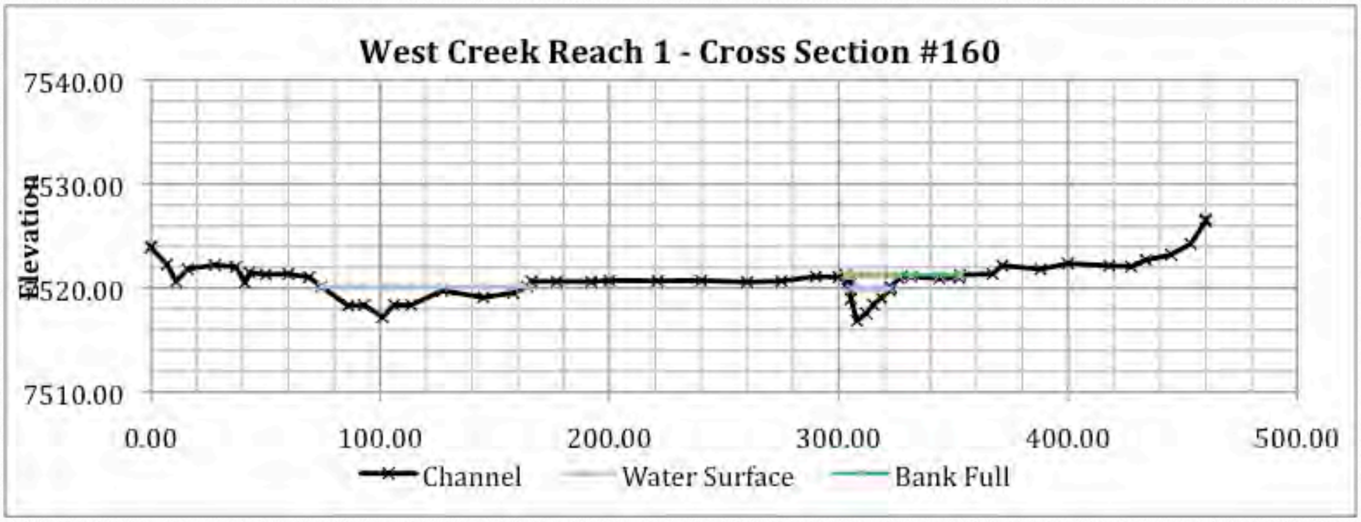


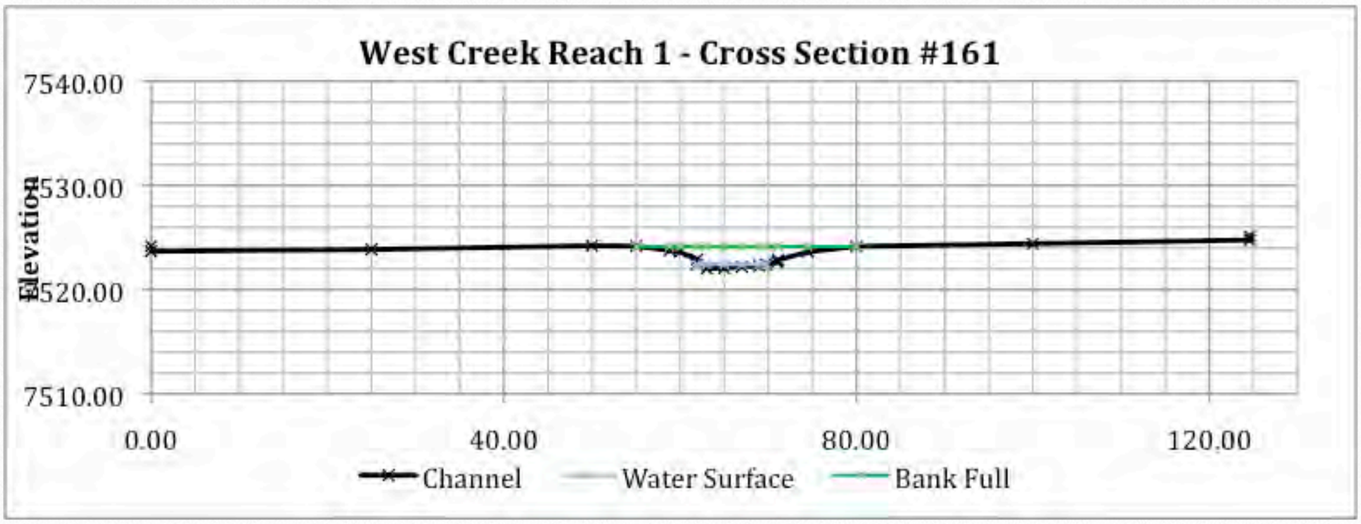


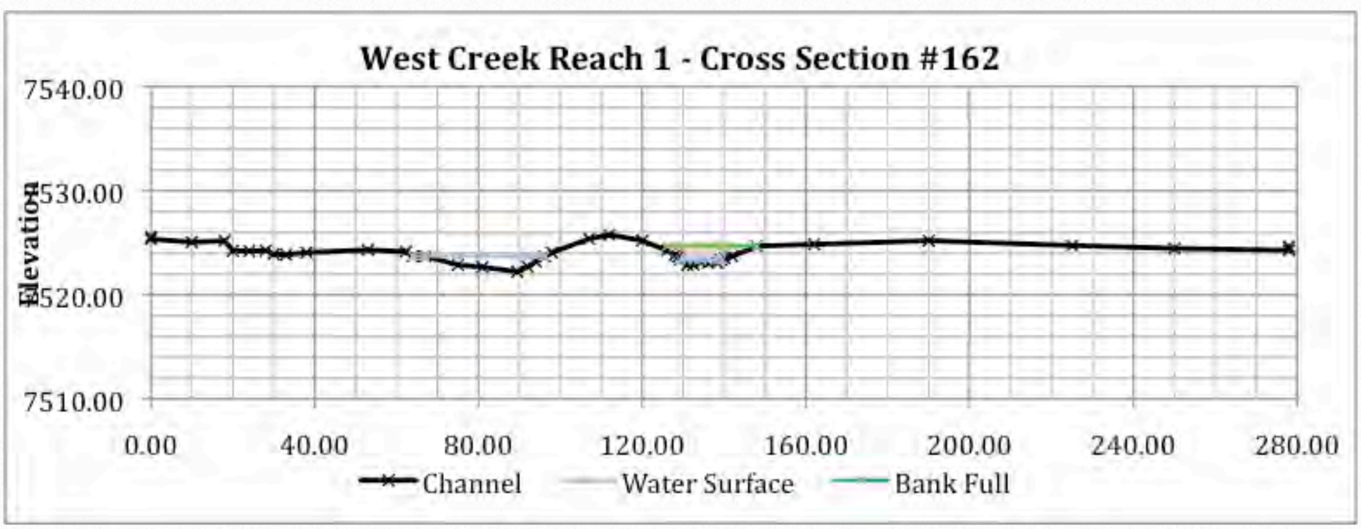


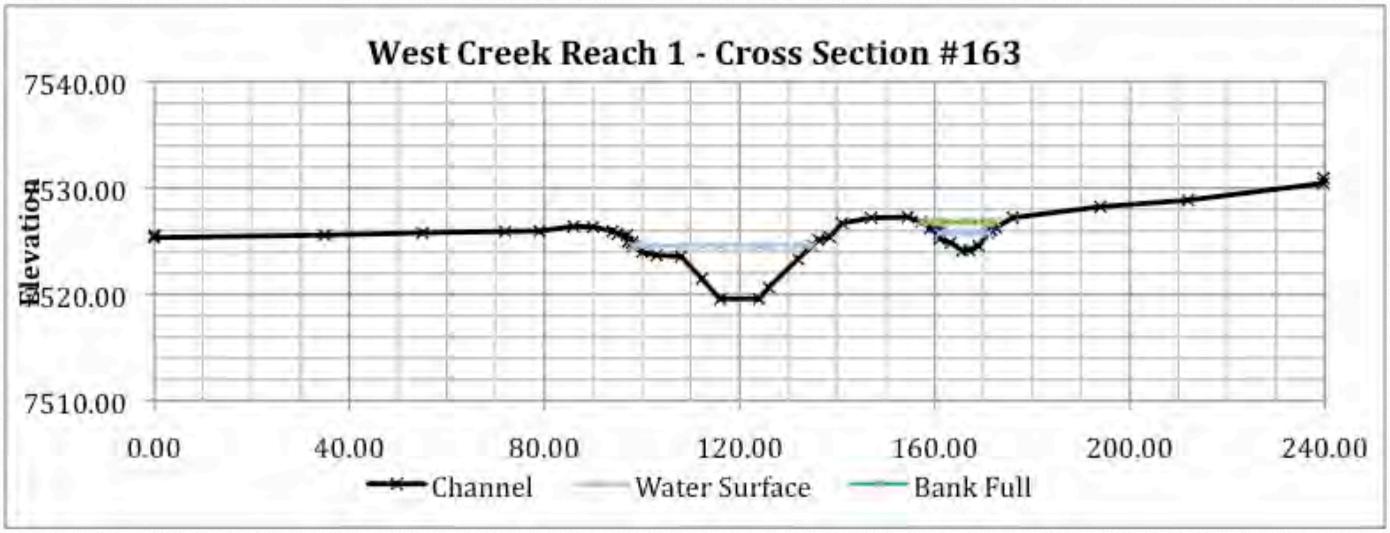
2013 Post-Project Longitudinal Profile of West Creek Reach 1

West Creek Reach 1				
Cross Section #	**160**	**161**	**162**	**163**
Bank Full Width	50.00	25.00	22.00	15.30
Mean Bank Full Depth	1.47	1.41	1.29	1.27
Width / Depth Ratio	34.12	17.77	17.07	12.01
Flood Prone Width	460.00	124.60	278.00	194.00
Entrenchment Ratio	0.11	0.20	0.08	0.08


West Creek Reach 1 - Cross Section #160
7540.00
7530.00
7520.00
7510.00
Elevation
0.00
100.00
200.00
300.00
400.00
500.00
Channel
Water Surface
Bank Full

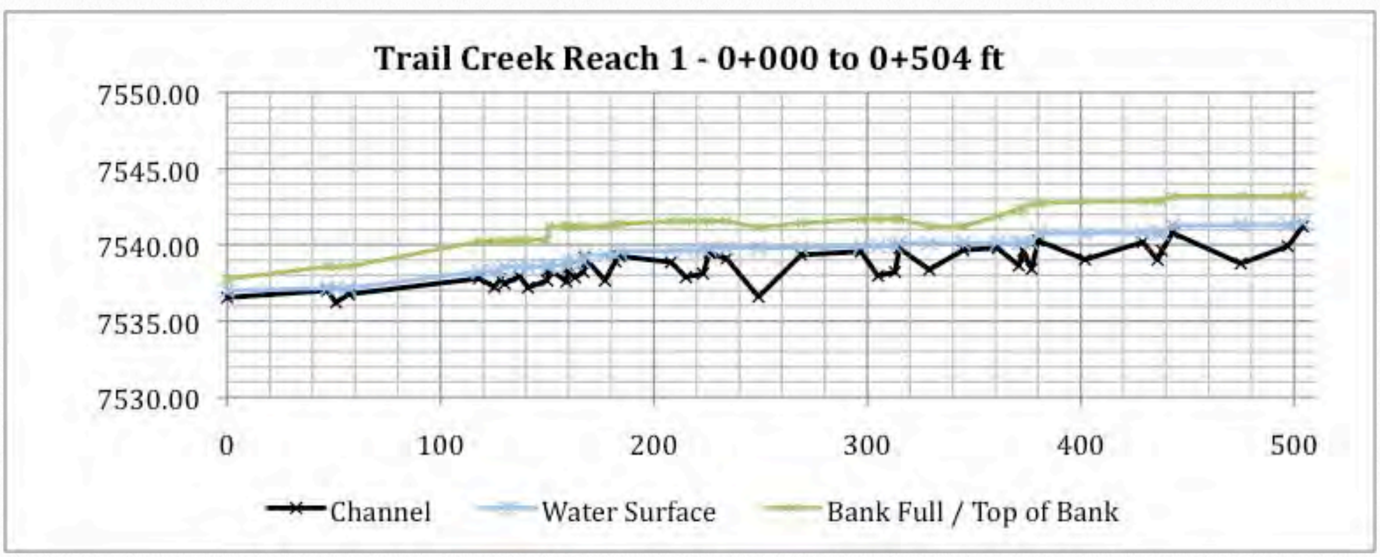

West Creek Reach 1 - Cross Section #161
7540.00
7530.00
7520.00
7510.00
Elevation
0.00
40.00
80.00
120.00
Channel
Water Surface
Bank Full


West Creek Reach 1 - Cross Section #162
7540.00
7530.00
7520.00
7510.00
Elevation
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
Channel
Water Surface
Bank Full



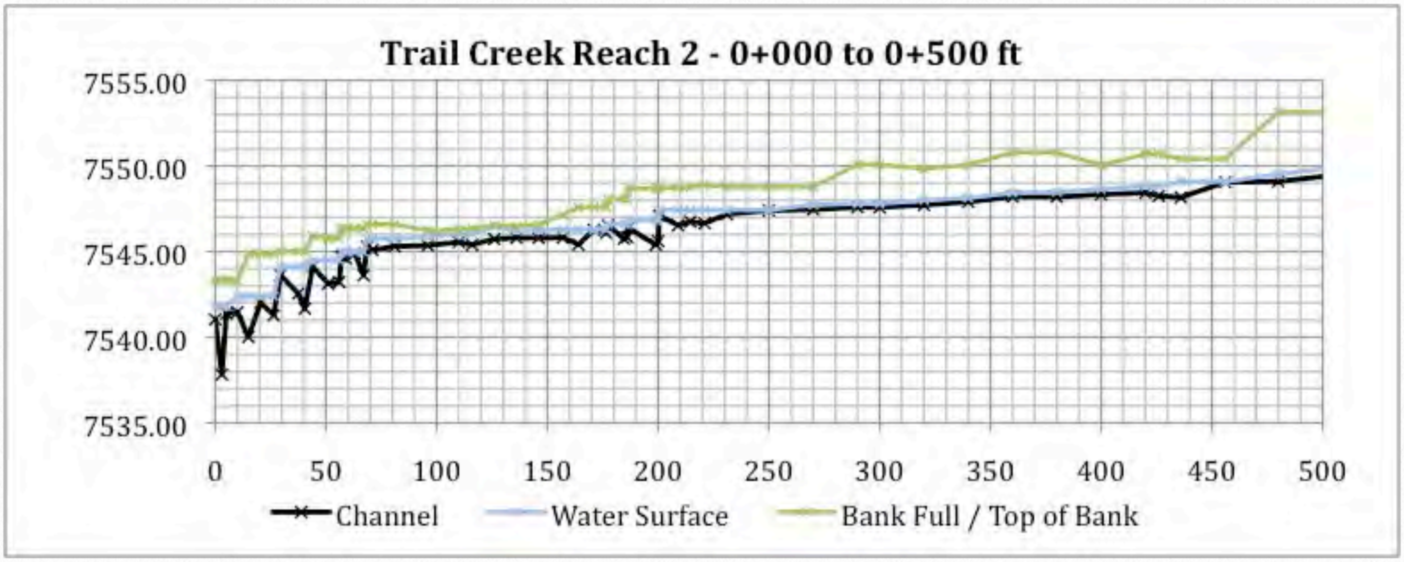
Trail Creek Reach 1

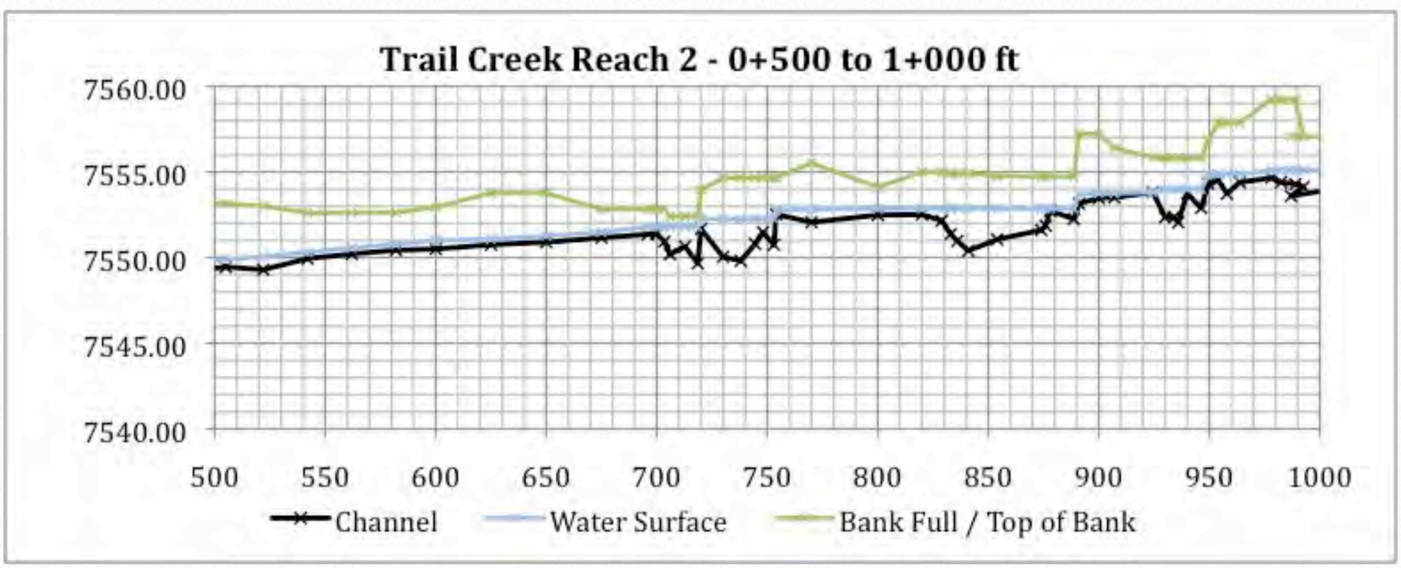
A longitudinal project and cross section survey was completed in the reach in 2013, and is plotted below. Channel slope in the reach was approximately 0.9%. Maximum pool depth at base flow within the reach ranged from 0.95 ft. to 3.20 ft., with an average of 1.71 ft. Residual pool depth ranged from 0.56 ft. to 2.51 ft., and averaged 1.25 ft.

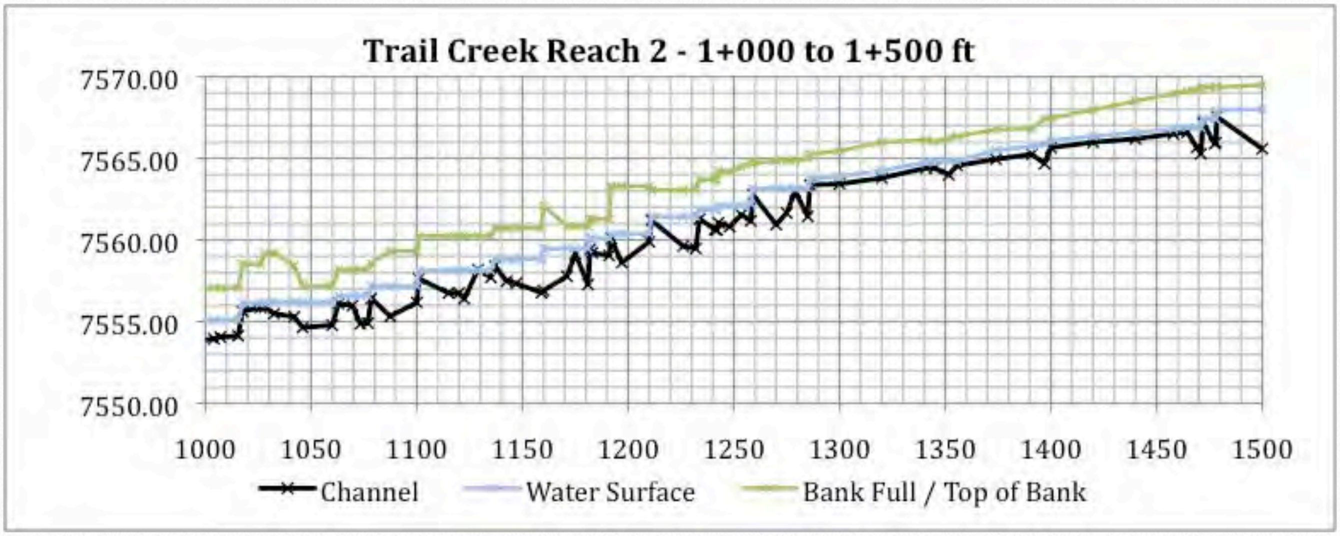


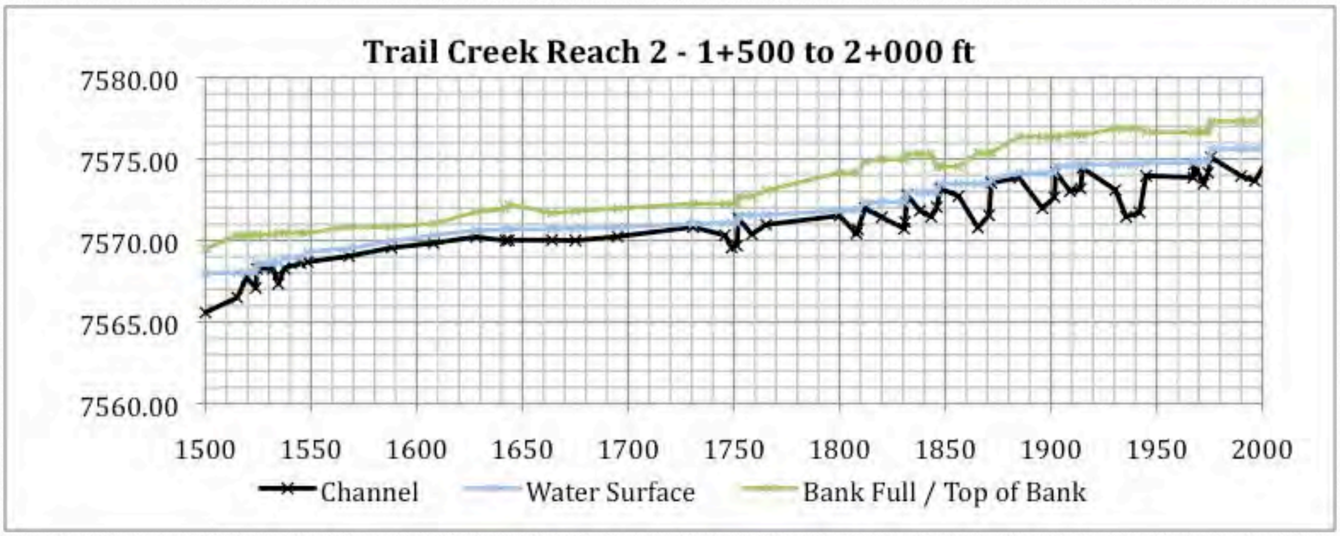
Trail Creek Reach 2

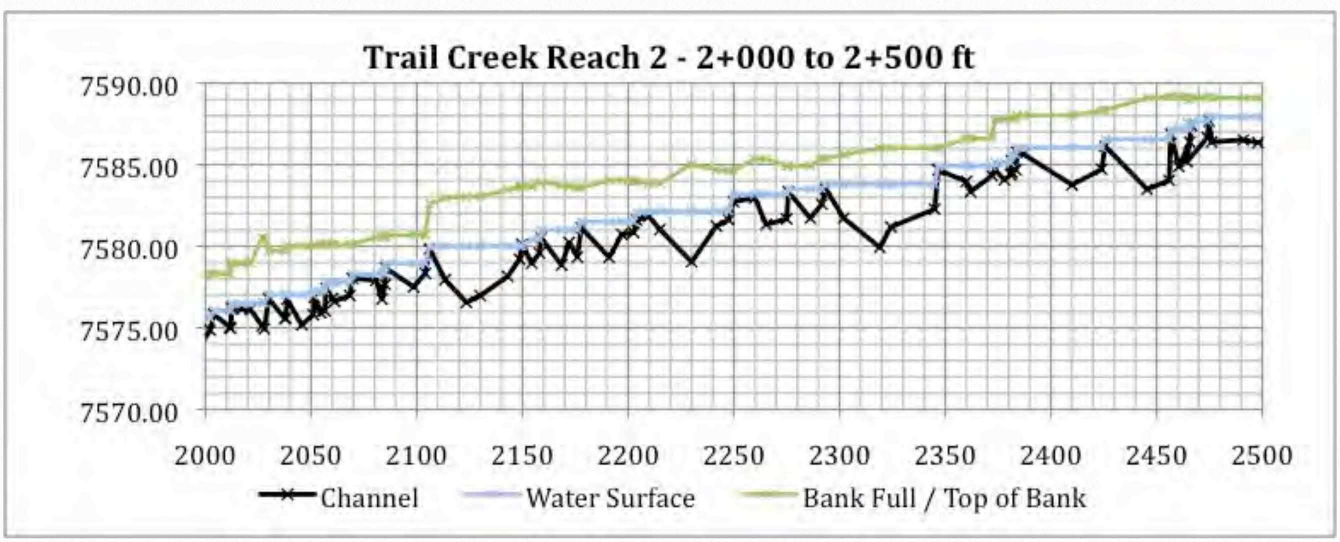
A longitudinal project and cross section survey was completed in the reach in 2013, and is plotted below. Channel slope in the reach was approximately 2%. Maximum pool depth at base flow within the reach ranged from 0.4 ft. to 4.0 ft., with an average of 1.66 ft. Residual pool depth ranged from 0.1 ft. to 3.6 ft., and averaged 1.23ft. Many trout were observed in the reach during the course of the survey.

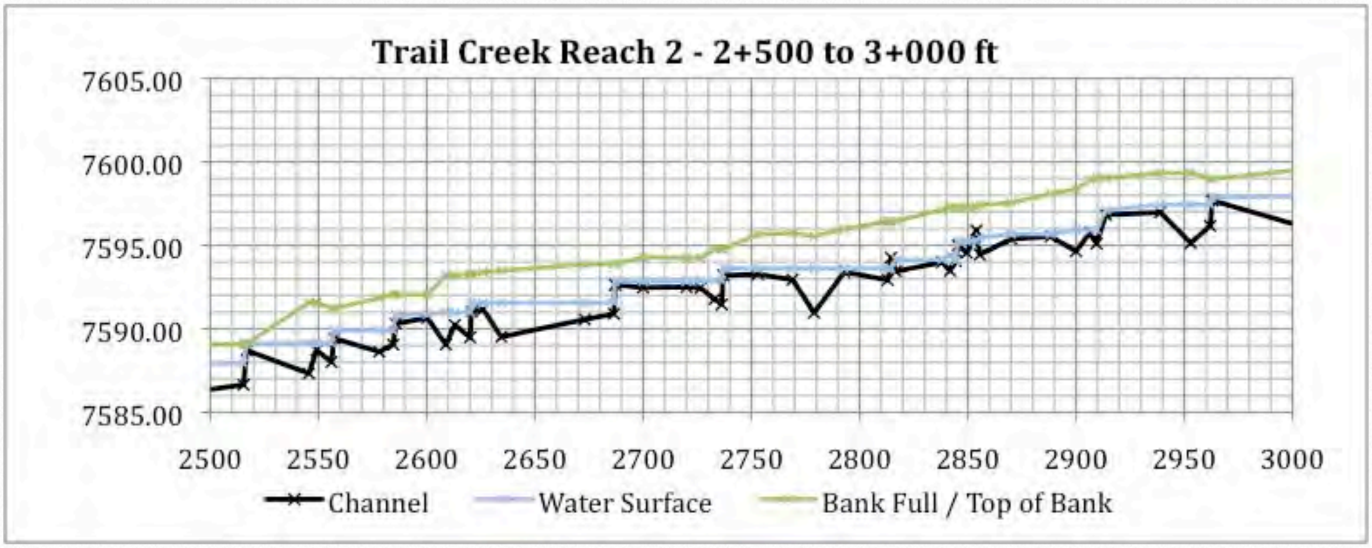


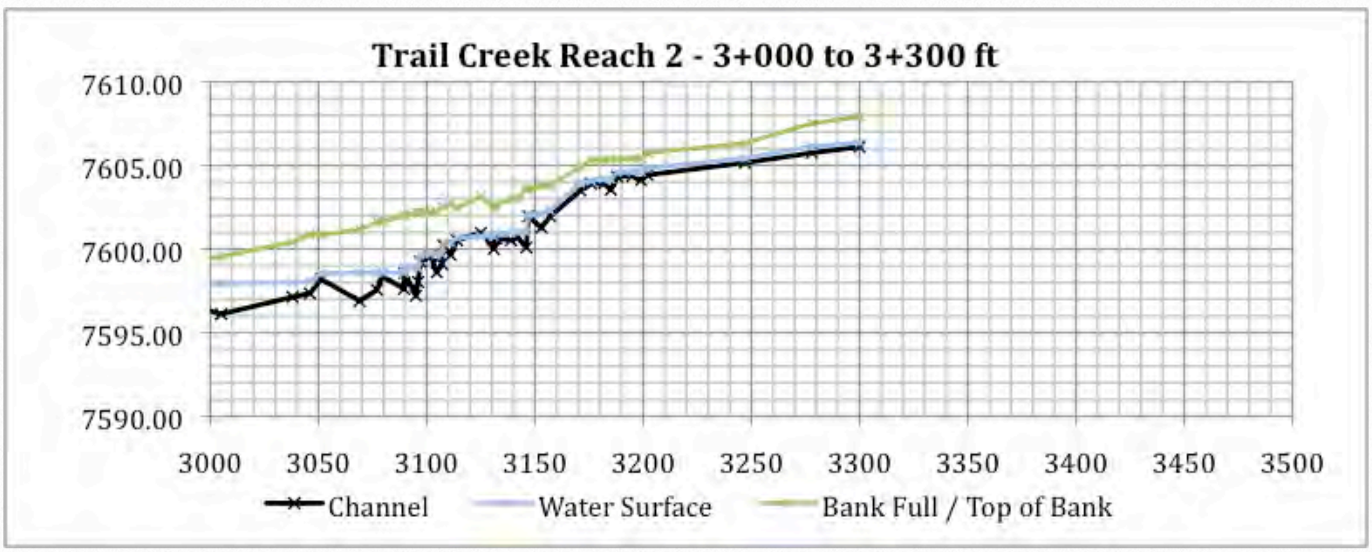



Trail Creek Reach 2 - 1+000 to 1+500 ft
7570.00
7565.00
7560.00
7555.00
7550.00
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
Channel
Water Surface
Bank Full / Top of Bank


Trail Creek Reach 2 - 1+500 to 2+000 ft
7580.00
7575.00
7570.00
7565.00
7560.00
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
Channel
Water Surface
Bank Full / Top of Bank

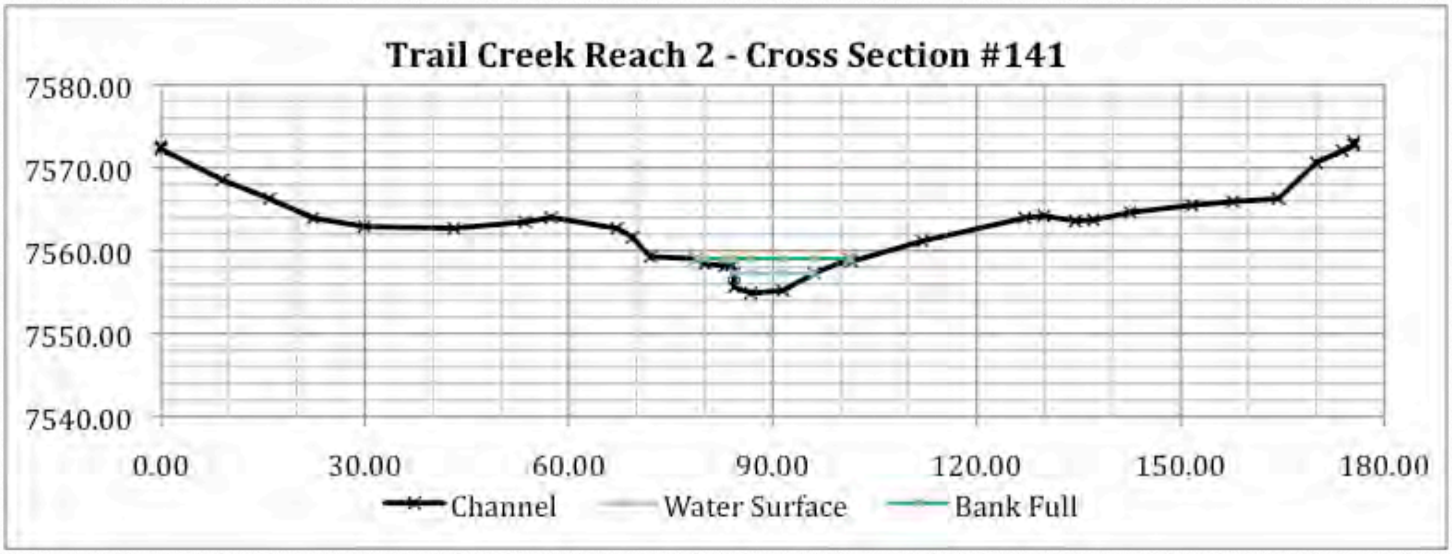

Trail Creek Reach 2 - 2+000 to 2+500 ft
7590.00
7585.00
7580.00
7575.00
7570.00
2000
2050
2100
2150
2200
2250
2300
2350
2400
2450
2500
Channel
Water Surface
Bank Full / Top of Bank

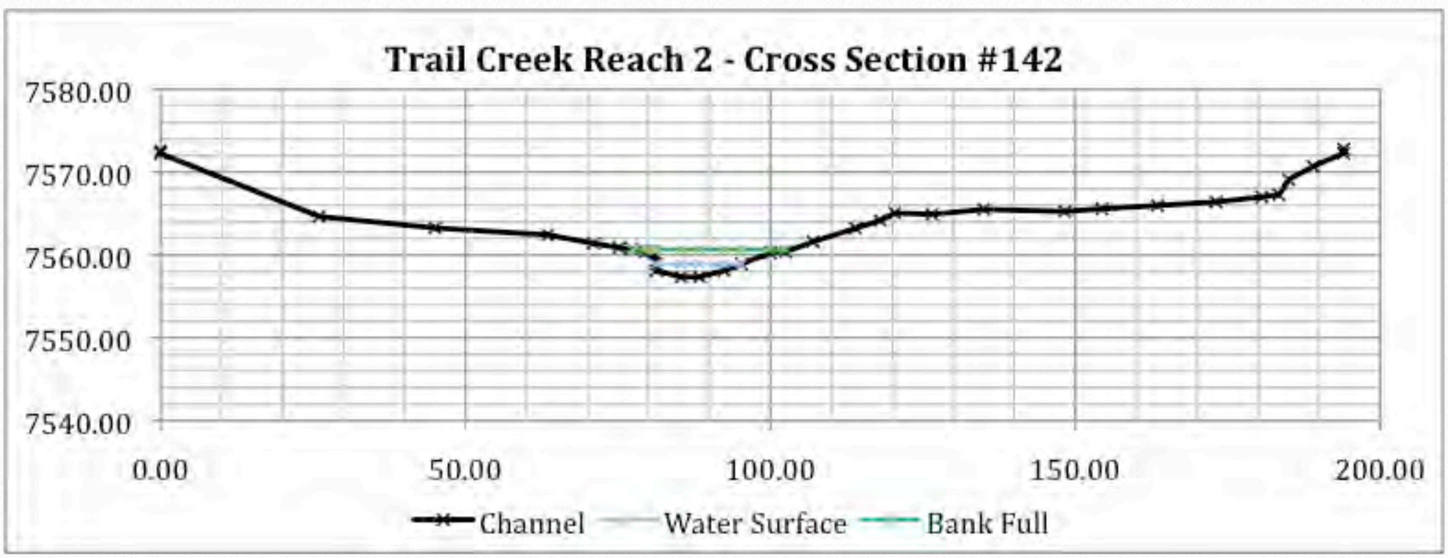


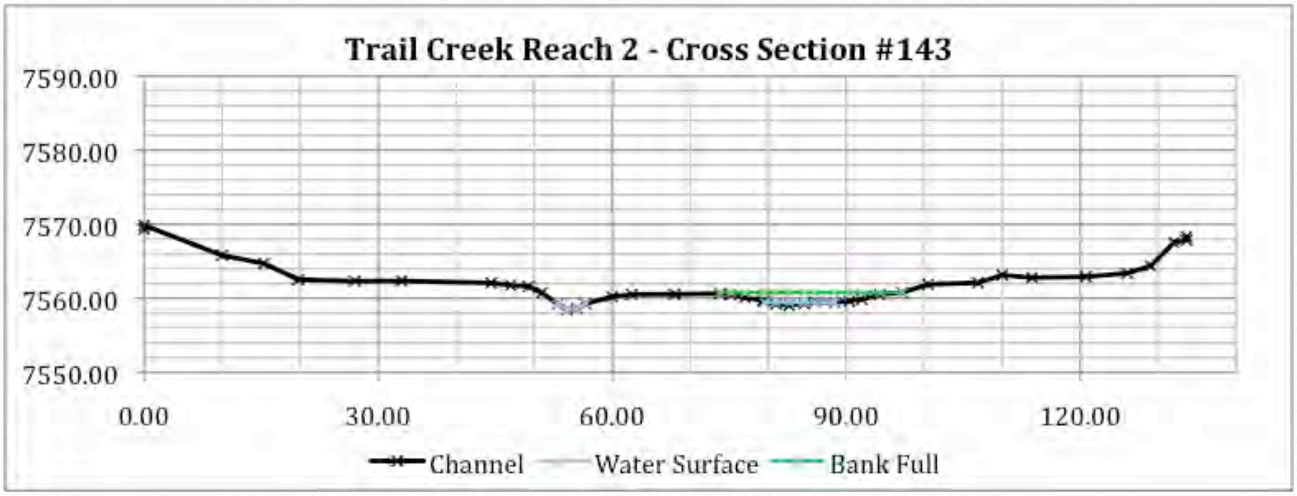


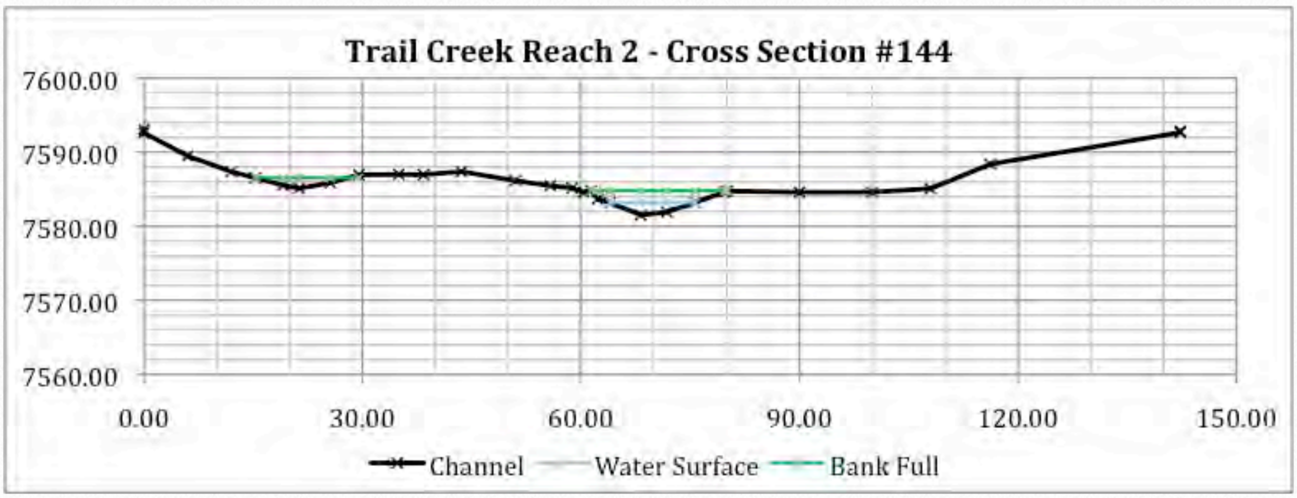
Five channel cross sections were established along Reach 2, and the locations are shown in the As-Build drawings in the appendix. Bank full width, mean bank full depth, width/depth ratio, flood prone width, and entrenchment ratios for each of the cross sections are shown in the table on the following page. Plots of the four cross sections are also presented here.

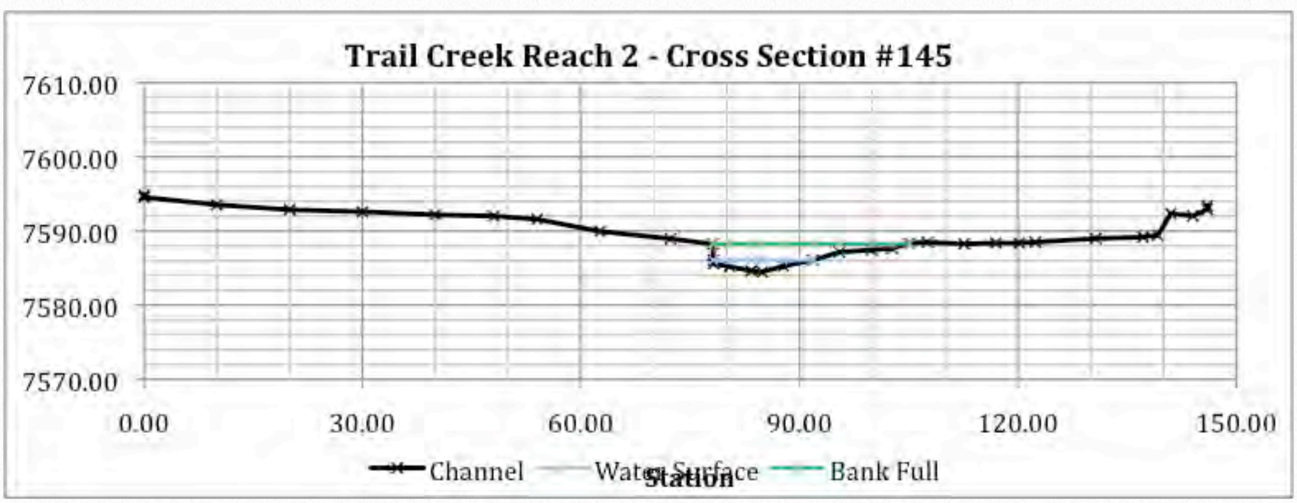
Trail Creek Reach 2						
Cross Section #	**#146**	**#142**	**#143**	**#144**	**#145**	**#146**
Bank Full Width	23.00	25.20	23.40	18.70	27.00	23.00
Mean Bank Full Depth	2.11	1.56	1.01	1.52	2.09	2.11
Width / Depth Ratio	10.89	16.15	23.20	12.34	12.93	10.89
Flood Prone Width	169.30	92.00	90.20	110.20	96.00	169.30
Entrenchment Ratio	0.14	0.27	0.26	0.17	0.28	0.14

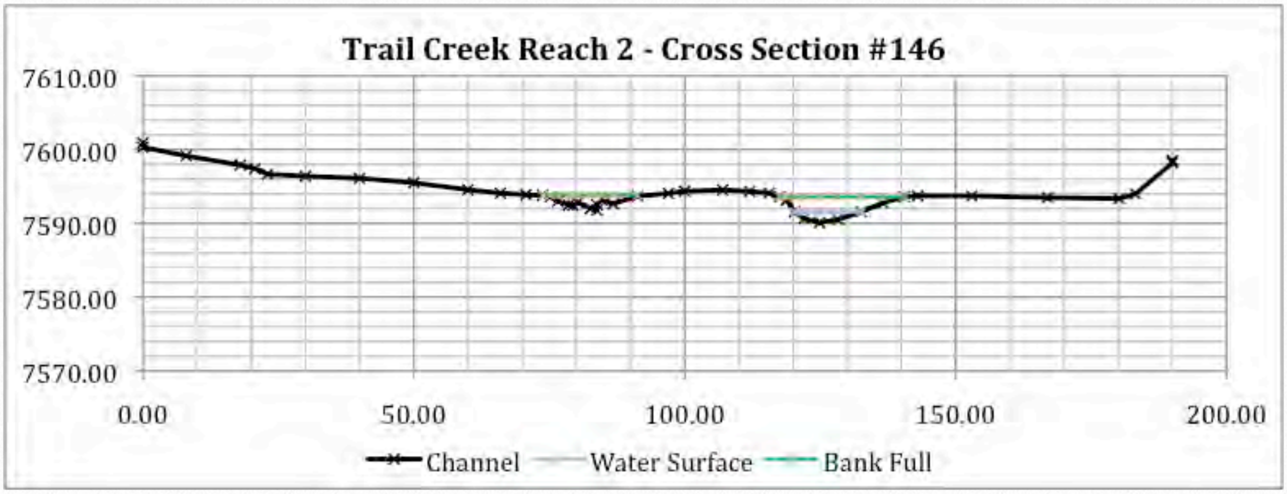





Trail Creek Reach 2 - Cross Section #143
7590.00
7580.00
7570.00
7560.00
7550.00
0.00
30.00
60.00
90.00
120.00
Channel
Water Surface
Bank Full

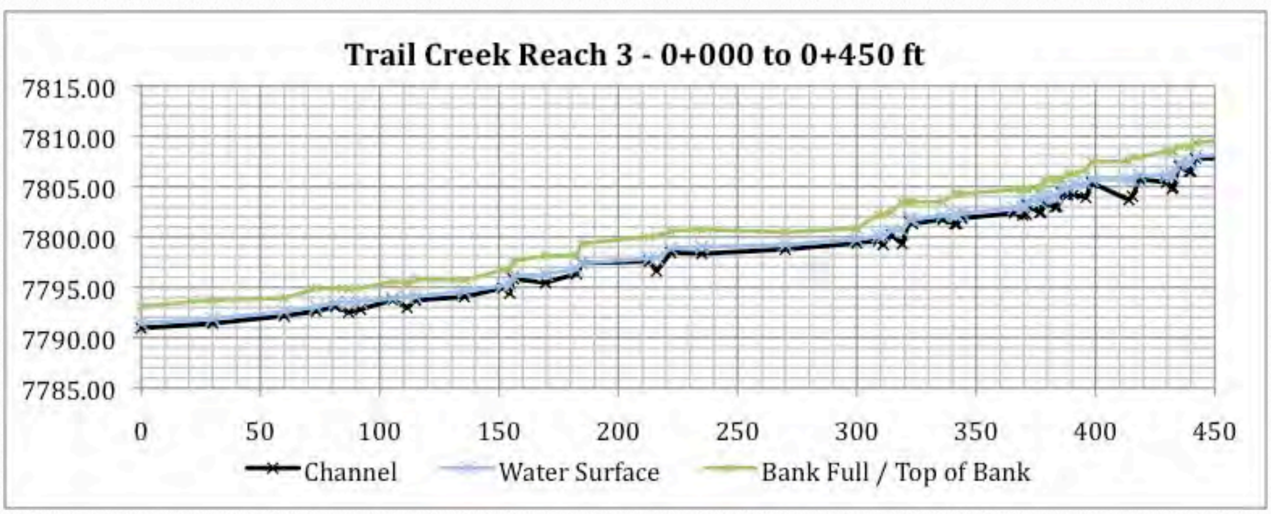

Trail Creek Reach 2 - Cross Section #144
7600.00
7590.00
7580.00
7570.00
7560.00
0.00
30.00
60.00
90.00
120.00
150.00
Channel
Water Surface
Bank Full

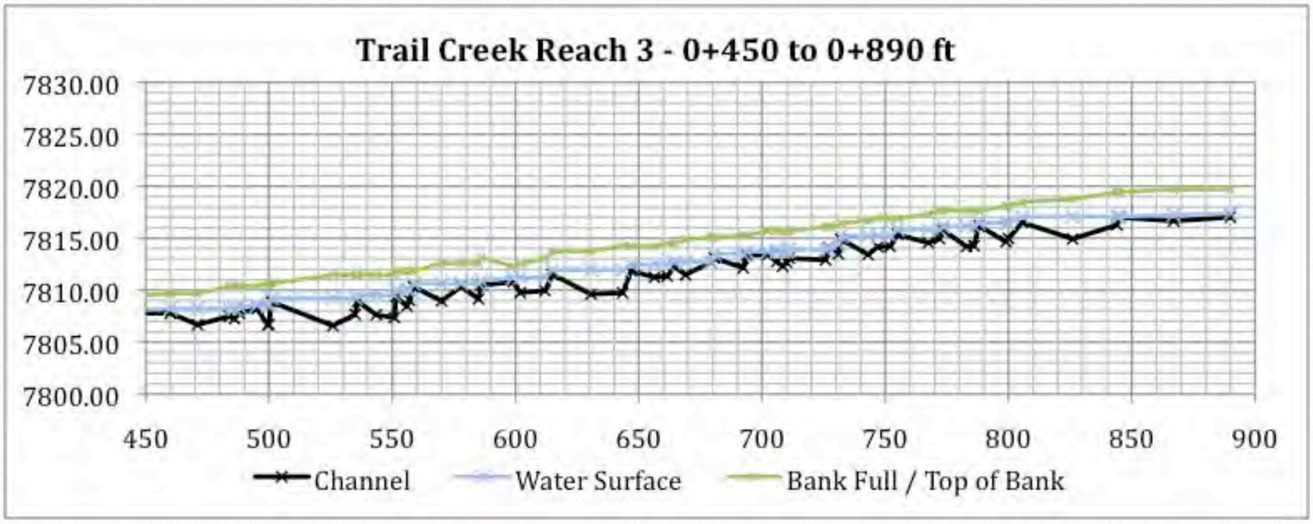

Trail Creek Reach 2 - Cross Section #145
7610.00
7600.00
7590.00
7580.00
7570.00
0.00
30.00
60.00
90.00
120.00
150.00
Channel
Water Surface
Station
Bank Full



Trail Creek Reach 3

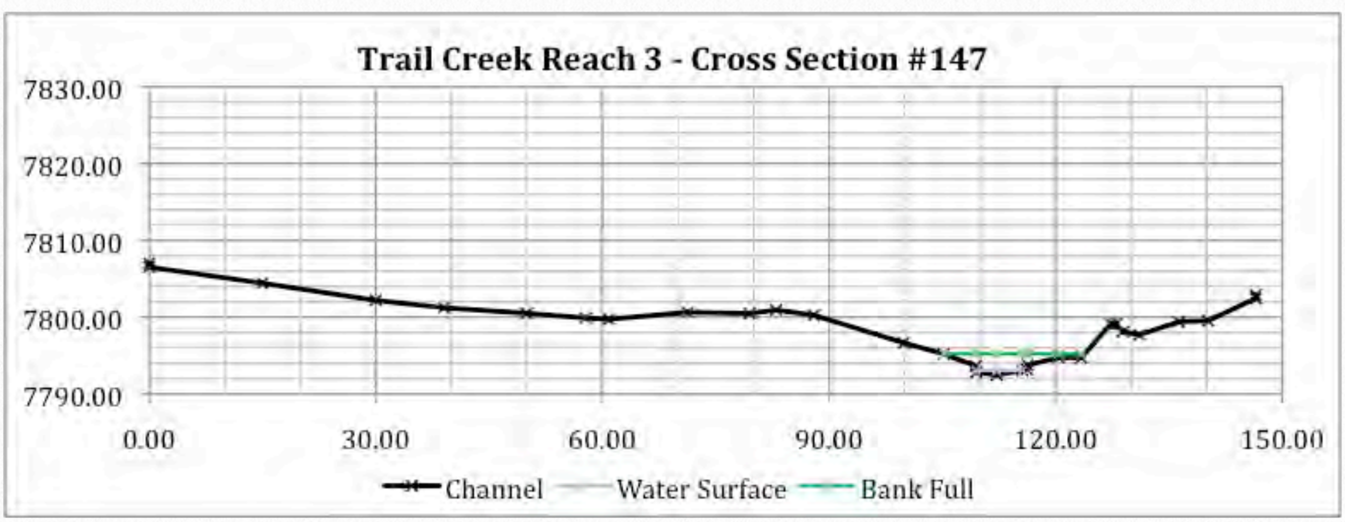
A longitudinal project and cross section survey was completed in the reach in 2013, and is plotted on the following pages. Channel slope in the reach was approximately 3%. Maximum pool depth at base flow within the reach ranged from 0.75 ft. to 2.7 ft., with an average of 1.4 ft. Residual pool depth ranged from 0.2 ft. to 2.3 ft., and averaged 0.94ft.

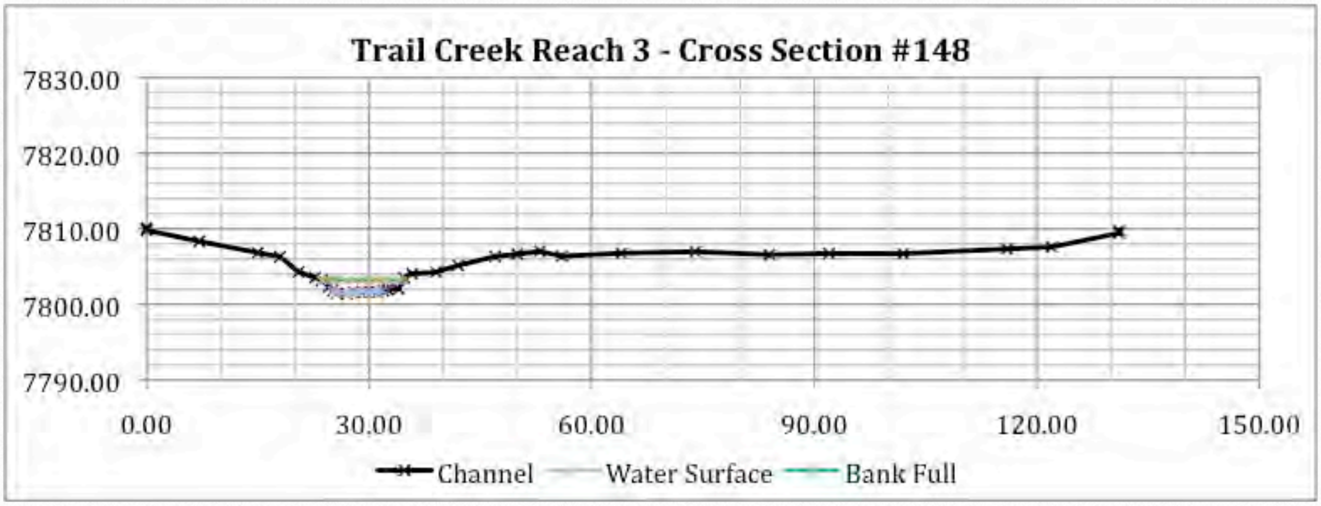


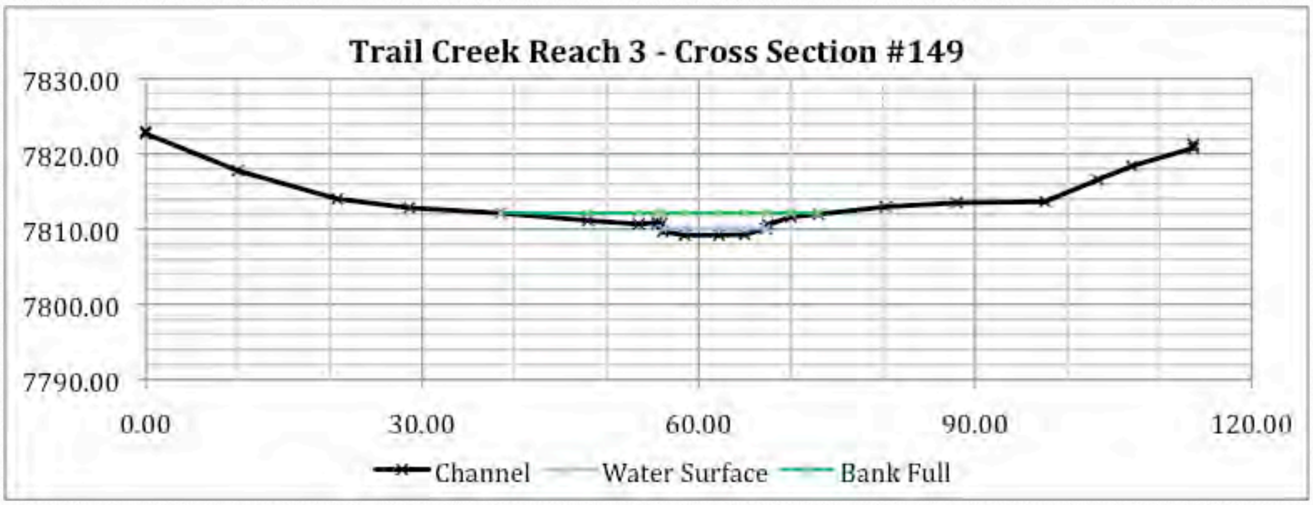


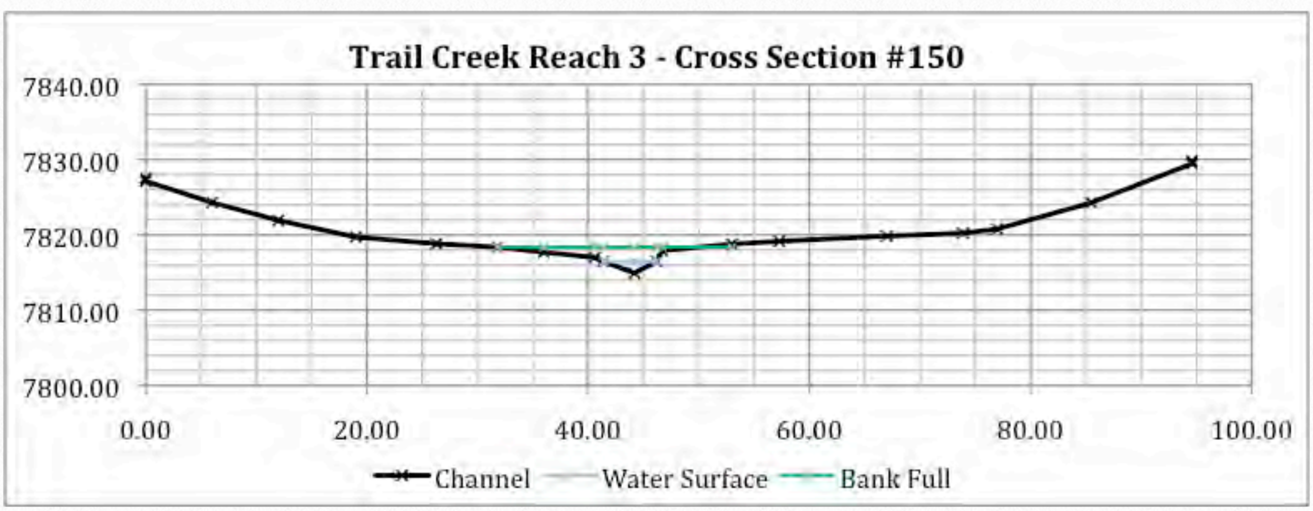
Four channel cross sections were established along Reach 3, and the locations are shown in the As-Build drawings in the Appendix. Bank full width, mean bank full depth, width/depth ratio, flood prone width, and entrenchment ratios for each of the cross sections are shown in the table below. Plots of the four cross sections are also presented here.

Trail Creek Reach 3				
Cross Section #	**147**	**148**	**149**	**150**
Bank Full Width	18.20	11.10	34.50	21.20
Mean Bank Full Depth	1.66	1.44	1.71	1.34
Width / Depth Ratio	10.96	7.69	20.20	15.77
Flood Prone Width	31.20	24.00	93.30	68.00
Entrenchment Ratio	0.58	0.46	0.37	0.31



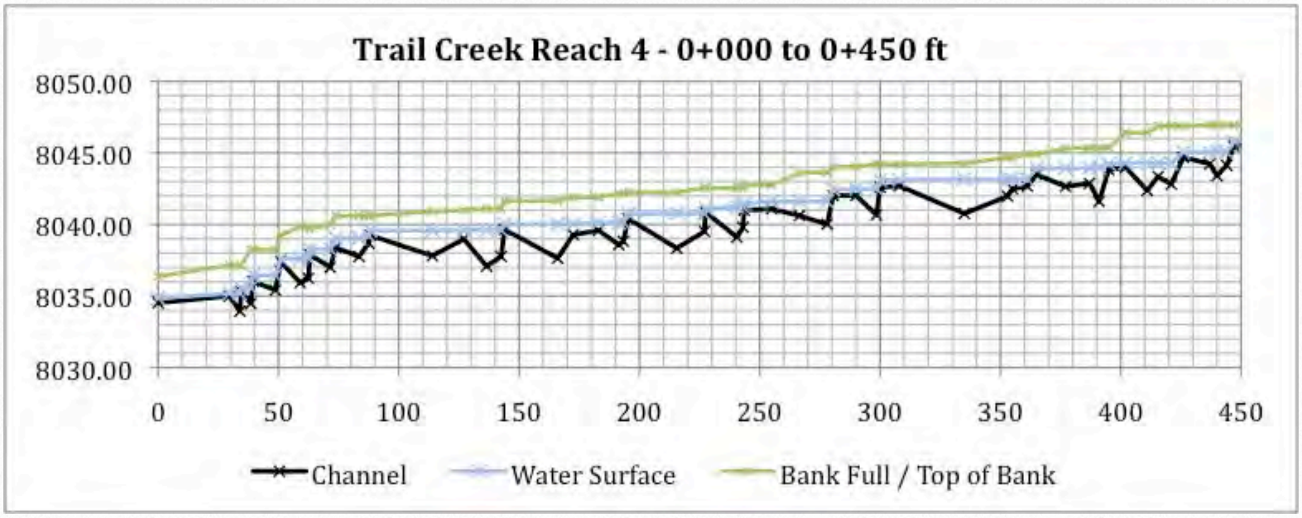

Trail Creek Reach 3 - Cross Section #148
7830.00
7820.00
7810.00
7800.00
7790.00
0.00
30.00
60.00
90.00
120.00
150.00
Channel
Water Surface
Bank Full

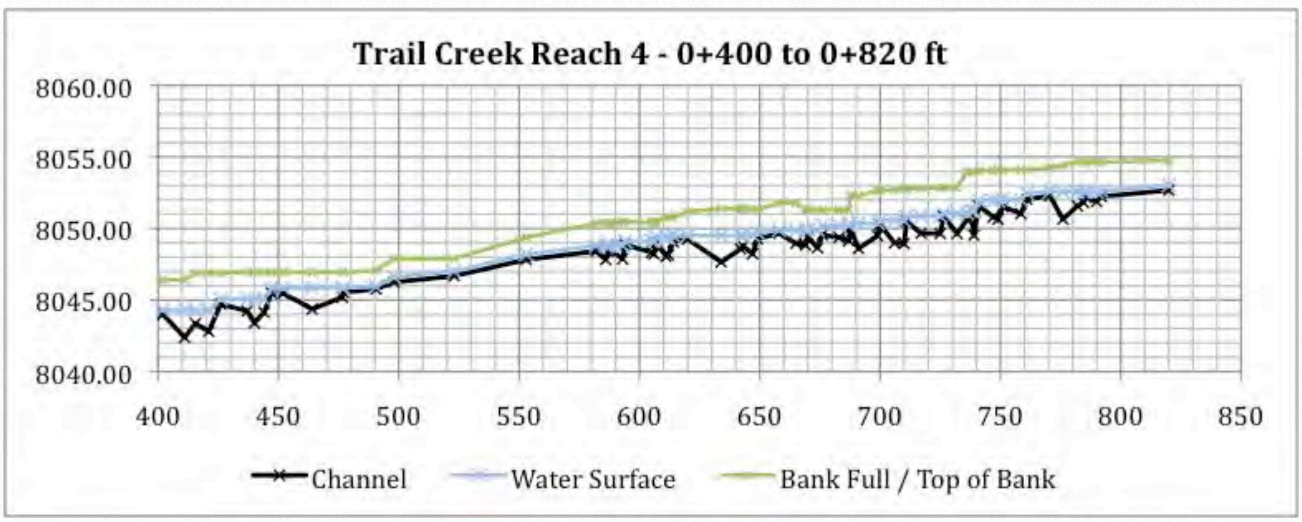

Trail Creek Reach 3 - Cross Section #149
7830.00
7820.00
7810.00
7800.00
7790.00
0.00
30.00
60.00
90.00
120.00
Channel
Water Surface
Bank Full


Trail Creek Reach 3 - Cross Section #150
7840.00
7830.00
7820.00
7810.00
7800.00
0.00
20.00
40.00
60.00
80.00
100.00
Channel
Water Surface
Bank Full

Trail Creek Reach 4

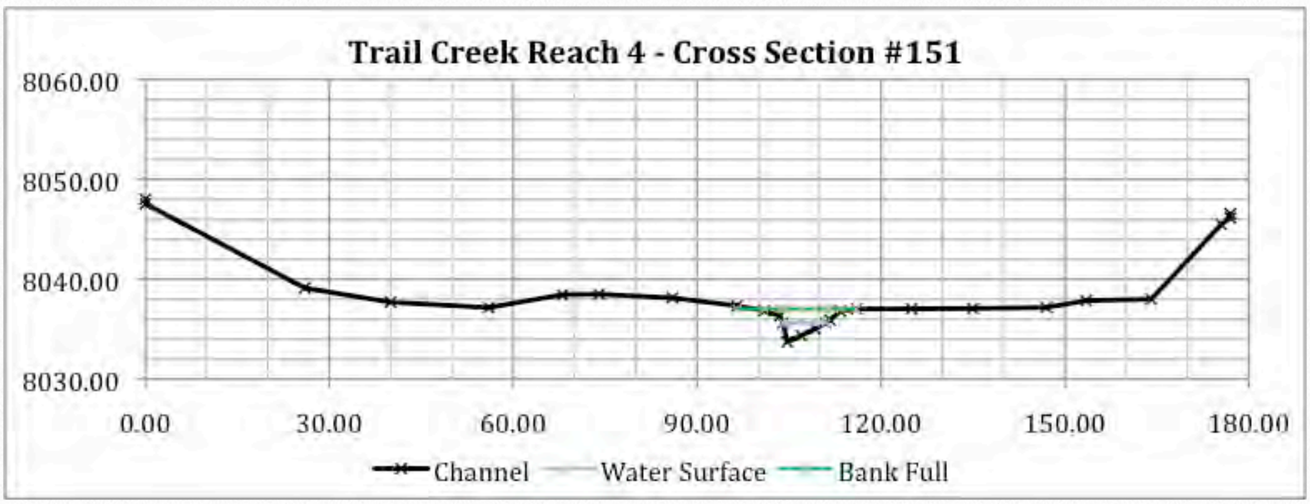
A longitudinal project and cross section survey was completed in the reach in 2013, and is plotted below. Channel slope in the reach was approximately 2%. Maximum pool depth at base flow within the reach ranged from 0.8 ft. to 2.5 ft., with an average of 1.55 ft. Residual pool depth ranged from 0.2 ft. to 2.1 ft., and averaged 1.16 ft.

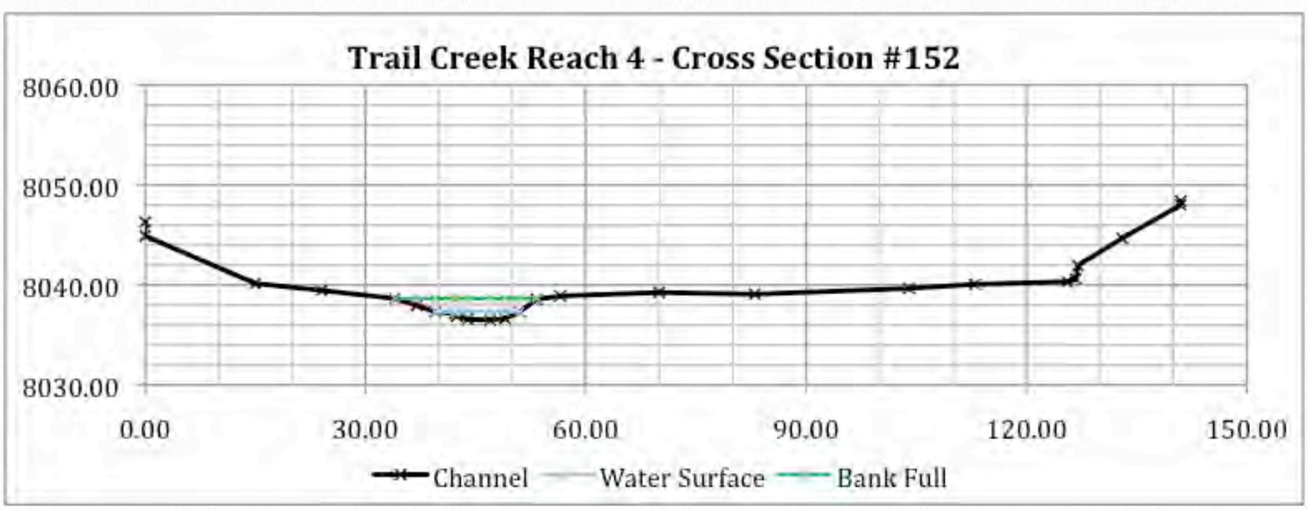


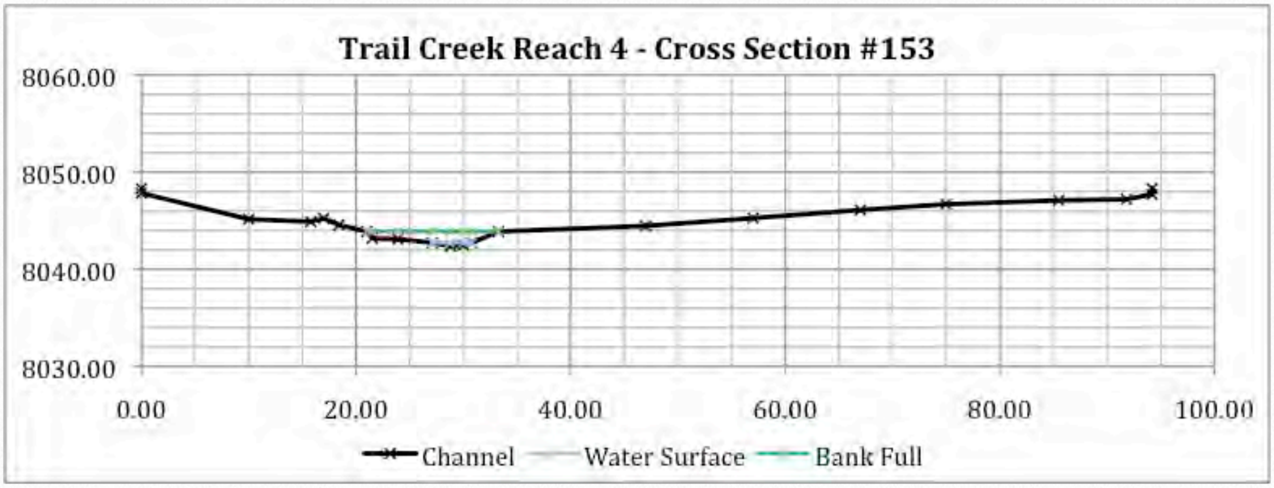


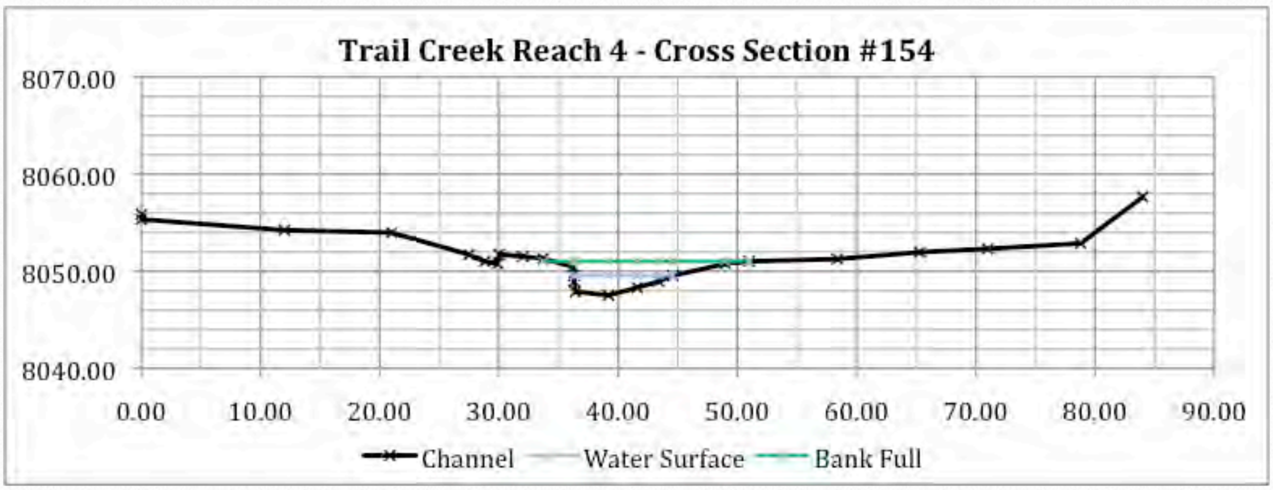
Five channel cross sections were established along Reach 4, and the locations are shown in the As-Build drawings on the previous pages. Bank full width, mean bank full depth, width/depth ratio, flood prone width, and entrenchment ratios for each of the cross sections are shown in the table below. Plots of the four cross sections are also presented here.

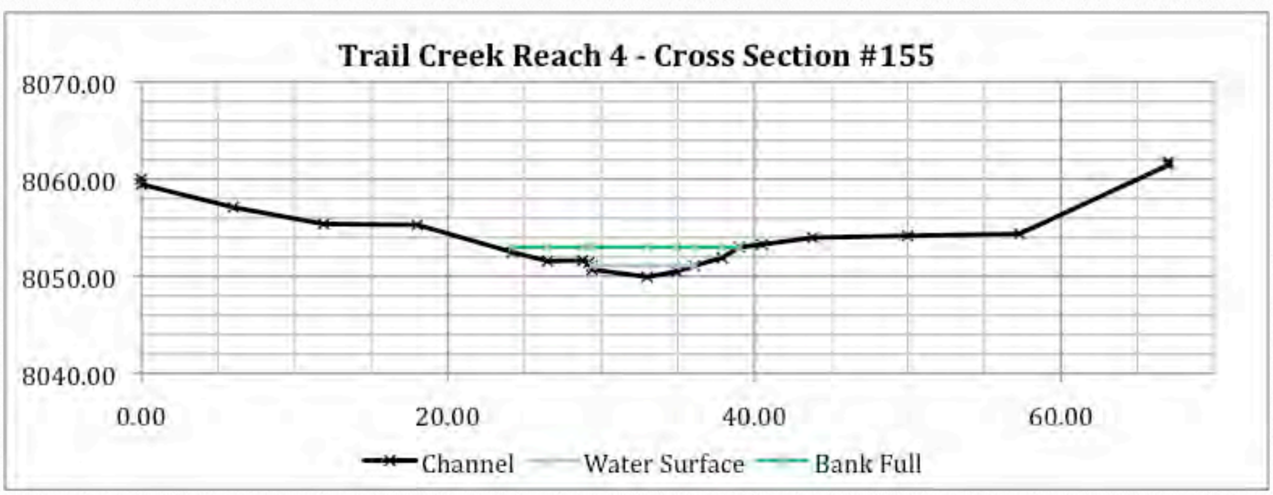
Trail Creek Reach 4					
Cross Section #	**151**	**152**	**153**	**154**	**155**
Bank Full Width	19.50	19.30	12.30	17.30	14.80
Mean Bank Full Depth	1.43	1.44	1.12	1.91	1.76
Width / Depth Ratio	13.63	13.38	11.01	9.06	8.39
Flood Prone Width	143.10	112.70	40.00	68.00	50.00
Entrenchment Ratio	0.14	0.17	0.31	0.25	0.30






Trail Creek Reach 4 - Cross Section #153
8060.00
8050.00
8040.00
8030.00
0.00
20.00
40.00
60.00
80.00
100.00
Channel
Water Surface
Bank Full

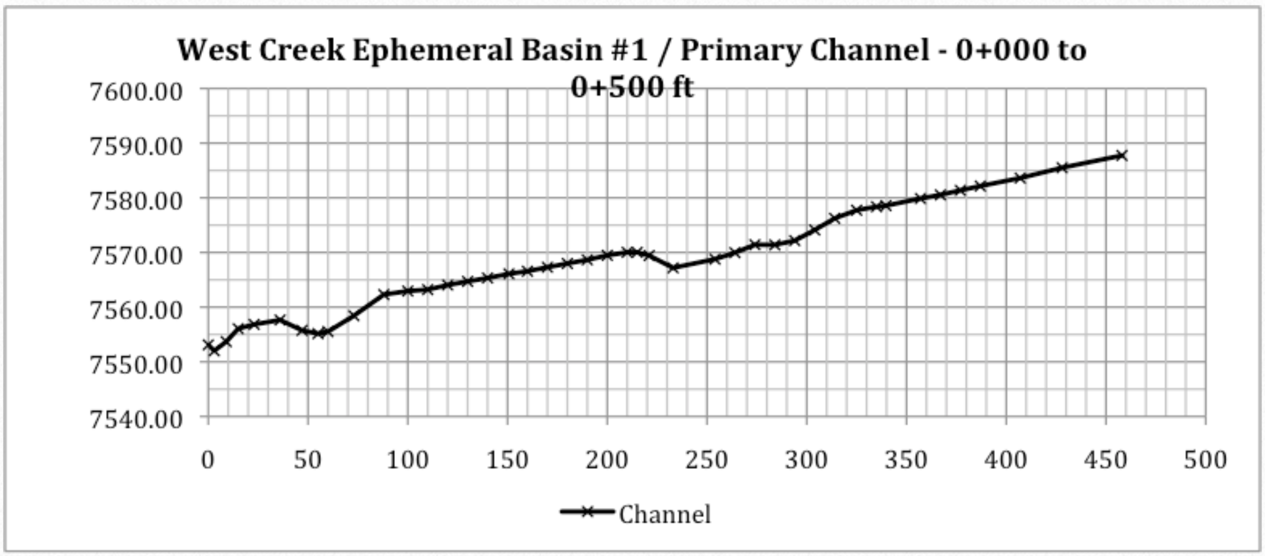

Trail Creek Reach 4 - Cross Section #154
8070.00
8060.00
8050.00
8040.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
Channel
Water Surface
Bank Full

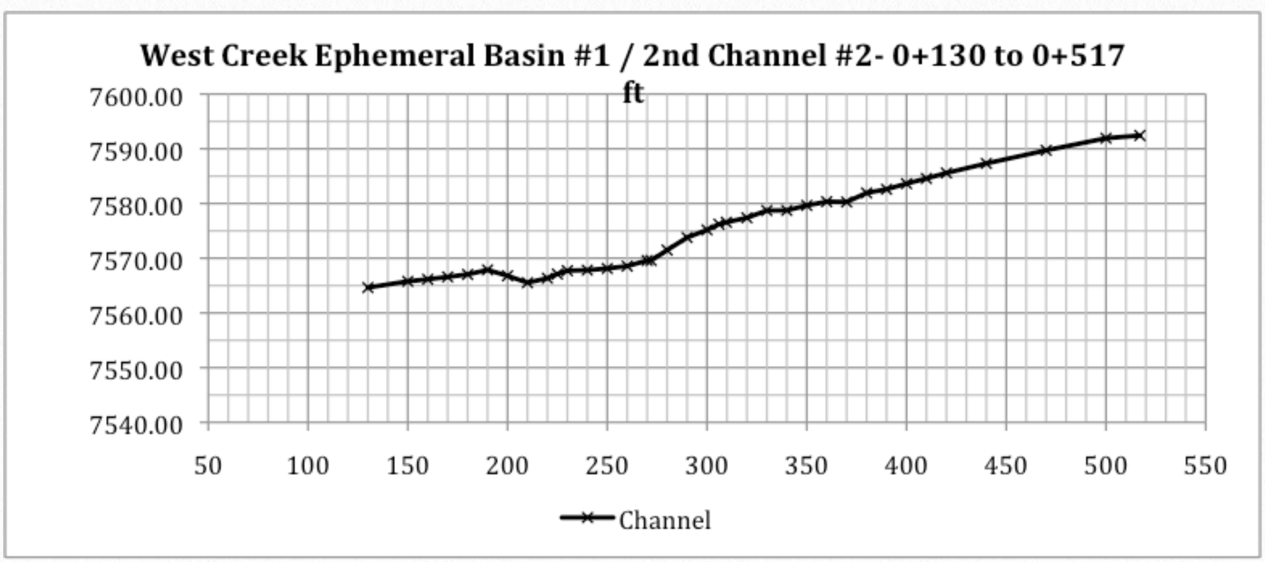

Trail Creek Reach 4 - Cross Section #155
8070.00
8060.00
8050.00
8040.00
0.00
20.00
40.00
60.00
Channel
Water Surface
Bank Full

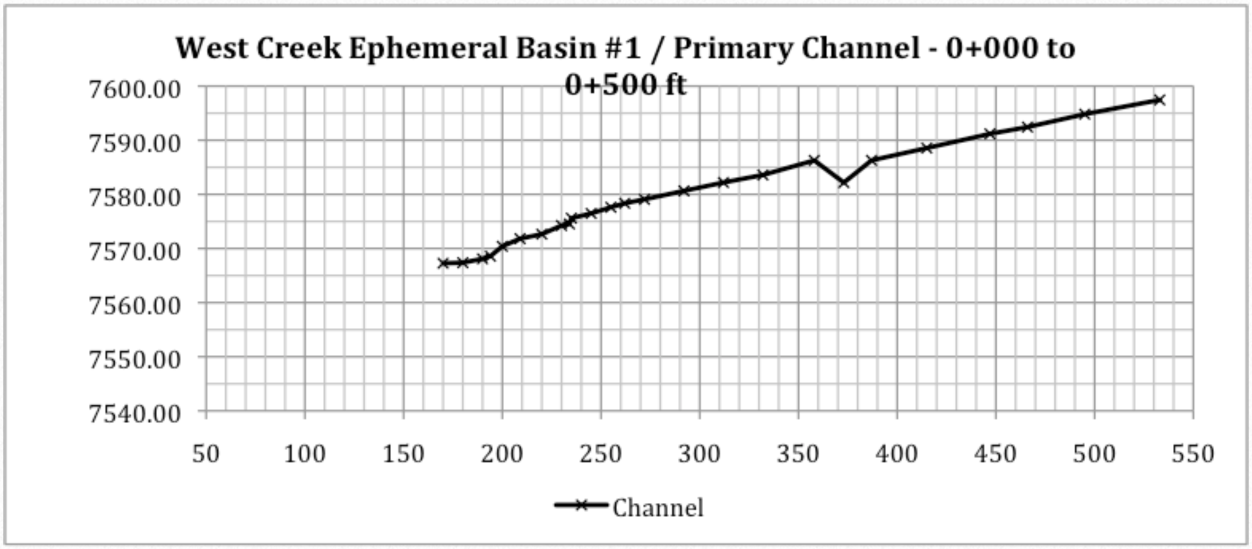
Ephemeral Channels and Alluvial Fans

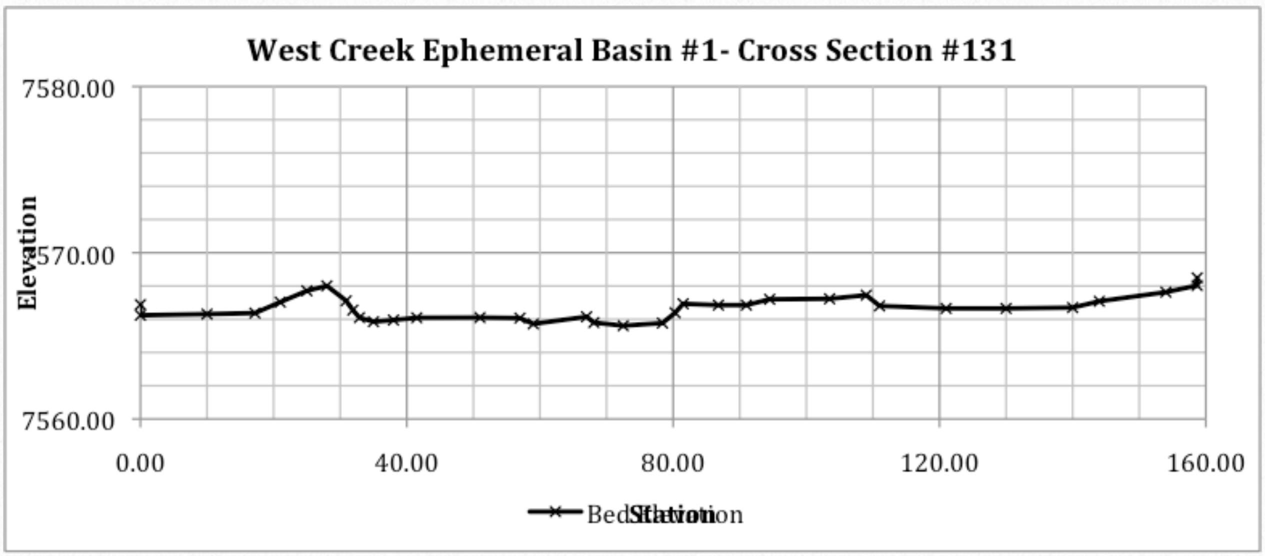
West Creek Ephemeral Draw #1

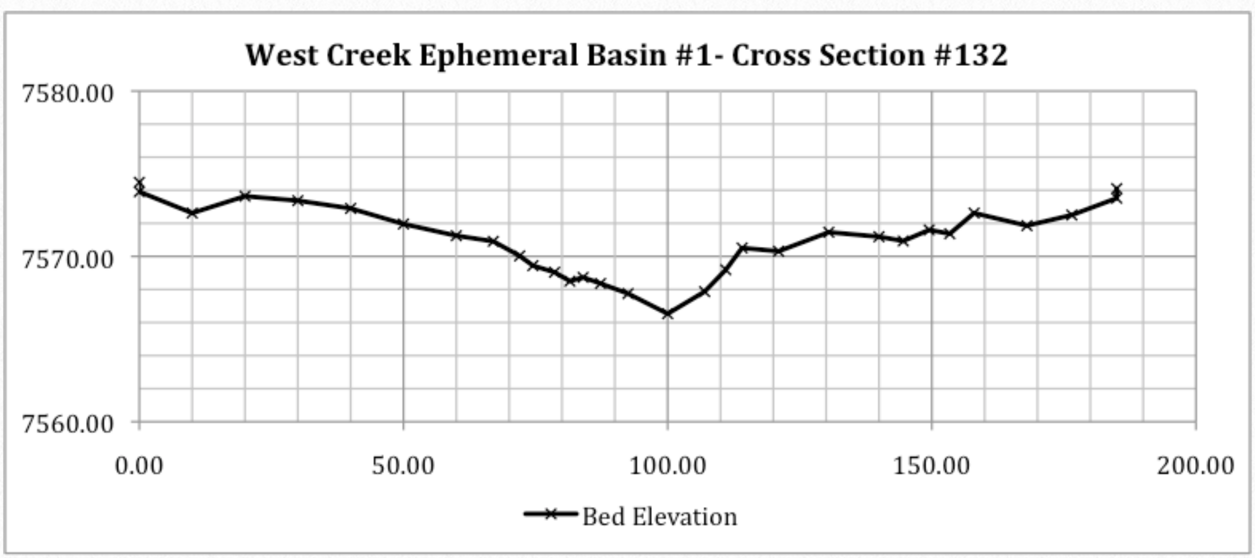
A longitudinal project and cross section survey was completed at the site in 2013. The main channel and two secondary channels were surveyed. These are plotted below. Channel slope in the primary channel and the "old" secondary channel (LP#2) was approximately 8%, and 9% in the "new" secondary channel (LP#3). Five channel cross sections were established along the project reach, and the locations are shown in the As-Build drawings in the Appendix.

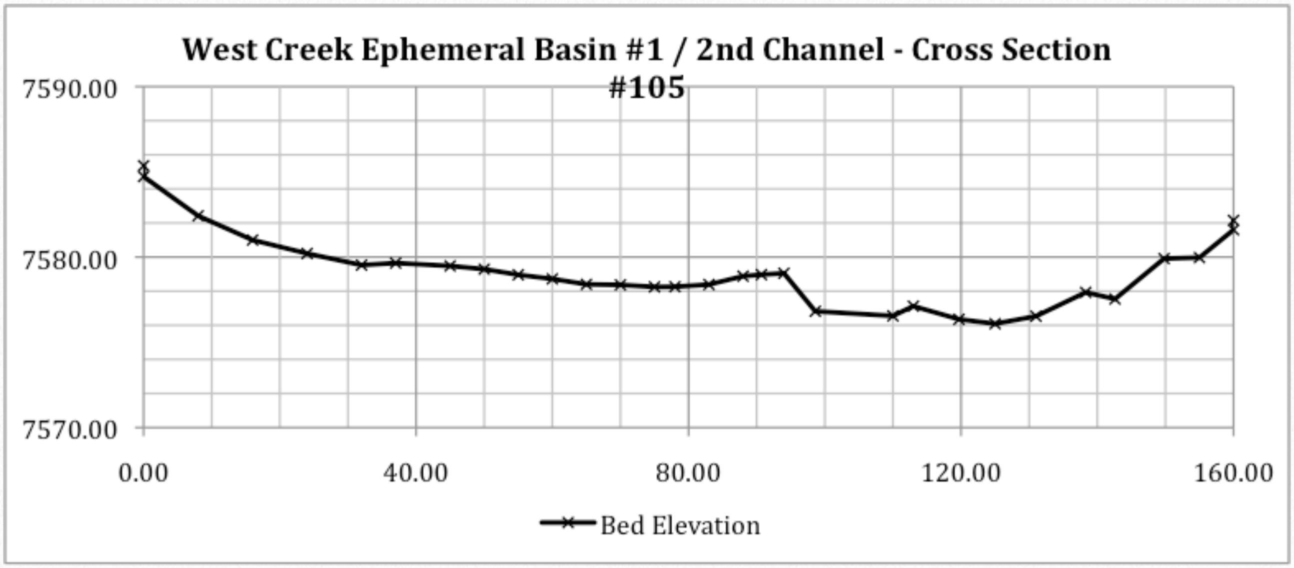


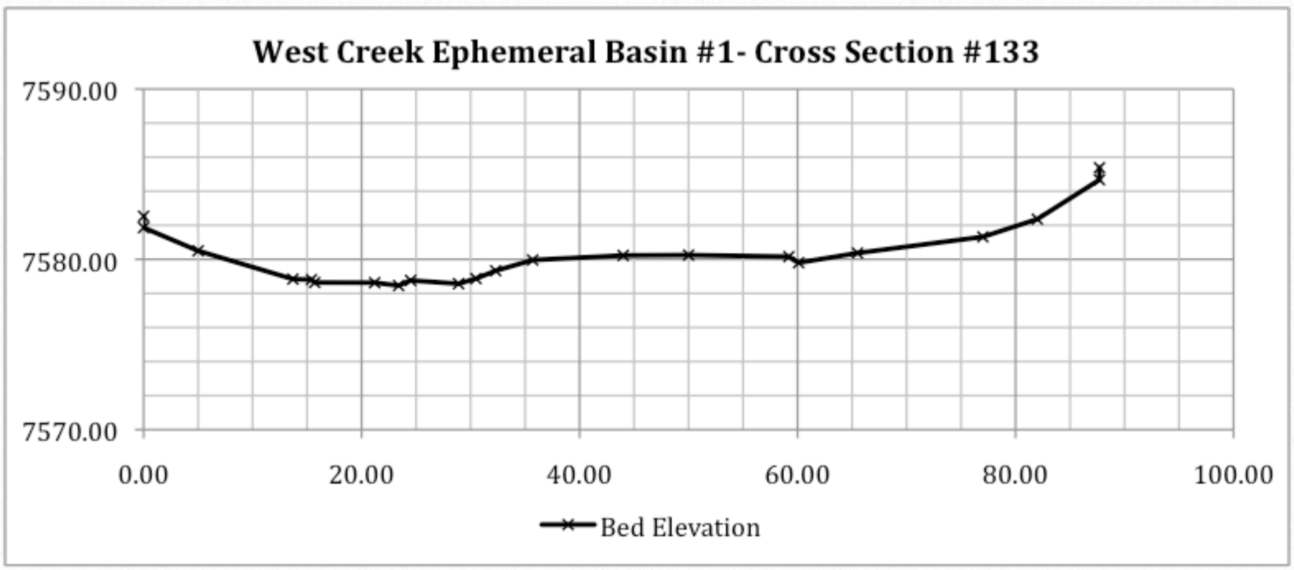



West Creek Ephemeral Basin #1 / Primary Channel - 0+000 to 0+500 ft
7600.00
7590.00
7580.00
7570.00
7560.00
7550.00
7540.00
50
100
150
200
250
300
350
400
450
500
550
Channel


West Creek Ephemeral Basin #1- Cross Section #131
Elevation
7580.00
7570.00
7560.00
0.00
40.00
80.00
120.00
160.00
Station
Bed Elevation

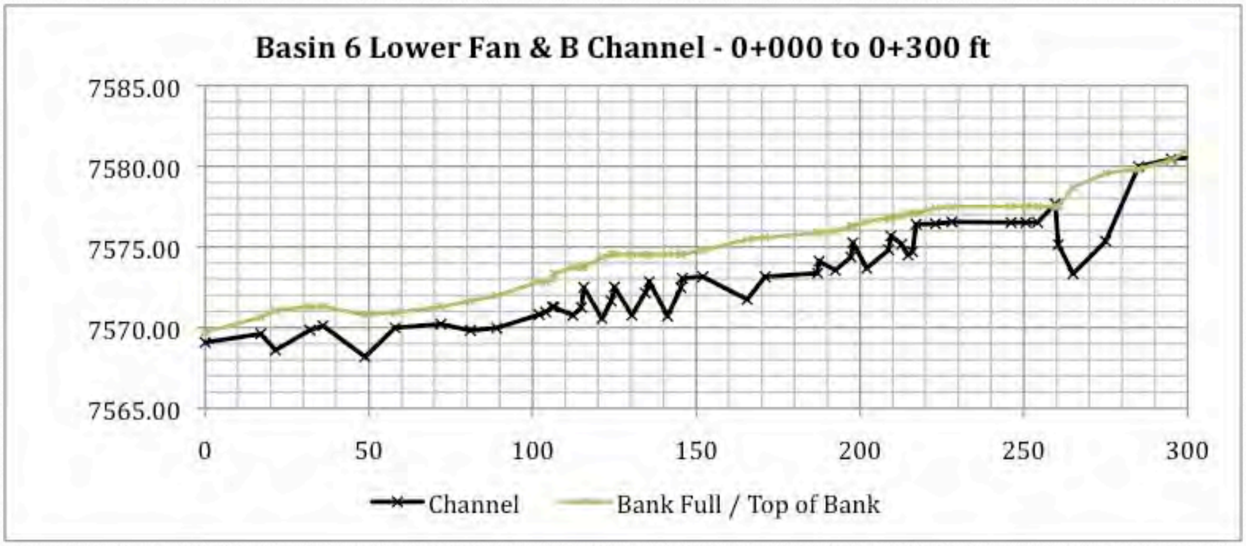

West Creek Ephemeral Basin #1- Cross Section #132
7580.00
7570.00
7560.00
0.00
50.00
100.00
150.00
200.00
Bed Elevation

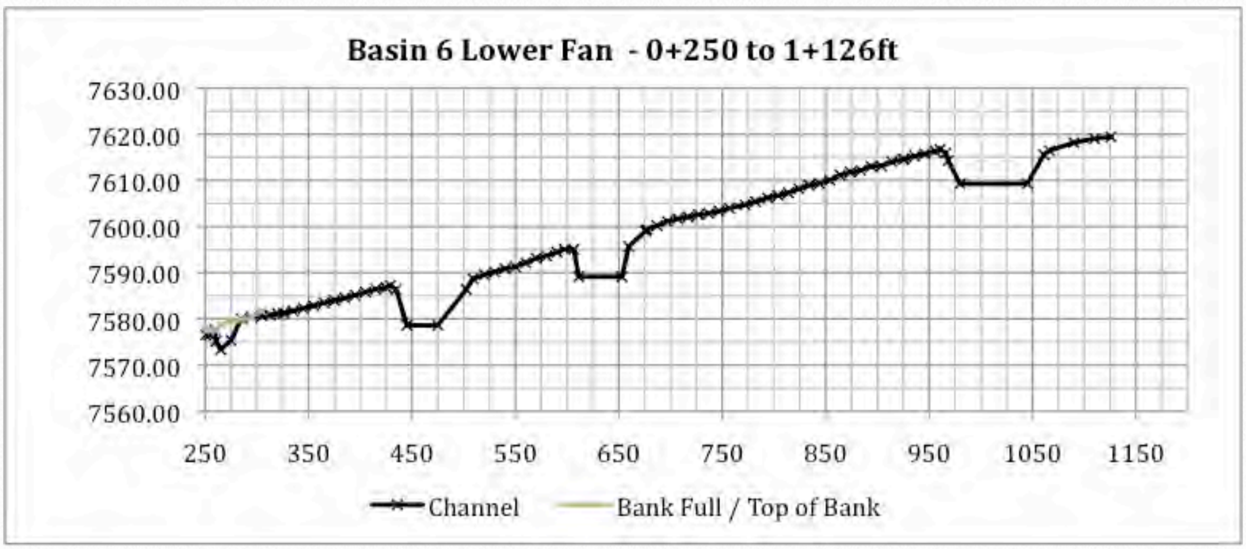


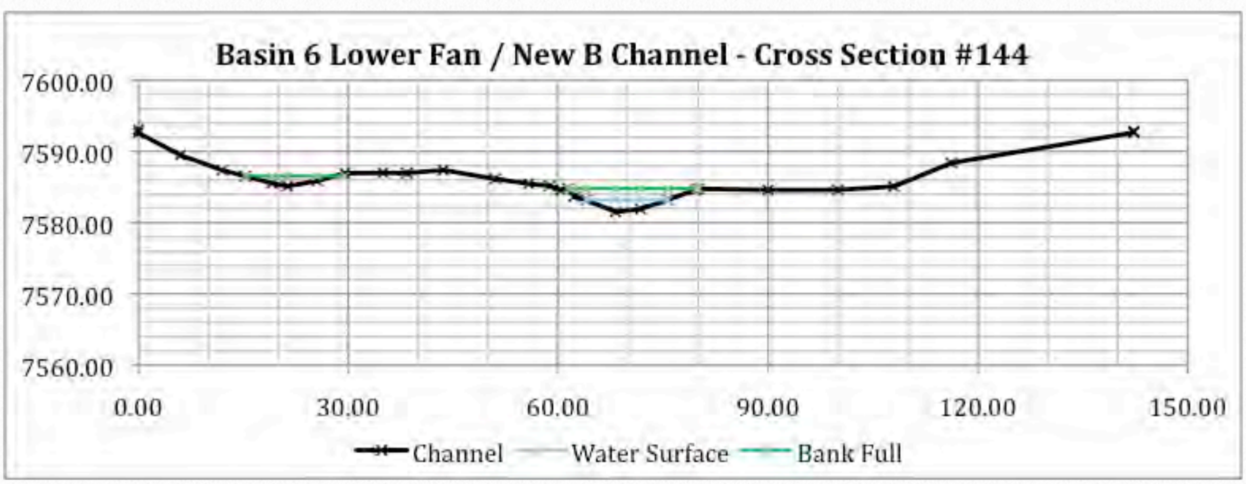


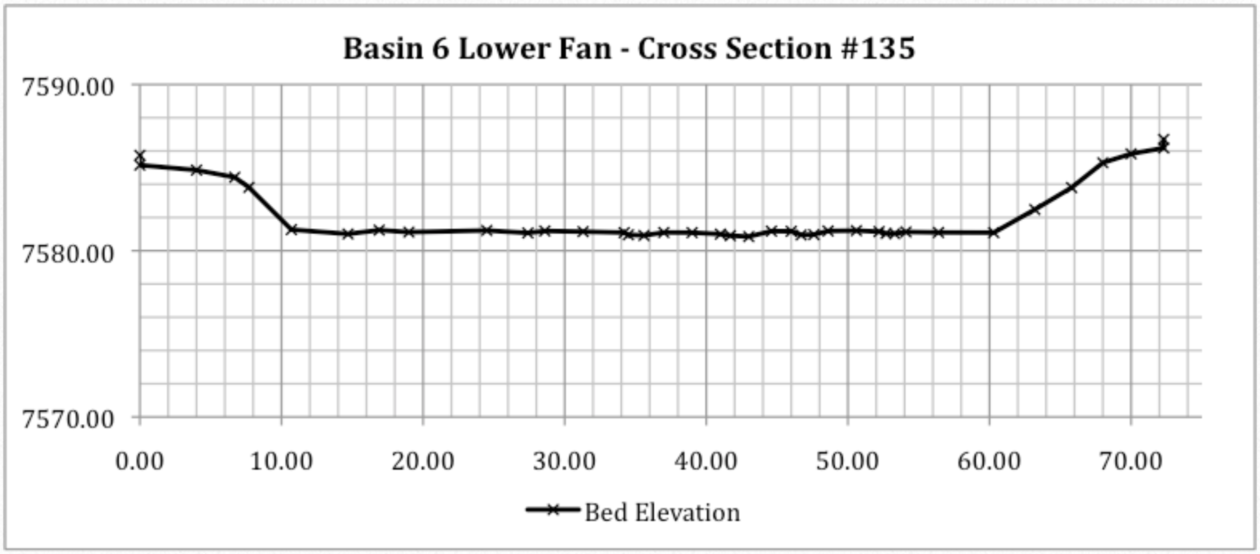
Trail Creek Basin 6 Lower Fan

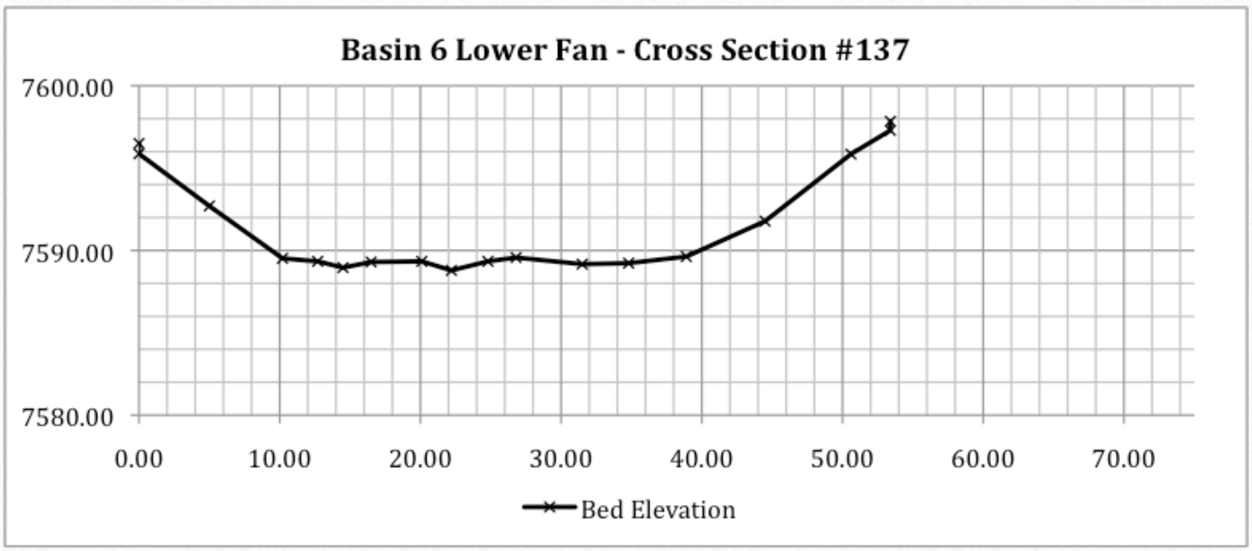
A longitudinal project and cross section survey was completed at the site in 2013. The main channel and one secondary channel were surveyed. A plot of the newly constructed B channel and the main stem of the lower fan are presented below. Channel slope in the newly constructed B channel is 3%. Between Sediment Detention Basin #1 and #3 the bed surface slope is also 3%. From Sediment Basin #3 to Sediment Basin #4 the surface slope increases to 6%. Six channel cross sections were established along the project reach, and the locations are shown in the As-Build drawings in the Appendix. Additionally, Cross Section #144 in Trail Creek Reach 2 incorporates the new B channel in this project reach.

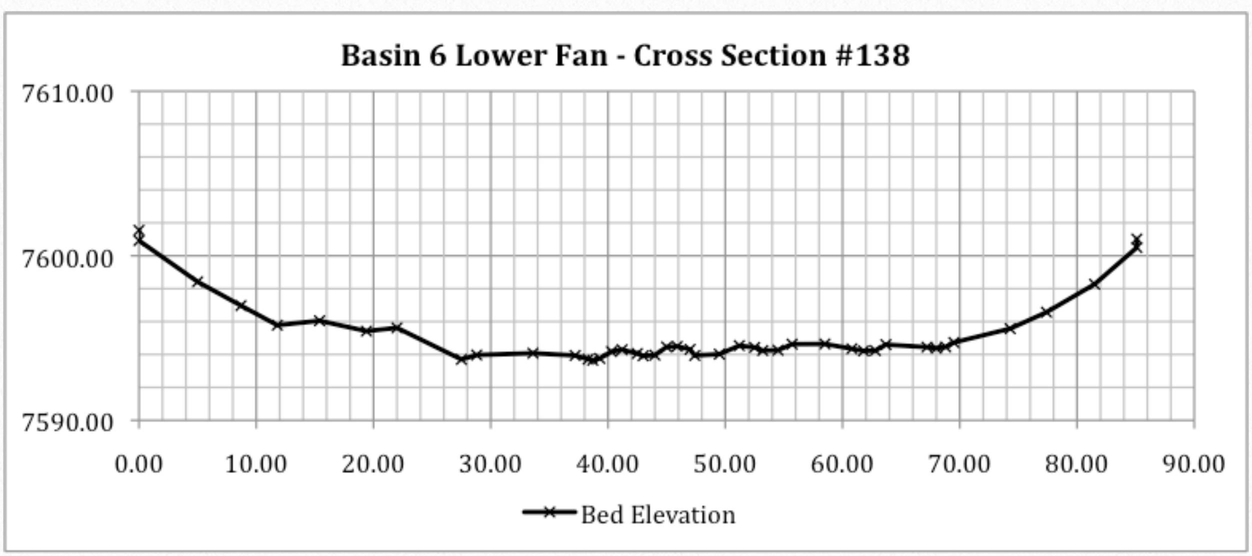


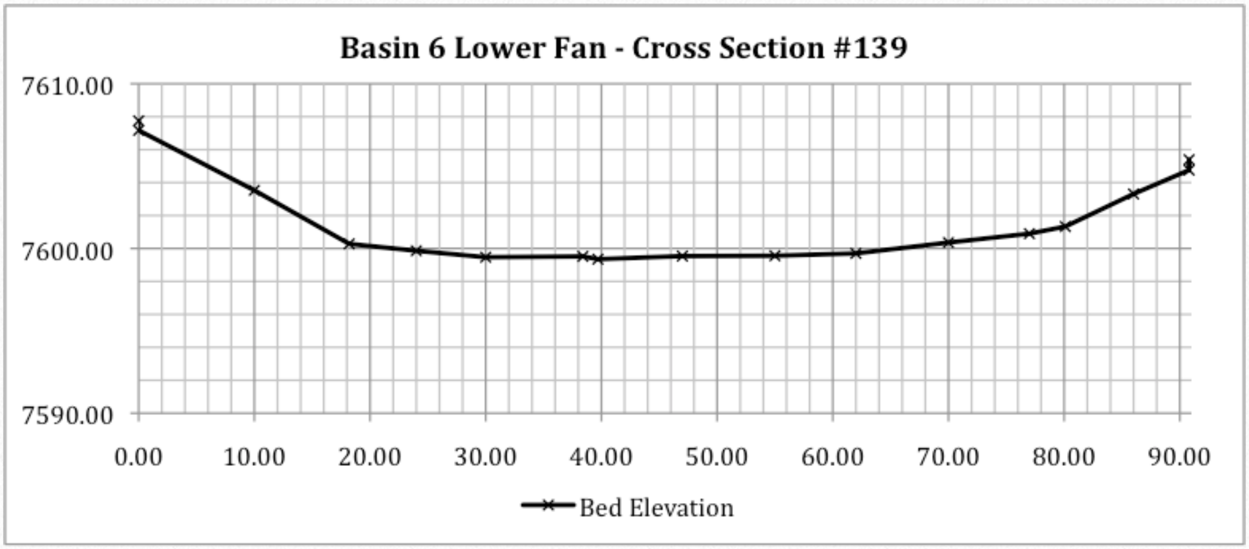


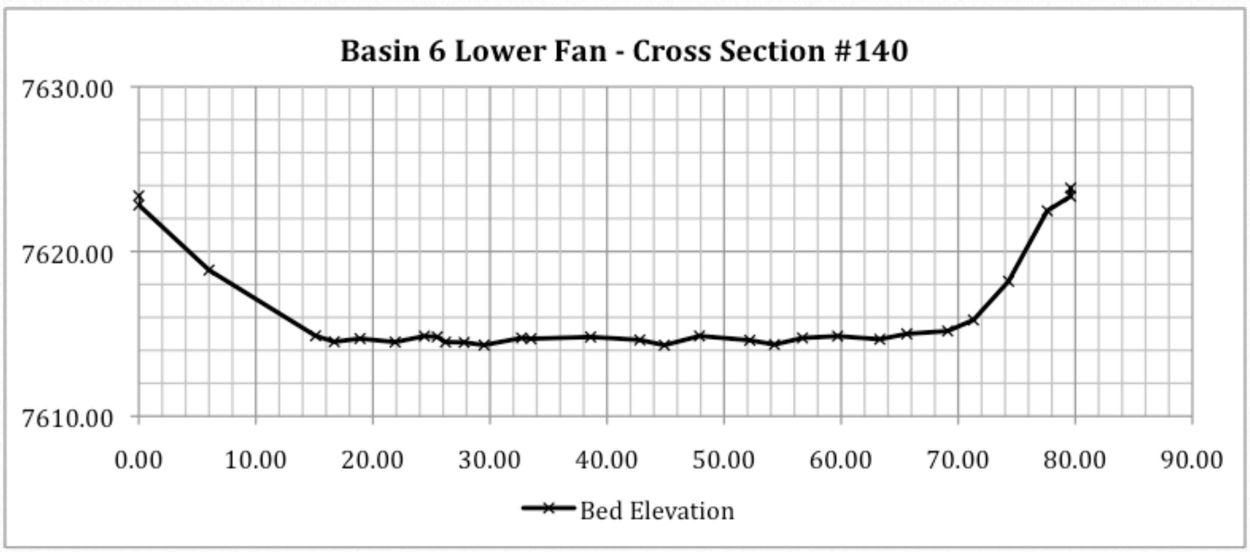



Basin 6 Lower Fan - Cross Section #135
7590.00
7580.00
7570.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Bed Elevation


Basin 6 Lower Fan - Cross Section #137
7600.00
7590.00
7580.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Bed Elevation

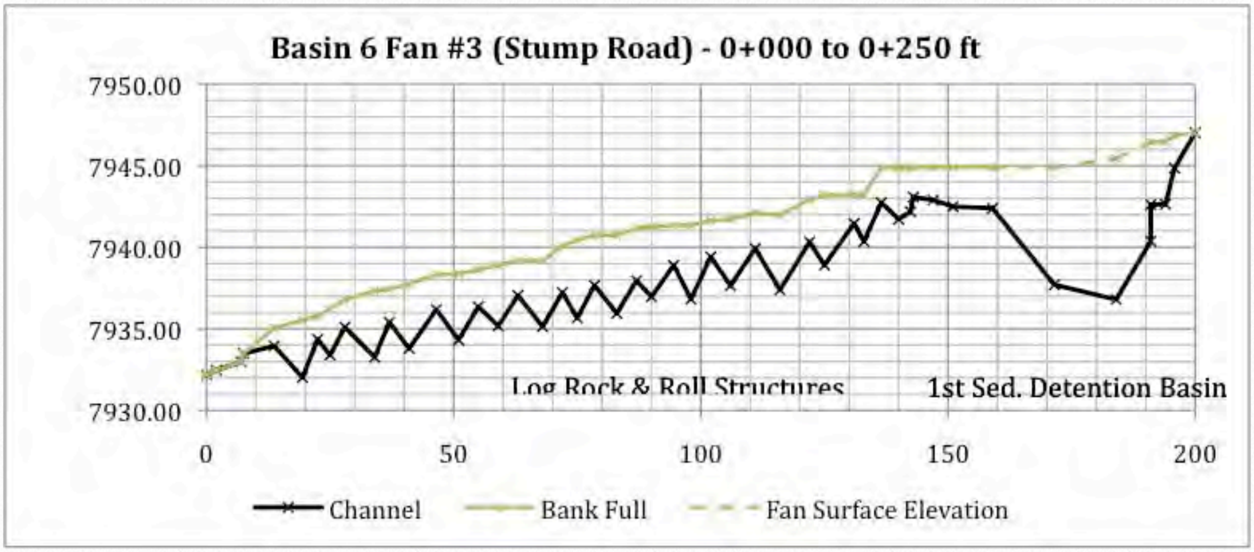

Basin 6 Lower Fan - Cross Section #138
7610.00
7600.00
7590.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
Bed Elevation

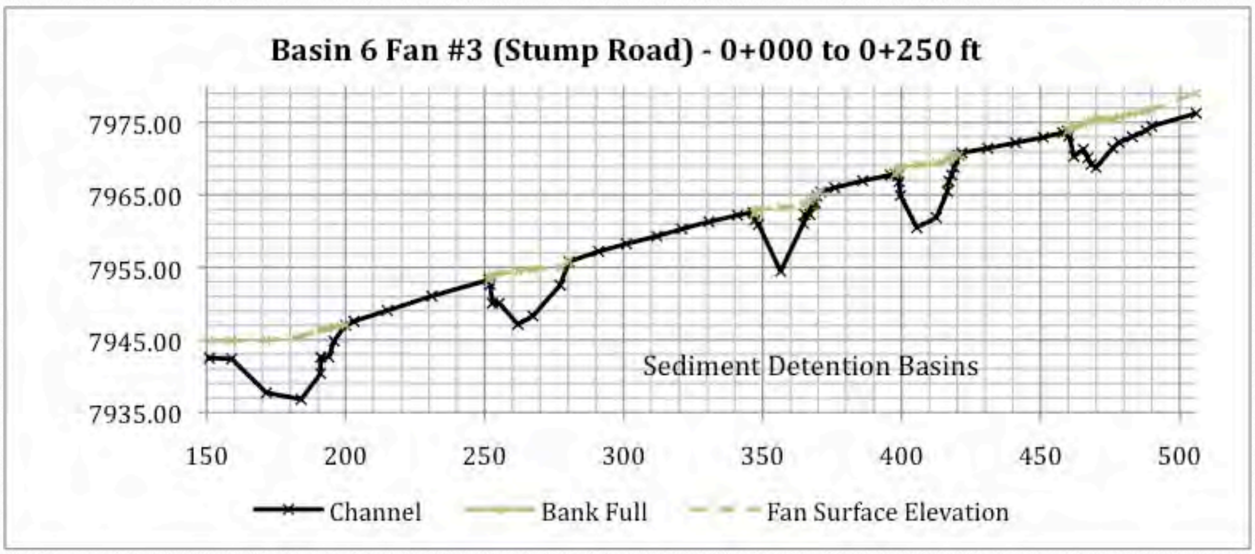


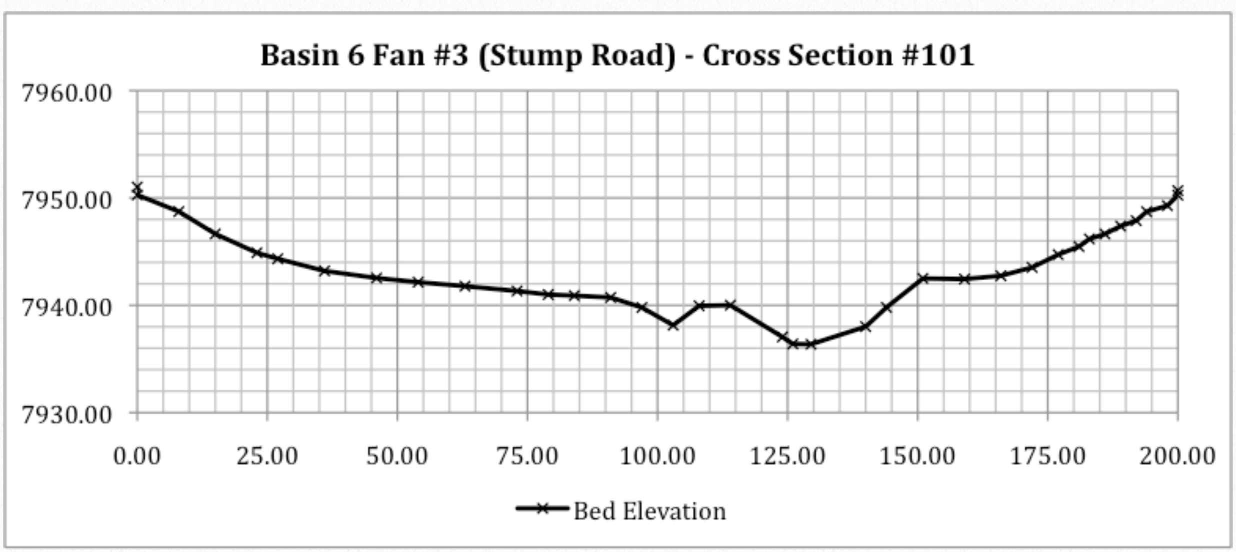


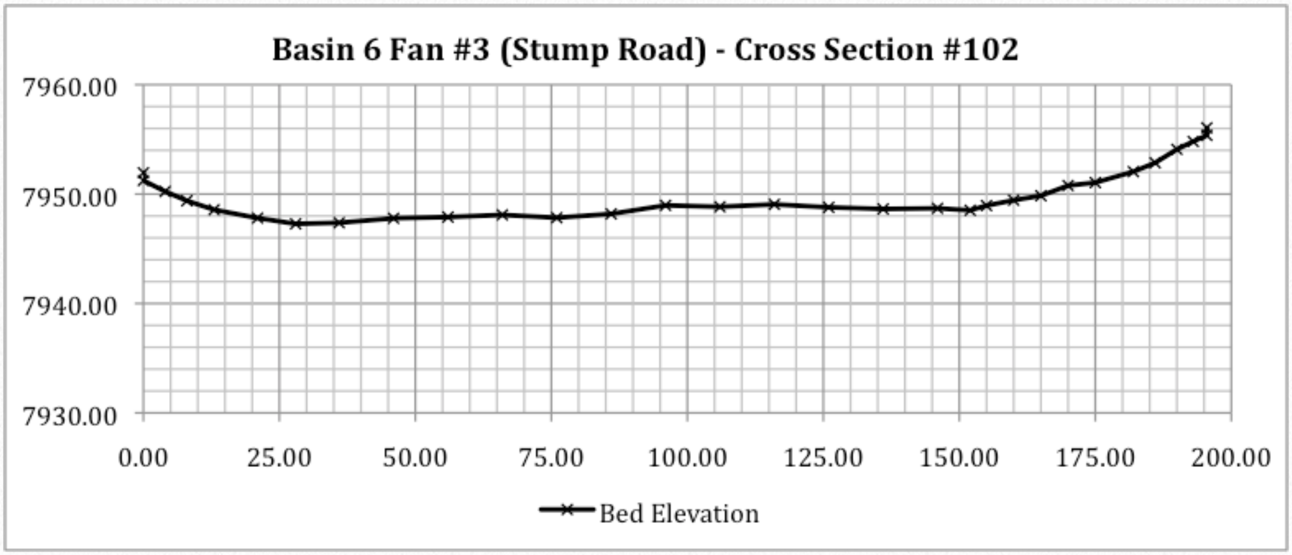
Trail Creek Basin 6 (Stump Road) Fan #3

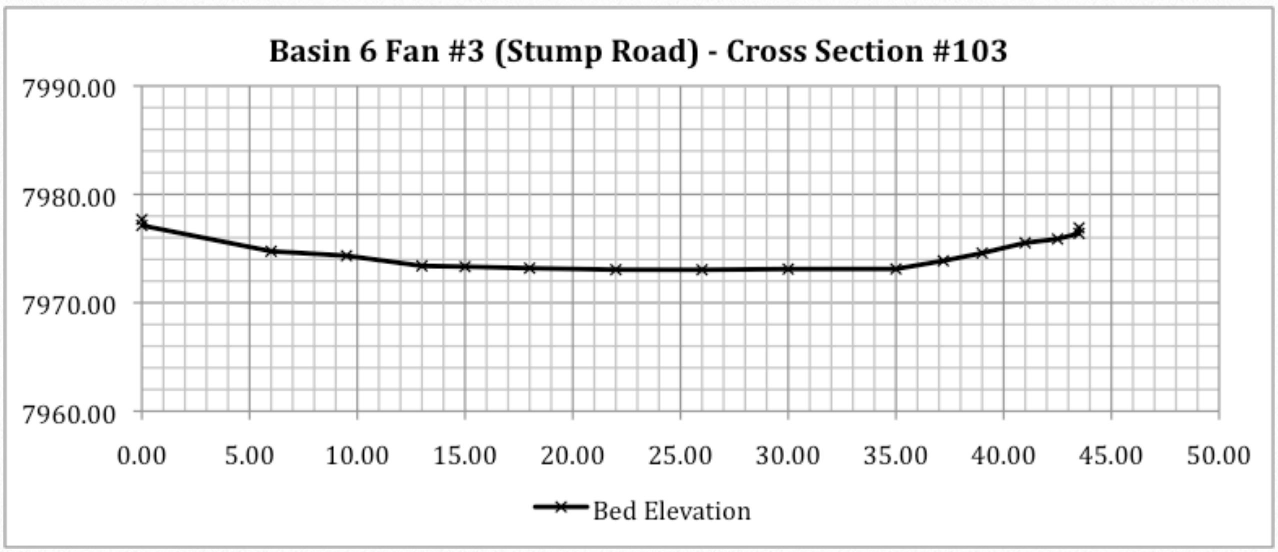
A longitudinal project and cross section survey was completed at the site in 2013. A plot of the log “Rock & Roll” channel and the fan surface elevation is presented on the next page. Channel slope in the log “Rock & Roll” channel was approximately 9%. The fan surface slope was 10%. Four channel cross sections were established along the project reach, and the locations are shown in the As-Build drawings in the Appendix.

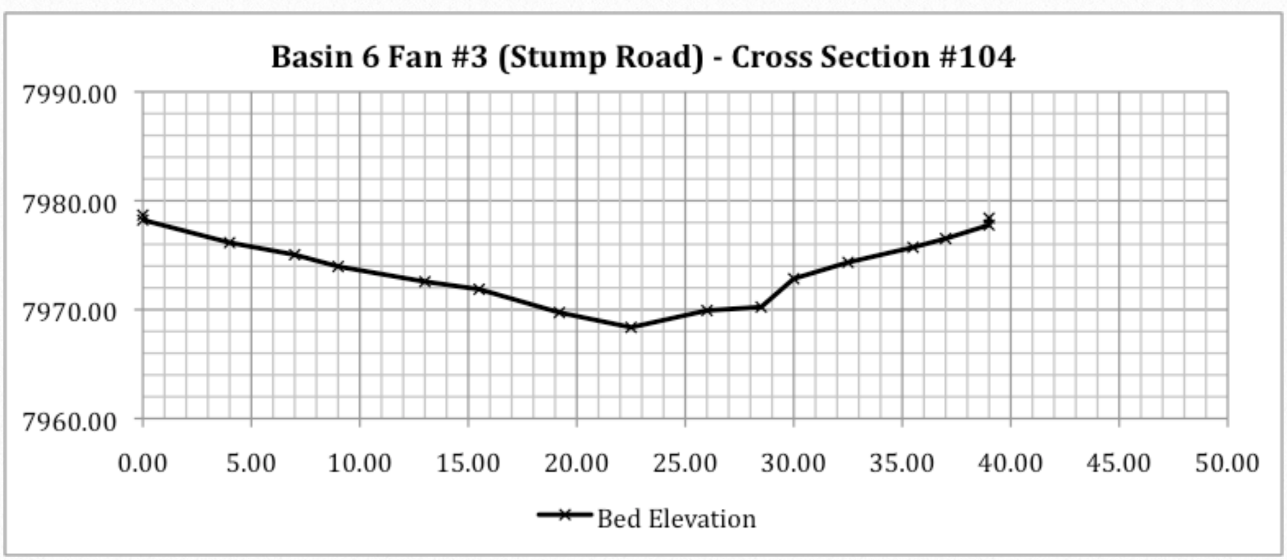

Basin 6 Fan #3 (Stump Road) - 0+000 to 0+250 ft
7950.00
7945.00
7940.00
7935.00
7930.00
0
50
100
150
200
Log Rock & Roll Structures
1st Sed. Detention Basin
Channel
Bank Full
Fan Surface Elevation


Basin 6 Fan #3 (Stump Road) - 0+000 to 0+250 ft
7975.00
7965.00
7955.00
7945.00
7935.00
150
200
250
300
350
400
450
500
Sediment Detention Basins
Channel
Bank Full
Fan Surface Elevation


Basin 6 Fan #3 (Stump Road) - Cross Section #101
7960.00
7950.00
7940.00
7930.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
Bed Elevation


Basin 6 Fan #3 (Stump Road) - Cross Section #102
7960.00
7950.00
7940.00
7930.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
Bed Elevation


Basin 6 Fan #3 (Stump Road) - Cross Section #103
7990.00
7980.00
7970.00
7960.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
Bed Elevation

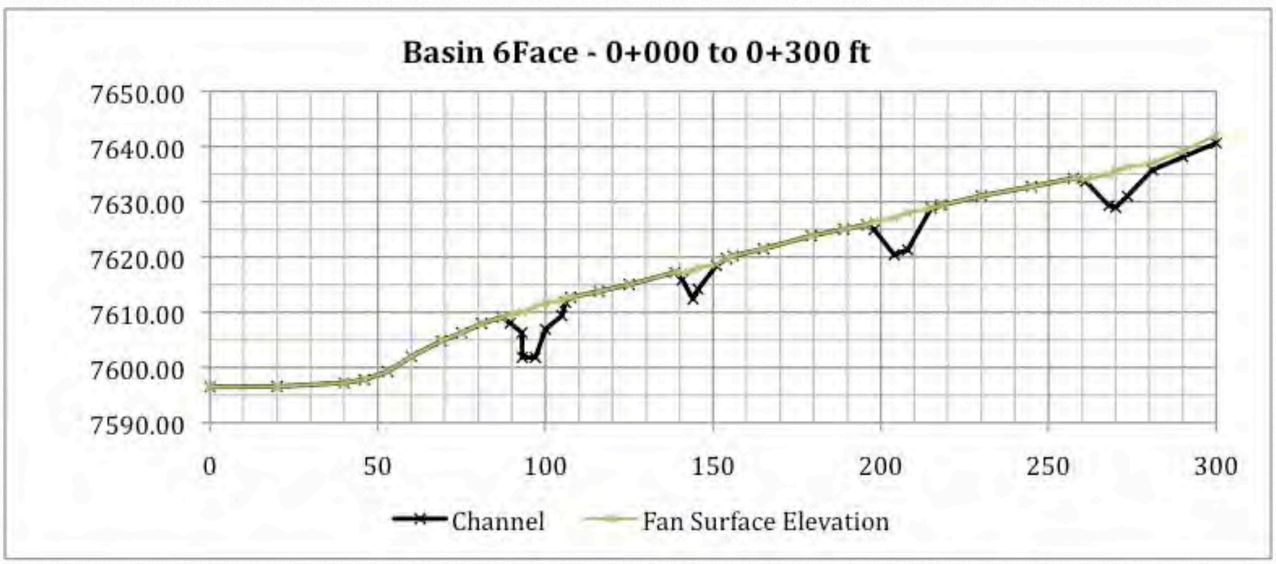

Basin 6 Fan #3 (Stump Road) - Cross Section #104
7990.00
7980.00
7970.00
7960.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
Bed Elevation

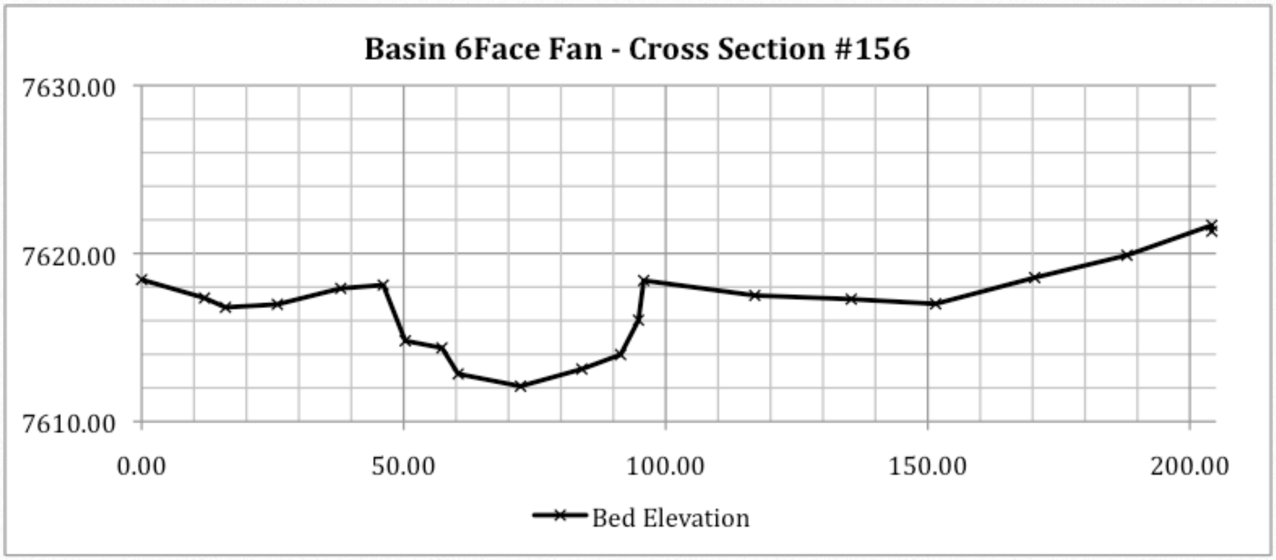
Trail Creek Basin 6 (Stump Road) Fan #4

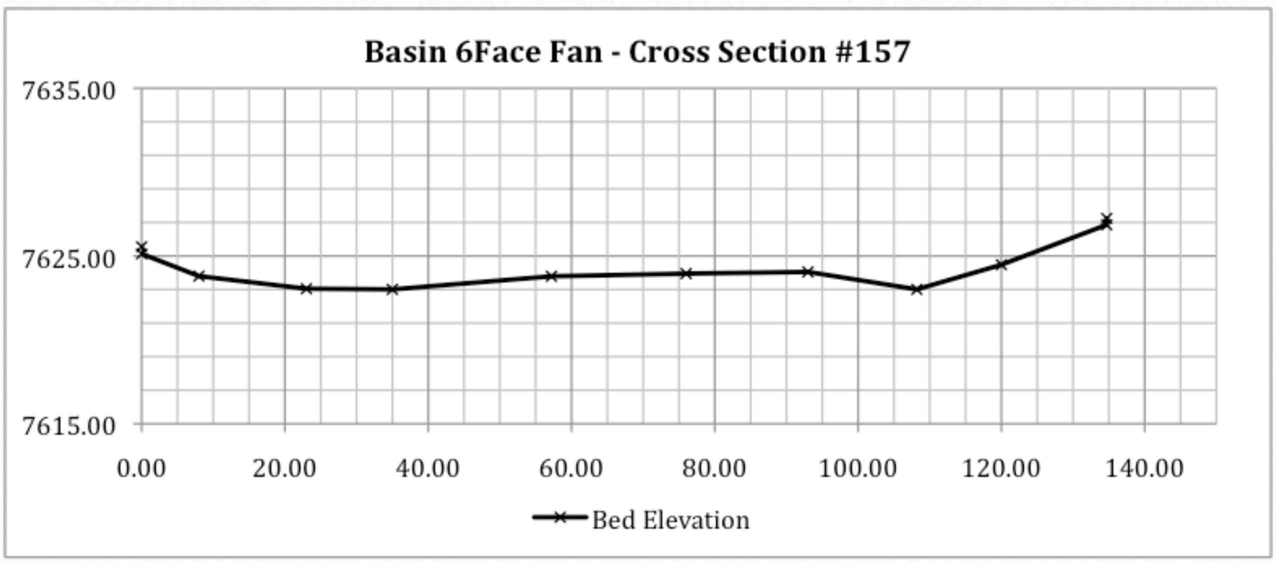
Permanent longitudinal profile and cross section survey pins have been established in the project reach, but we did not have an opportunity to conduct the post project survey before the site was inaccessible due to snow. We anticipate collecting post project survey data for the site when we do follow-up monitoring in future years. An As-Built Drawing of the completed project reach can be found in the Appendix.

Trail Creek Basin 6Face Fan

A longitudinal project and cross section survey was completed at the site in 2013, and a plot of the fan surface elevation is presented below. The fan surface slope was 17%. Two channel cross sections were established along the project reach, and the locations are shown in the As-Build drawings in the Appendix.

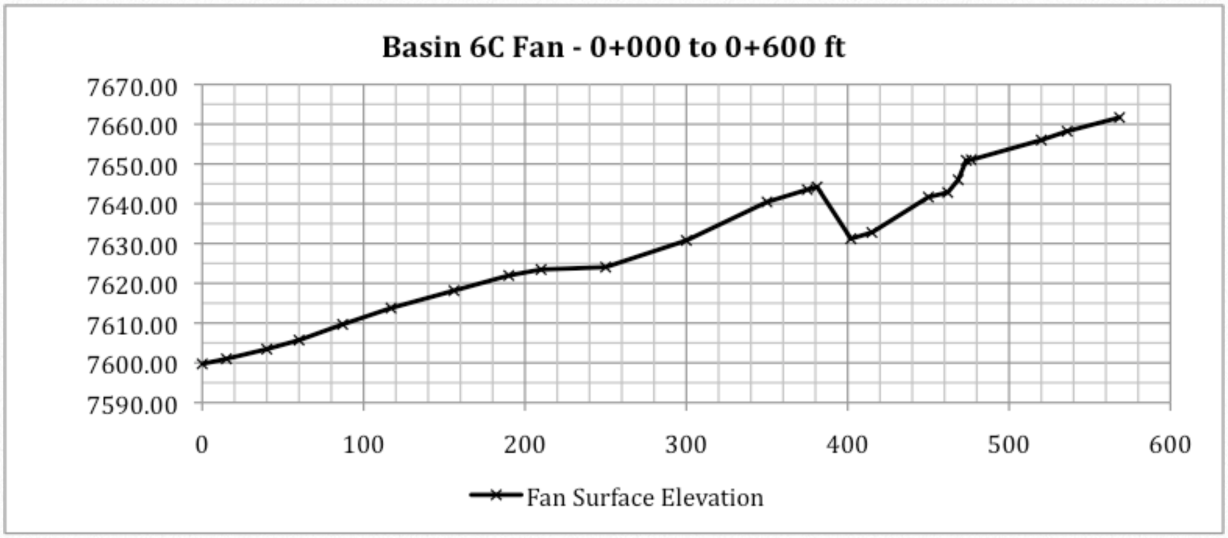


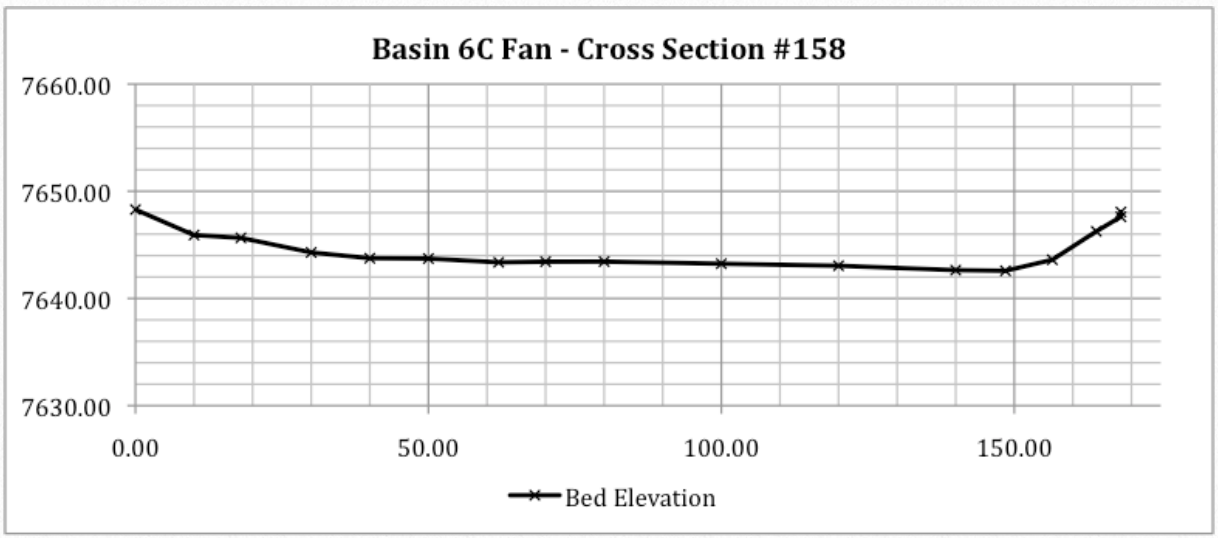


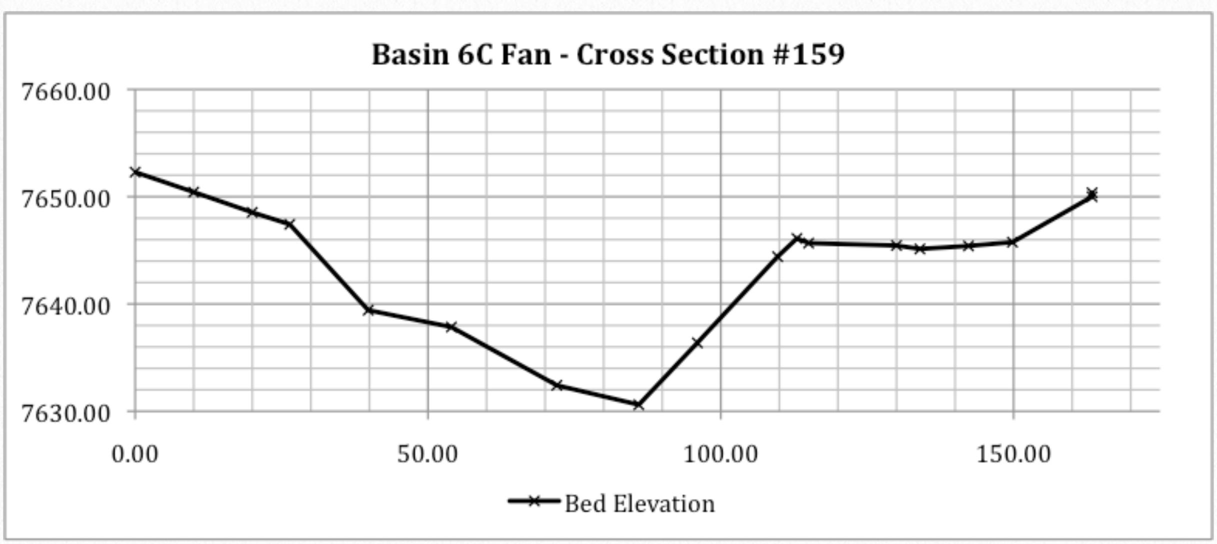


Trail Creek Basin 6C Fan

A longitudinal project and cross section survey was completed at the site in 2013, and a plot of the fan surface elevation is presented on the next page. The fan surface slope was 11%. Two channel cross sections were established along the project reach.


Basin 6C Fan - 0+000 to 0+600 ft
7670.00
7660.00
7650.00
7640.00
7630.00
7620.00
7610.00
7600.00
7590.00
0
100
200
300
400
500
600
Fan Surface Elevation


Basin 6C Fan - Cross Section #158
7660.00
7650.00
7640.00
7630.00
0.00
50.00
100.00
150.00
Bed Elevation


Basin 6C Fan - Cross Section #159
7660.00
7650.00
7640.00
7630.00
0.00
50.00
100.00
150.00
Bed Elevation

Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrates, or small animals (including insects, worms, and crustaceans) living in the streambed, are valuable indicators of ecological stream health. Federal partners sampled for benthic macroinvertebrates in Trail Creek prior to the Trail Creek Project, but were unable to find many.

In an effort to understand the impacts of the Trail Creek Project on ecological health, benthic macroinvertebrate sampling was conducted in several of the project reaches one year following construction. Sampling followed the Colorado Department of Public Health and Environment Water Quality Control Division protocol (WQCDSOP-001, May 2010) for one-meter grab samples, and the collected samples were processed and analyzed by the CPHE-WQCD Standards Unit lab in Denver, Colorado. Field personnel from the Coalition for the Upper South Platte and Fin-Up Habitat Consultants collected samples from 7 sites over a two day period in November 2013. The following equipment was used to collect the samples:

- Wildco Hesse Sampler
- Sampler Area = 0.086 meters^2
- 11 Sets per Sample Site
- Site Sample Area = 0.946 meters^2

Samples were reduced of excess vegetation and other inorganic materials using a sieve and wash bucket on site, preserved in a 95% ETOH solution, and sealed in Nalgene bottles for transport to the lab.

Sample Sites

The seven collection sites sampled in 2013 are described in detail below. The selected sites were typically in cobble/gravel riffles, and were located in specific reference and treated segments of the creek. Site descriptions, collected data, site locations, and photo points are included in the following pages. A variety of benthic macroinvertebrates were found in each sampled site. The data tables for each site show the results of the CDPHE-WQCD Standards Unit Lab analysis of the 2013 sampling data. The data is presented in raw form. Further statistical analysis will be conducted following future benthic macroinvertebrate sampling in the project sites.

WC01: West Creek Project Reach 1

This site has gravel/cobble riffles at the tail-out of two J-Hook log vane structures and cobble riffle near the upstream boundary of the reach. The substrate is very loose with no embeddedness. Moderate aquatic vegetation is present within the sample site.

Photos 55-57
Sample Date = 11/13/2013
GPS Point = WC01

Station	Name	Organism	Individuals	Stage	CommentsTaxa	RepNum	Grids	CommentsRep
CUSP-WC01	West Creek	Nais spp.	3			1	0.5	300 count
CUSP-WC01	West Creek	Baetis tricaudatus	10			1	0.5	300 count
CUSP-WC01	West Creek	Tricorythodes explicatus	14			1	0.5	300 count
CUSP-WC01	West Creek	Cheumatopsyche	6			1	0.5	300 count
CUSP-WC01	West Creek	Hydropsyche	5			1	0.5	300 count
CUSP-WC01	West Creek	Optioservus	1	A		1	0.5	300 count
CUSP-WC01	West Creek	Optioservus	9			1	0.5	300 count
CUSP-WC01	West Creek	Brillia	1			1	0.5	300 count
CUSP-WC01	West Creek	Cardiocladius	2			1	0.5	300 count
CUSP-WC01	West Creek	Ceratopogonidae	9			1	0.5	300 count
CUSP-WC01	West Creek	Chaetocladius	1			1	0.5	300 count
CUSP-WC01	West Creek	Chelifera/Metachela	1			1	0.5	300 count
CUSP-WC01	West Creek	Cricotopus/Orthocladius	19			1	0.5	300 count
CUSP-WC01	West Creek	Diamesa	2			1	0.5	300 count
CUSP-WC01	West Creek	Diplocladius	70			1	0.5	300 count
CUSP-WC01	West Creek	Eukiefferiella	41			1	0.5	300 count
CUSP-WC01	West Creek	Eukiefferiella	1	P		1	0.5	300 count
CUSP-WC01	West Creek	Hexatoma	2			1	0.5	300 count
CUSP-WC01	West Creek	Micropsectra	2			1	0.5	300 count
CUSP-WC01	West Creek	Microtendipes	1			1	0.5	300 count
CUSP-WC01	West Creek	Muscidae	1			1	0.5	300 count
CUSP-WC01	West Creek	Pagastia	9			1	0.5	300 count
CUSP-WC01	West Creek	Parametriocnemus	2			1	0.5	300 count
CUSP-WC01	West Creek	Pericoma/Telmatoscopus	3			1	0.5	300 count
CUSP-WC01	West Creek	Rheotanytarsus	76			1	0.5	300 count
CUSP-WC01	West Creek	Simulium	73			1	0.5	300 count
CUSP-WC01	West Creek	Thienemannimyia group	6			1	0.5	300 count
CUSP-WC01	West Creek	Tvetenia	1			1	0.5	300 count
CUSP-WC01	West Creek	Physidae	1			1	0.5	300 count
CUSP-WC01	West Creek	Erpobdella punctata	1			1	15	100% Count
CUSP-WC01	West Creek	Tipula	6			1	15	100% Count

TC01: Trail Creek Project Reach 2

This site has gravel/cobble riffles at the tail-out of two J-Hook log vane structures and a gravel/cobble riffle at the upstream boundary of the sample site. The substrate is relatively loose with no embeddedness. Moderate aquatic vegetation is present within the sample site.

Photos 58-60

Sample Date = 11/13/2013

GPS Point = TC01

Station	Name	Organism	Individuals	Stage	CommentsTaxa	RepNum	Grids	CommentsRep
CUSP-TC01	Trail Creek	Enchytraeidae	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Nais spp.	2			1	0.5	300 count
CUSP-TC01	Trail Creek	Slavina appendiculata	4			1	0.5	300 count
CUSP-TC01	Trail Creek	Atractides	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Lebertia	2			1	0.5	300 count
CUSP-TC01	Trail Creek	Sperchon	3			1	0.5	300 count
CUSP-TC01	Trail Creek	Ophiogomphus severus	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Baetis tricaudatus	236			1	0.5	300 count
CUSP-TC01	Trail Creek	Fallceon quilleri	2			1	0.5	300 count
CUSP-TC01	Trail Creek	Ephemerella	22			1	0.5	300 count
CUSP-TC01	Trail Creek	Paraleptophlebia	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Chloroperlidae	3			1	0.5	300 count
CUSP-TC01	Trail Creek	Perlodidae	4			1	0.5	300 count
CUSP-TC01	Trail Creek	Podmosta/Prostoia	57			1	0.5	300 count
CUSP-TC01	Trail Creek	Skwala americana	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Glossosoma	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Hydropsyche	17			1	0.5	300 count
CUSP-TC01	Trail Creek	Hydroptila	8			1	0.5	300 count
CUSP-TC01	Trail Creek	Lepidostoma	5			1	0.5	300 count
CUSP-TC01	Trail Creek	Oecetis	2			1	0.5	300 count
CUSP-TC01	Trail Creek	Optioservus	52			1	0.5	300 count
CUSP-TC01	Trail Creek	Antocha	2			1	0.5	300 count
CUSP-TC01	Trail Creek	Cardiocladius	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Ceratopogonidae	4			1	0.5	300 count
CUSP-TC01	Trail Creek	Chelifera/Metachela	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Cricotopus/Orthocladius	16			1	0.5	300 count
CUSP-TC01	Trail Creek	Cricotopus/Orthocladius	3	P		1	0.5	300 count
CUSP-TC01	Trail Creek	Cryptochironomus	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Diamesa	7			1	0.5	300 count
CUSP-TC01	Trail Creek	Dicranota	2			1	0.5	300 count
CUSP-TC01	Trail Creek	Eukiefferiella	20			1	0.5	300 count
CUSP-TC01	Trail Creek	Heleniella	9			1	0.5	300 count
CUSP-TC01	Trail Creek	Hexatoma	25			1	0.5	300 count
CUSP-TC01	Trail Creek	Micropsectra	4			1	0.5	300 count
CUSP-TC01	Trail Creek	Neoplasta	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Orthocladius	3	P		1	0.5	300 count
CUSP-TC01	Trail Creek	Pagastia	1			1	0.5	300 count
CUSP-TC01	Trail Creek	Rheotanytarsus	21			1	0.5	300 count
CUSP-TC01	Trail Creek	Simulium	191			1	0.5	300 count
CUSP-TC01	Trail Creek	Simulium	2	P		1	0.5	300 count
CUSP-TC01	Trail Creek	Synorthocladius	6			1	0.5	300 count
CUSP-TC01	Trail Creek	Synorthocladius	3	P		1	0.5	300 count
CUSP-TC01	Trail Creek	Thienemannimyia group	10			1	0.5	300 count
CUSP-TC01	Trail Creek	Tvetenia	1	P		1	0.5	300 count
CUSP-TC01	Trail Creek	Physidae	34			1	0.5	300 count

TC02: Trail Creek Project Reach 3

This site has gravel/cobble riffles near the downstream boundary of the project reach, and at the tail-out of two J-Hook log vane structures within the reach. The substrate is relatively loose with no embeddedness. Moderate aquatic vegetation is present within the sample site.

Photos 61-64
Sample Date = 11/14/2013
GPS Point = TC02

Station	Name	Organism	Individuals	Stage	CommentsTaxa	RepNum	Grids	CommentsRep
CUSP-TC02	Trail Creek	Atractides	2			1	0.5	300 count
CUSP-TC02	Trail Creek	Lebertia	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Sperchon	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Baetis tricaudatus	39			1	0.5	300 count
CUSP-TC02	Trail Creek	Fallceon quilleri	6			1	0.5	300 count
CUSP-TC02	Trail Creek	Ephemerella	20			1	0.5	300 count
CUSP-TC02	Trail Creek	Paraleptophlebia	6			1	0.5	300 count
CUSP-TC02	Trail Creek	Capniidae	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Chloroperlidae	8			1	0.5	300 count
CUSP-TC02	Trail Creek	Eucapnopsis brevicauda	2			1	0.5	300 count
CUSP-TC02	Trail Creek	Podmosta/Prostoia	21			1	0.5	300 count
CUSP-TC02	Trail Creek	Sweltsa	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Glossosoma	2			1	0.5	300 count
CUSP-TC02	Trail Creek	Hydropsyche	9			1	0.5	300 count
CUSP-TC02	Trail Creek	Lepidostoma	127			1	0.5	300 count
CUSP-TC02	Trail Creek	Oecetis	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Optioservus	20			1	0.5	300 count
CUSP-TC02	Trail Creek	Antocha	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Cardiocladius	4			1	0.5	300 count
CUSP-TC02	Trail Creek	Chaetocladius	2			1	0.5	300 count
CUSP-TC02	Trail Creek	Cricotopus/Orthocladius	24			1	0.5	300 count
CUSP-TC02	Trail Creek	Cricotopus/Orthocladius	12	P		1	0.5	300 count
CUSP-TC02	Trail Creek	Diamesa	54			1	0.5	300 count
CUSP-TC02	Trail Creek	Dicranota	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Eukiefferiella	6			1	0.5	300 count
CUSP-TC02	Trail Creek	Heleniella	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Hexatoma	4			1	0.5	300 count
CUSP-TC02	Trail Creek	Lopescladius	5			1	0.5	300 count
CUSP-TC02	Trail Creek	Simulium	289			1	0.5	300 count
CUSP-TC02	Trail Creek	Simulium	1	P		1	0.5	300 count
CUSP-TC02	Trail Creek	Thienemannimyia group	1			1	0.5	300 count
CUSP-TC02	Trail Creek	Pteronarcella badia	1			1	15	100% Count

TC03: Trail Creek Project B3 Reference Reach

This site is located immediately upstream of the new FS717 trail re-route, between Project Reach 3 & Project Reach 4, and was identified as a reference reach in the Trail Creek WARSSS. The sample site consists of a cobble riffle immediately upstream of the 717 trail crossing. The substrate is relatively loose with no embeddedness. There is minimal aquatic vegetation within the sample site. A duplicate sample was taken at this site.

Photos 65-66 and Photos 71-72
Sample Date = 11/14/2013
GPS Point = TC03

Station	Name	Organism	Individuals	Stage	CommentsTaxa	RepNum	Grids	CommentsRep
CUSP-TC03	Trail Creek	Atractides	4			1	0.5	300 count
CUSP-TC03	Trail Creek	Lebertia	3			1	0.5	300 count
CUSP-TC03	Trail Creek	Sperchon	2			1	0.5	300 count
CUSP-TC03	Trail Creek	Testudacarus	2			1	0.5	300 count
CUSP-TC03	Trail Creek	Ameletus	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Baetis tricaudatus	116			1	0.5	300 count
CUSP-TC03	Trail Creek	Fallceon quilleri	3			1	0.5	300 count
CUSP-TC03	Trail Creek	Ephemerella	13			1	0.5	300 count
CUSP-TC03	Trail Creek	Tricorythodes explicatus	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Chloroperlidae	2			1	0.5	300 count
CUSP-TC03	Trail Creek	Eucapnopsis brevicauda	2			1	0.5	300 count
CUSP-TC03	Trail Creek	Isoperla	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Podmosta/Prostoia	55			1	0.5	300 count
CUSP-TC03	Trail Creek	Sweltsa	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Zapada cinctipes	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Glossosoma	2			1	0.5	300 count
CUSP-TC03	Trail Creek	Hydropsyche	32			1	0.5	300 count
CUSP-TC03	Trail Creek	Lepidostoma	285			1	0.5	300 count
CUSP-TC03	Trail Creek	Oecetis	4			1	0.5	300 count
CUSP-TC03	Trail Creek	Optioservus	12	A		1	0.5	300 count
CUSP-TC03	Trail Creek	Optioservus	44			1	0.5	300 count
CUSP-TC03	Trail Creek	Cardiocladius	3			1	0.5	300 count
CUSP-TC03	Trail Creek	Ceratopogonidae	3			1	0.5	300 count
CUSP-TC03	Trail Creek	Cricotopus/Orthocladius	20			1	0.5	300 count
CUSP-TC03	Trail Creek	Cricotopus/Orthocladius	4	P		1	0.5	300 count
CUSP-TC03	Trail Creek	Diamesa	68			1	0.5	300 count
CUSP-TC03	Trail Creek	Dicranota	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Eukiefferiella	15			1	0.5	300 count
CUSP-TC03	Trail Creek	Hexatoma	4			1	0.5	300 count
CUSP-TC03	Trail Creek	Maruina	2			1	0.5	300 count
CUSP-TC03	Trail Creek	Micropsectra	6			1	0.5	300 count
CUSP-TC03	Trail Creek	Muscidae	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Neoplasta	1			1	0.5	300 count

Station	Name	Organism	Individuals	Stage	CommentsTaxa	RepNum	Grids	CommentsRep
CUSP-TC03	Trail Creek	Simulium	101			1	0.5	300 count
CUSP-TC03	Trail Creek	Simulium	1	P		1	0.5	300 count
CUSP-TC03	Trail Creek	Thienemannimyia group	7			1	0.5	300 count
CUSP-TC03	Trail Creek	Lymnaeidae	1			1	0.5	300 count
CUSP-TC03	Trail Creek	Physidae	32			1	0.5	300 count
CUSP-TC03	Trail Creek	Skwala americana	1			1	15	100% Count
CUSP-TC03	Trail Creek	Tipula	1			1	15	100% Count
CUSP-TC03	Trail Creek	Nais spp.	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Atractides	2			3	0.5	300 count
CUSP-TC03	Trail Creek	Lebertia	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Baetis tricaudatus	83			3	0.5	300 count
CUSP-TC03	Trail Creek	Ephemerella	2			3	0.5	300 count
CUSP-TC03	Trail Creek	Chloroperlidae	2			3	0.5	300 count
CUSP-TC03	Trail Creek	Eucapnopsis brevicauda	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Isoperla	3			3	0.5	300 count
CUSP-TC03	Trail Creek	Podmosta/Prostoia	48			3	0.5	300 count
CUSP-TC03	Trail Creek	Sweltsa	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Brachycentrus americanus	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Glossosoma	2			3	0.5	300 count
CUSP-TC03	Trail Creek	Hydropsyche	21			3	0.5	300 count
CUSP-TC03	Trail Creek	Lepidostoma	139			3	0.5	300 count
CUSP-TC03	Trail Creek	Oecetis	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Rhyacophila brunnea group	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Optioservus	7	A		3	0.5	300 count
CUSP-TC03	Trail Creek	Optioservus	15			3	0.5	300 count
CUSP-TC03	Trail Creek	Brillia	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Cricotopus/Orthocladius	6			3	0.5	300 count
CUSP-TC03	Trail Creek	Cricotopus/Orthocladius	2	P		3	0.5	300 count
CUSP-TC03	Trail Creek	Diamesa	42			3	0.5	300 count
CUSP-TC03	Trail Creek	Diamesa	2	P		3	0.5	300 count
CUSP-TC03	Trail Creek	Eukiefferiella	6			3	0.5	300 count
CUSP-TC03	Trail Creek	Hexatoma	7			3	0.5	300 count
CUSP-TC03	Trail Creek	Micropsectra	4			3	0.5	300 count
CUSP-TC03	Trail Creek	Simulium	64			3	0.5	300 count
CUSP-TC03	Trail Creek	Simulium	1	P		3	0.5	300 count
CUSP-TC03	Trail Creek	Thienemannimyia group	2			3	0.5	300 count
CUSP-TC03	Trail Creek	Tipula	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Tvetenia	1			3	0.5	300 count
CUSP-TC03	Trail Creek	Lymnaeidae	3			3	0.5	300 count
CUSP-TC03	Trail Creek	Physidae	12			3	0.5	300 count
CUSP-TC03	Trail Creek	Skwala americana	2			3	15	100% Count

TC04: Trail Creek Project Reach 4

This site has gravel/cobble riffles in the middle of the project reach. The substrate is relatively loose with no embeddedness. Moderate aquatic vegetation is present within the sample site.

Photos 67-68

Sample Date = 11/14/2013

GPS Point = TC04

Station	Name	Organism	Individuals	Stage	CommentsTaxa	RepNum	Grids	CommentsRep
CUSP-TC04	Trail Creek	Nais spp.	7			1	0.5	300 count
CUSP-TC04	Trail Creek	Slavina appendiculata	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Atractides	4			1	0.5	300 count
CUSP-TC04	Trail Creek	Sperchon	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Testudacarus	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Baetis tricaudatus	162			1	0.5	300 count
CUSP-TC04	Trail Creek	Drunella grandis	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Ephemerella	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Chloroperlidae	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Eucapnopsis brevicauda	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Podmosta/Prostoia	6			1	0.5	300 count
CUSP-TC04	Trail Creek	Sweltsa	7			1	0.5	300 count
CUSP-TC04	Trail Creek	Brachycentrus americanus	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Glossosoma	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Hydropsyche	4			1	0.5	300 count
CUSP-TC04	Trail Creek	Lepidostoma	62			1	0.5	300 count
CUSP-TC04	Trail Creek	Rhyacophila brunnea group	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Optioservus	25	A		1	0.5	300 count
CUSP-TC04	Trail Creek	Optioservus	102			1	0.5	300 count
CUSP-TC04	Trail Creek	Chaetocladius	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Cricotopus/Orthocladius	20			1	0.5	300 count
CUSP-TC04	Trail Creek	Cricotopus/Orthocladius	1	P		1	0.5	300 count
CUSP-TC04	Trail Creek	Diamesa	40			1	0.5	300 count
CUSP-TC04	Trail Creek	Dicranota	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Eukiefferiella	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Heleniella	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Hexatoma	5			1	0.5	300 count
CUSP-TC04	Trail Creek	Maruina	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Micropsectra	101			1	0.5	300 count
CUSP-TC04	Trail Creek	Neoplasta	4			1	0.5	300 count
CUSP-TC04	Trail Creek	Parochlus	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Polypedilum	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Radotanypus	2			1	0.5	300 count
CUSP-TC04	Trail Creek	Rheocricotopus	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Simulium	209			1	0.5	300 count
CUSP-TC04	Trail Creek	Simulium	8	P		1	0.5	300 count
CUSP-TC04	Trail Creek	Synorthocladius	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Thienemannimyia group	11			1	0.5	300 count
CUSP-TC04	Trail Creek	Tvetenia	1			1	0.5	300 count
CUSP-TC04	Trail Creek	Physidae	65			1	0.5	300 count
CUSP-TC04	Trail Creek	Skwala americana	4			1	15	100% Count

TC05: Trail Creek Project Impaired Reach

This site is located adjacent to the large complex alluvial fan at the downstream boundary of Joe Huff's Trail Creek Ranch. This segment of Trail Creek was treated in the spring of 2013. The sample site consists of a gravel and cobble riffle running along the toe of the alluvial fan. There is a road and river crossing upstream of the sample site, and the road is parallel and adjacent to the stream throughout the site. The substrate is somewhat compact and is more embedded than other Trail Creek sites. There is moderate aquatic vegetation within the sample site.

Photos 69-70

Sample Date = 11/14/2013

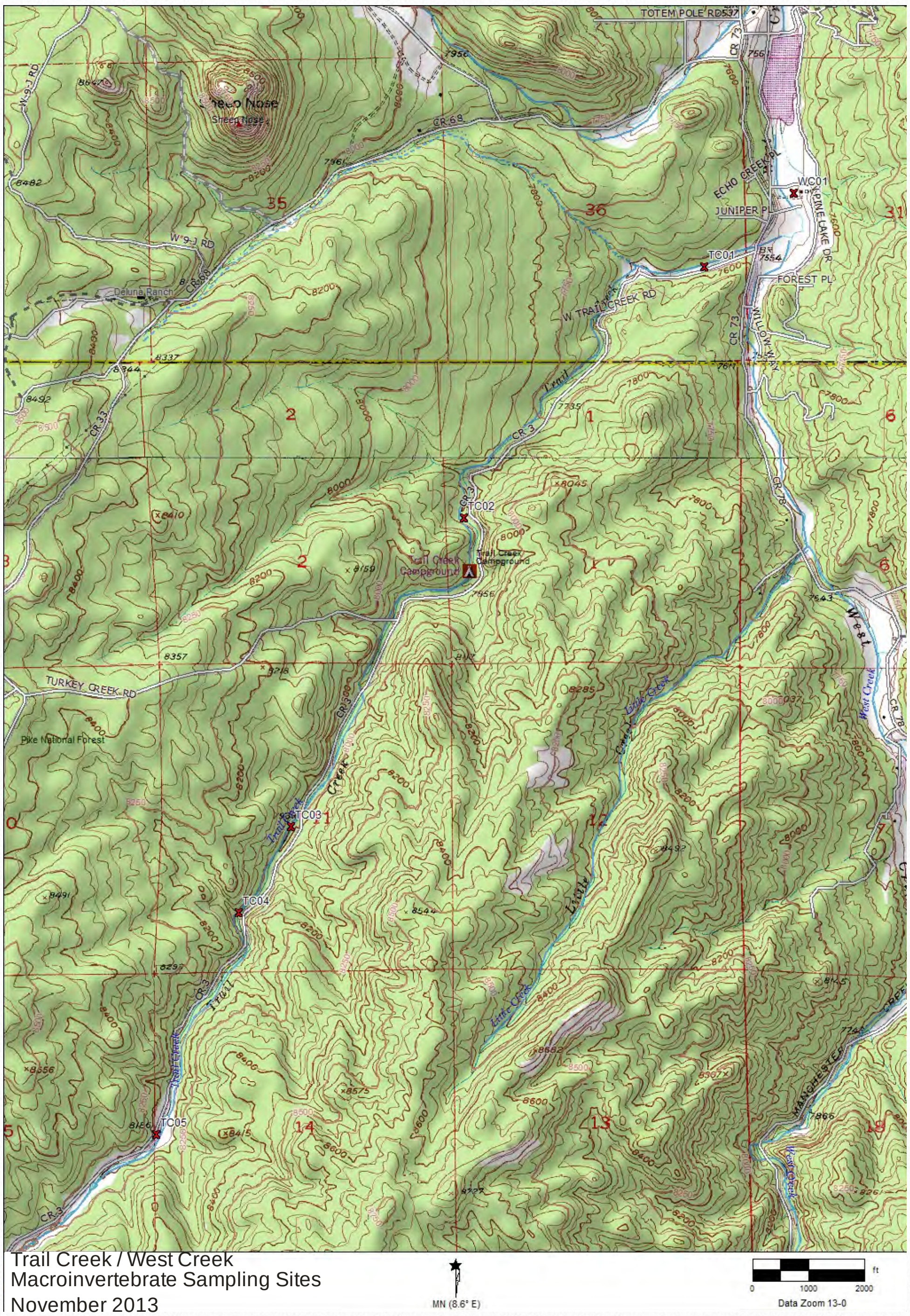
GPS Point = TC05

Station	Name	Organism	Individuals	Stage	CommentsTaxa	RepNum	Grids	CommentsRep
CUSP-TC05	Trail Creek	Enchytraeidae	2			1	1	300 count
CUSP-TC05	Trail Creek	Atractides	1			1	1	300 count
CUSP-TC05	Trail Creek	Lebertia	1			1	1	300 count
CUSP-TC05	Trail Creek	Baetis tricaudatus	166			1	1	300 count
CUSP-TC05	Trail Creek	Fallceon quilleri	2			1	1	300 count
CUSP-TC05	Trail Creek	Drunella grandis	1			1	1	300 count
CUSP-TC05	Trail Creek	Paraleptophlebia	1			1	1	300 count
CUSP-TC05	Trail Creek	Capniidae	8			1	1	300 count
CUSP-TC05	Trail Creek	Chloroperlidae	6			1	1	300 count
CUSP-TC05	Trail Creek	Eucapnopsis brevicauda	1			1	1	300 count
CUSP-TC05	Trail Creek	Podmosta/Prostoia	18			1	1	300 count
CUSP-TC05	Trail Creek	Brachycentrus americanus	2			1	1	300 count
CUSP-TC05	Trail Creek	Glossosoma	1			1	1	300 count
CUSP-TC05	Trail Creek	Lepidostoma	14			1	1	300 count
CUSP-TC05	Trail Creek	Optioservus	10	A		1	1	300 count
CUSP-TC05	Trail Creek	Optioservus	35			1	1	300 count
CUSP-TC05	Trail Creek	Brillia	4			1	1	300 count
CUSP-TC05	Trail Creek	Ceratopogonidae	1			1	1	300 count
CUSP-TC05	Trail Creek	Chaetocladius	1			1	1	300 count
CUSP-TC05	Trail Creek	Cricotopus/Orthocladius	4			1	1	300 count
CUSP-TC05	Trail Creek	Diamesa	22			1	1	300 count
CUSP-TC05	Trail Creek	Eukiefferiella	2			1	1	300 count
CUSP-TC05	Trail Creek	Heleniella	2			1	1	300 count
CUSP-TC05	Trail Creek	Hexatoma	1			1	1	300 count
CUSP-TC05	Trail Creek	Micropsectra	10			1	1	300 count
CUSP-TC05	Trail Creek	Neoplasta	1			1	1	300 count
CUSP-TC05	Trail Creek	Parametriocnemus	1			1	1	300 count
CUSP-TC05	Trail Creek	Polypedilum	1			1	1	300 count
CUSP-TC05	Trail Creek	Radotanypus	1			1	1	300 count
CUSP-TC05	Trail Creek	Rheocricotopus	1			1	1	300 count
CUSP-TC05	Trail Creek	Simulium	326			1	1	300 count
CUSP-TC05	Trail Creek	Simulium	5	P		1	1	300 count
CUSP-TC05	Trail Creek	Thienemannimyia group	3			1	1	300 count
CUSP-TC05	Trail Creek	Tvetenia	1			1	1	300 count
CUSP-TC05	Trail Creek	Physidae	8			1	1	300 count
CUSP-TC05	Trail Creek	Tipula	2			1	15	100% Count

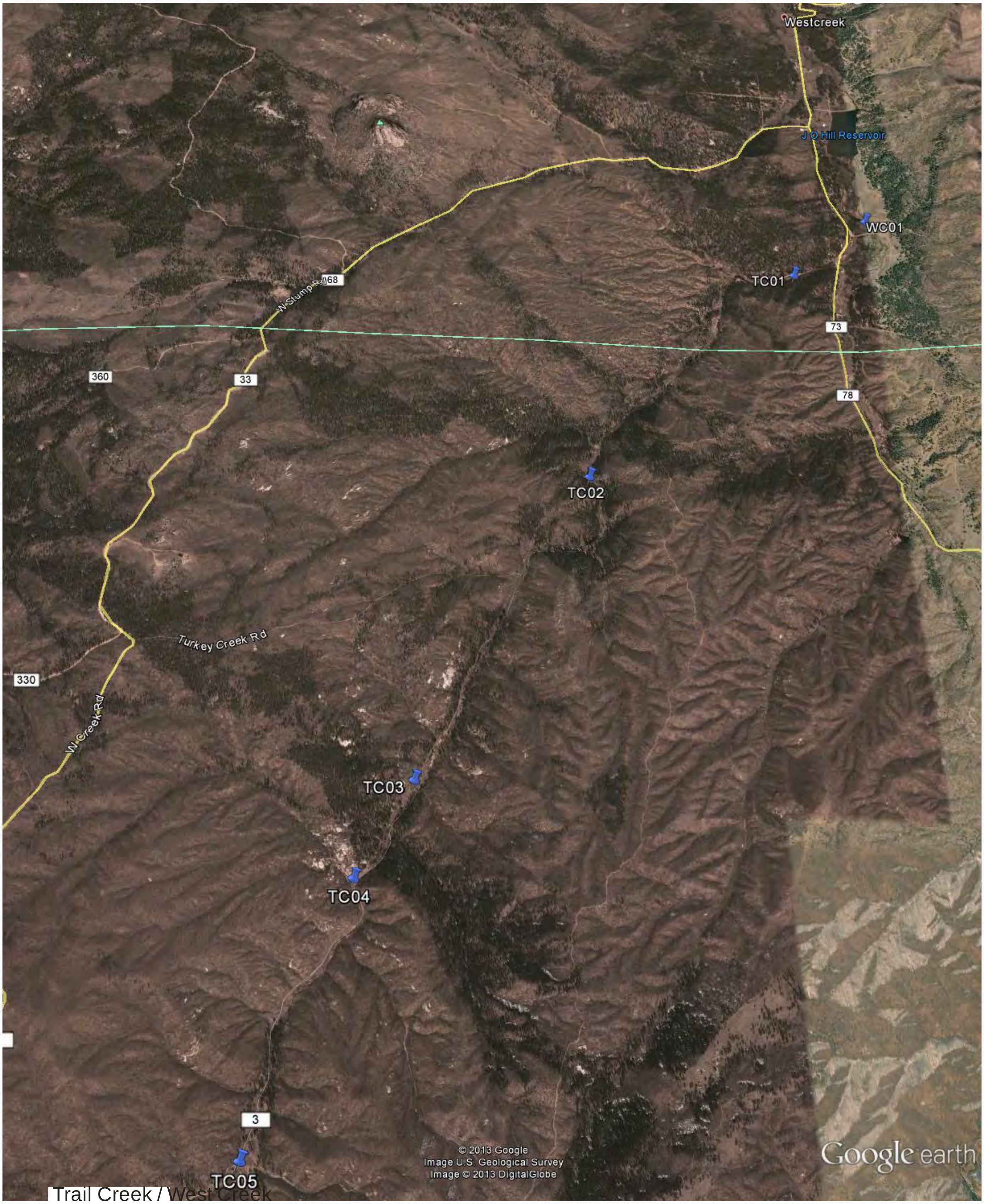
Sample Site Locations

Trail Creek/West Creek Benthic Macroinvertebrate Sample Site GPS Metadata

Site ID	Site Name	Latitude	Longitude	Elevation	Datum
TC01	Trail Creek Reach 2	39.13415599	-105.16512	2302.045410	WGS-84
TC02	Trail Creek Reach 3	39.12199996	-105.18006	2389.327148	WGS-84
TC03	Trail Creek B3 Reference Site	39.10708998	-105.19086	2437.555664	WGS-84
TC04	Trail Creek Reach 4	39.10289903	-105.19412	2458.300293	WGS-84
TC05	Trail Creek Impaired Channel Site	39.09219702	-105.19928	2493.037109	WGS-84
WC01	West Creek Reach 1	39.13771997	-105.15952	2341.356689	WGS-84



Trail Creek and West Creek Benthic Macroinvertebrate Sites - November 2013



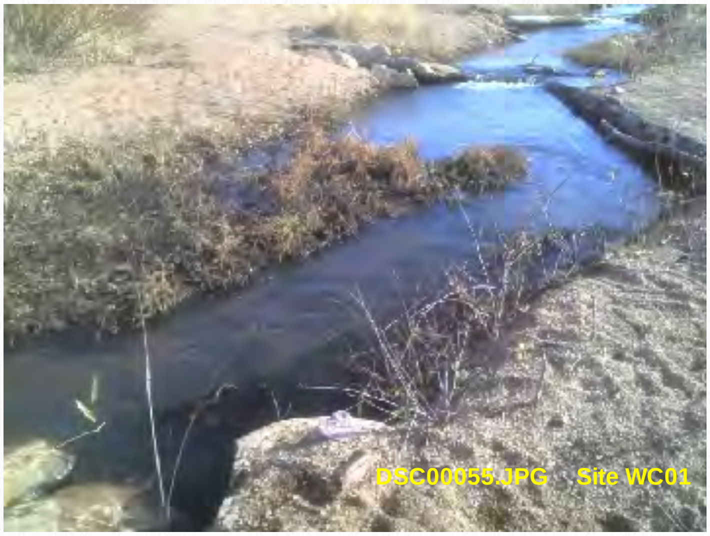
Trail Creek / West Creek
Macroinvertebrate Sampling Sites
November 2013

Lower Trail Creek and West Creek Benthic Macroinvertebrate Sites - November 2013

Sample Site Photo Points

Trail Creek/West Creek Benthic Macroinvertebrate Sampling Nov. 2013 - Photo Metadata

File	Date Created	Sample Site	File Size	Image Size	Date Shot	Device	Latitude	Longitude	Altitude	Heading	Map Datum
DSC00055.JPG	11/13/2013 14:11	WC01	1.15 MB	2592 x 1944	11/13/2013 14:11	Montana 650	N 39−8.273' (39−8'16.4")	W 105−9.573' (105−9'34.4")	2315.57m	50.33 (T)	WGS-84
DSC00056.JPG	11/13/2013 14:11	WC01	1.17 MB	2592 x 1944	11/13/2013 14:11	Montana 650	N 39−8.266' (39−8'15.9")	W 105−9.574' (105−9'34.4")	2309.49m	39.39 (T)	WGS-84
DSC00057.JPG	11/13/2013 14:12	WC01	703 KB	2592 x 1944	11/13/2013 14:12	Montana 650	N 39−8.260' (39−8'15.6")	W 105−9.571' (105−9'34.3")	2307.55m	65.60 (T)	WGS-84
DSC00058.JPG	11/13/2013 15:02	TC01	687 KB	2592 x 1944	11/13/2013 15:02	Montana 650	N 39−8.049' (39−8'2.9")	W 105−9.904' (105−9'54.3")	2320.20m	341.97 (T)	WGS-84
DSC00059.JPG	11/13/2013 15:02	TC01	771 KB	2592 x 1944	11/13/2013 15:02	Montana 650	N 39−8.050' (39−8'3.0")	W 105−9.906' (105−9'54.3")	2320.75m	149.24 (T)	WGS-84
DSC00060.JPG	11/13/2013 15:04	TC01	825 KB	2592 x 1944	11/13/2013 15:04	Montana 650	N 39−8.046' (39−8'2.7")	W 105−9.962' (105−9'57.7")	2323.89m	122.56 (T)	WGS-84
DSC00061.JPG	11/14/2013 9:45	TC02	1.11 MB	2592 x 1944	11/14/2013 9:45	Montana 650	N 39−7.329' (39−7'19.7")	W 105−10.821' (105−10'49.3")	2406.89m	305.74 (T)	WGS-84
DSC00062.JPG	11/14/2013 9:45	TC02	730 KB	2592 x 1944	11/14/2013 9:45	Montana 650	N 39−7.322' (39−7'19.3")	W 105−10.827' (105−10'49.6")	2405.09m	21.38 (T)	WGS-84
DSC00063.JPG	11/14/2013 9:46	TC02	938 KB	2592 x 1944	11/14/2013 9:46	Montana 650	N 39−7.314' (39−7'18.8")	W 105−10.797' (105−10'47.8")	2408.49m	69.53 (T)	WGS-84
DSC00064.JPG	11/14/2013 9:47	TC02	1.24 MB	2592 x 1944	11/14/2013 9:47	Montana 650	N 39−7.299' (39−7'18.0")	W 105−10.769' (105−10'46.1")	2409.20m	180.05 (T)	WGS-84
DSC00065.JPG	11/14/2013 10:33	TC03	0.98 MB	2592 x 1944	11/14/2013 10:33	Montana 650	N 39−6.436' (39−6'26.1")	W 105−11.452' (105−11'27.1")	2458.61m	89.30 (T)	WGS-84
DSC00066.JPG	11/14/2013 10:34	TC03	1.15 MB	2592 x 1944	11/14/2013 10:34	Montana 650	N 39−6.416' (39−6'24.9")	W 105−11.448' (105−11'26.9")	2459.07m	258.49 (T)	WGS-84
DSC00067.JPG	11/14/2013 11:18	TC04	1.09 MB	2592 x 1944	11/14/2013 11:18	Montana 650	N 39−6.164' (39−6'9.8")	W 105−11.650' (105−11'39.0")	2477.06m	286.81 (T)	WGS-84
DSC00068.JPG	11/14/2013 11:19	TC04	1.31 MB	2592 x 1944	11/14/2013 11:19	Montana 650	N 39−6.181' (39−6'10.8")	W 105−11.636' (105−11'38.1")	2476.25m	141.38 (T)	WGS-84
DSC00069.JPG	11/14/2013 12:38	TC05	871 KB	2592 x 1944	11/14/2013 12:38	Montana 650	N 39−5.547' (39−5'32.8")	W 105−11.959' (105−11'57.5")	2503.11m	74.92 (T)	WGS-84
DSC00070.JPG	11/14/2013 12:39	TC05	1.20 MB	2592 x 1944	11/14/2013 12:39	Montana 650	N 39−5.521' (39−5'31.3")	W 105−11.973' (105−11'58.4")	2505.58m	313.69 (T)	WGS-84
DSC00071.JPG	11/14/2013 14:20	TC03	1.17 MB	2592 x 1944	11/14/2013 14:20	Montana 650	N 39−6.416' (39−6'25.0")	W 105−11.453' (105−11'27.2")	2463.46m	127.27 (T)	WGS-84
DSC00072.JPG	11/14/2013 14:21	TC03	1.10 MB	2592 x 1944	11/14/2013 14:21	Montana 650	N 39−6.396' (39−6'23.7")	W 105−11.463' (105−11'27.8")	2462.14m	298.03 (T)	WGS-84


DSC00055.JPG Site WC01


DSC00057.JPG Site WC01

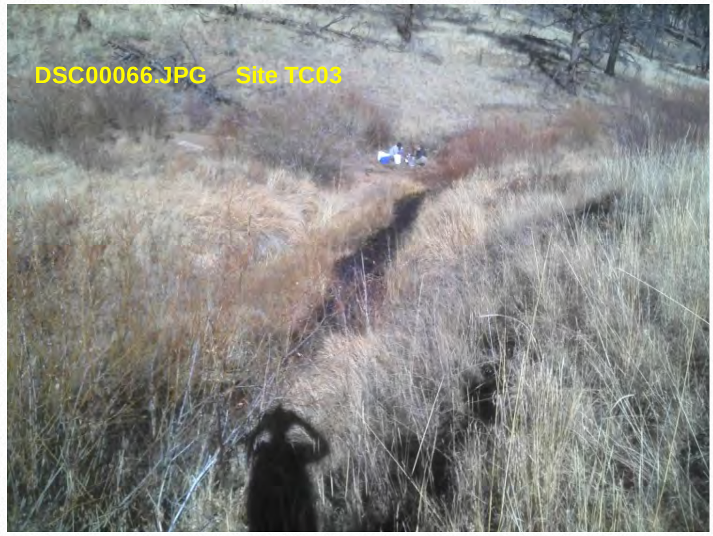

DSC00060.JPG Site TC01


DSC00062.JPG Site TC02


DSC00059.JPG Site TC01


DSC00061.JPG Site TC02


DSC00064.JPG Site TC02


DSC00066.JPG Site TC03


DSC00063.JPG Site TC02


DSC00065.JPG Site TC03


DSC00068.JPG Site TC04


DSC00070.JPG Site TC05


DSC00067.JPG Site TC04

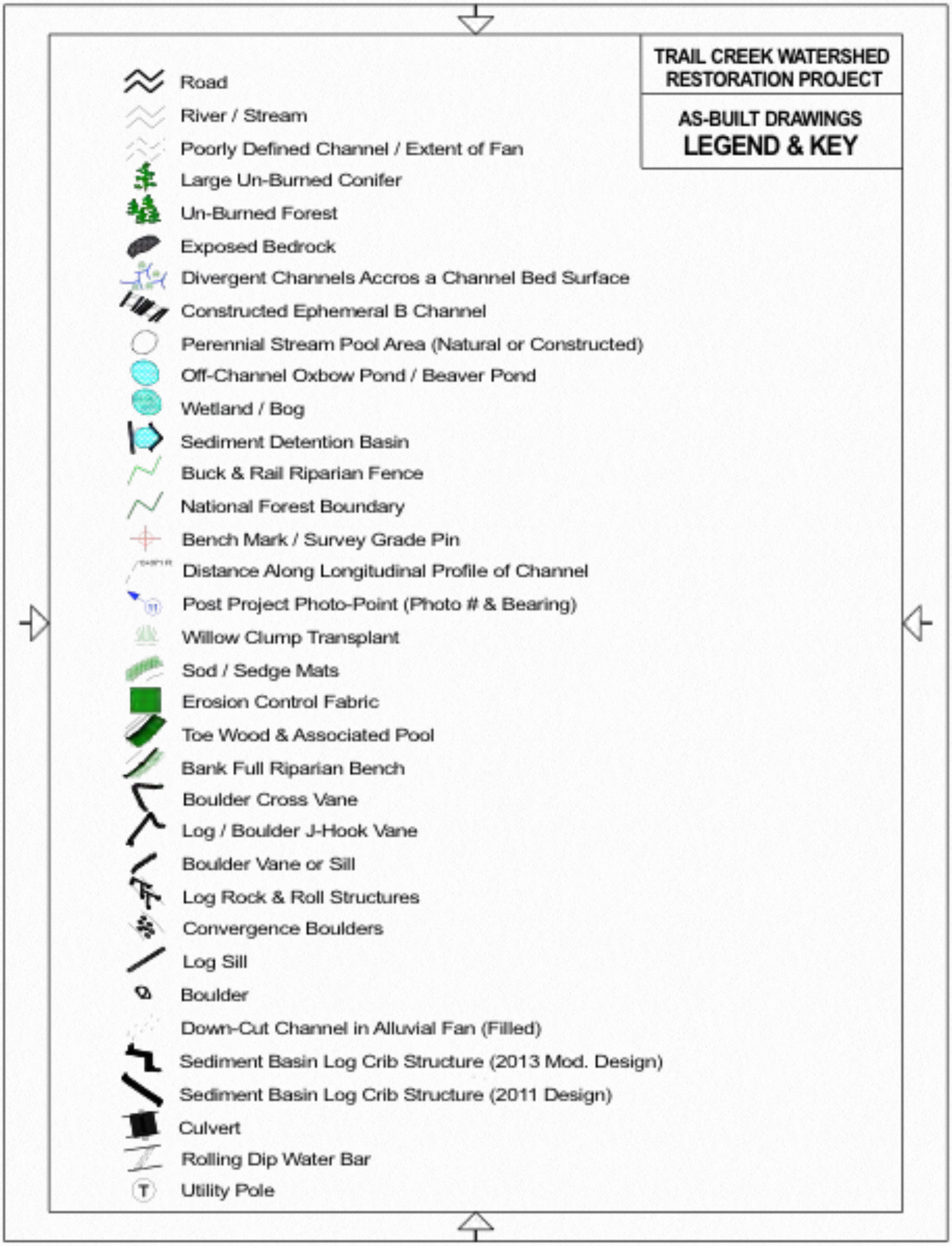

DSC00069.JPG Site TC05


DSC00071.JPG Site TC03 Dupe.

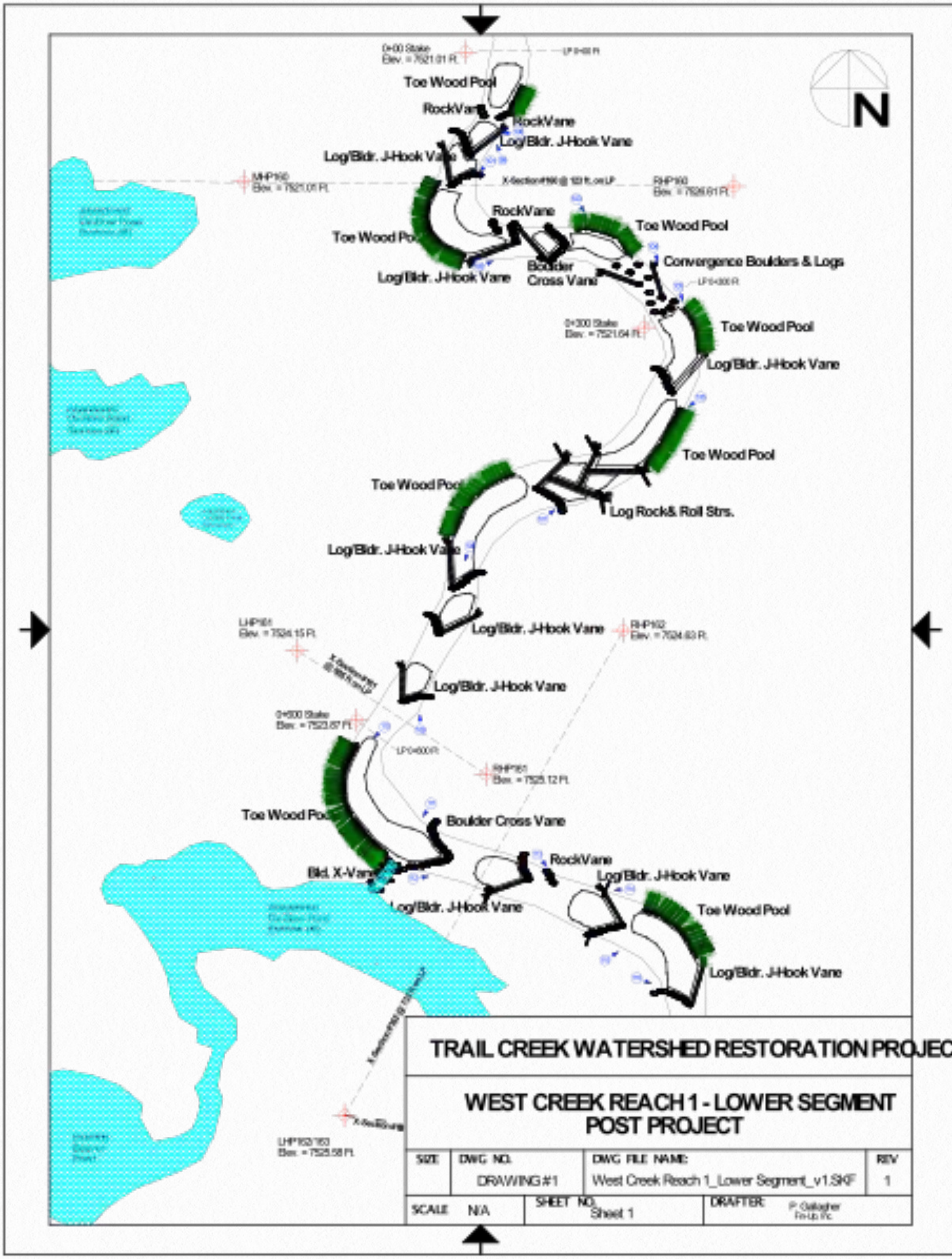

DSC00072.JPG Site TC03 Dupe.

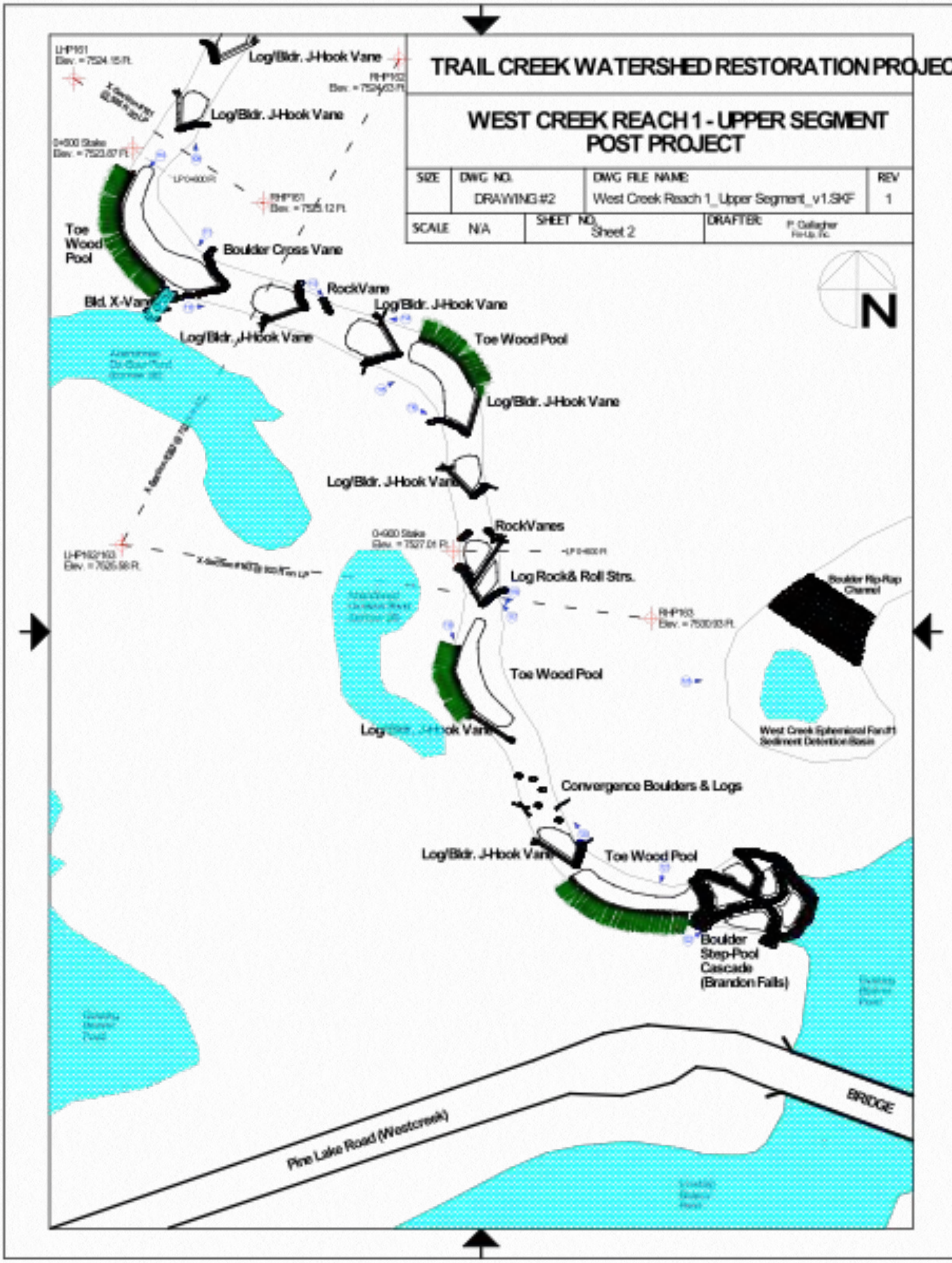
Appendix

As-Built Drawings

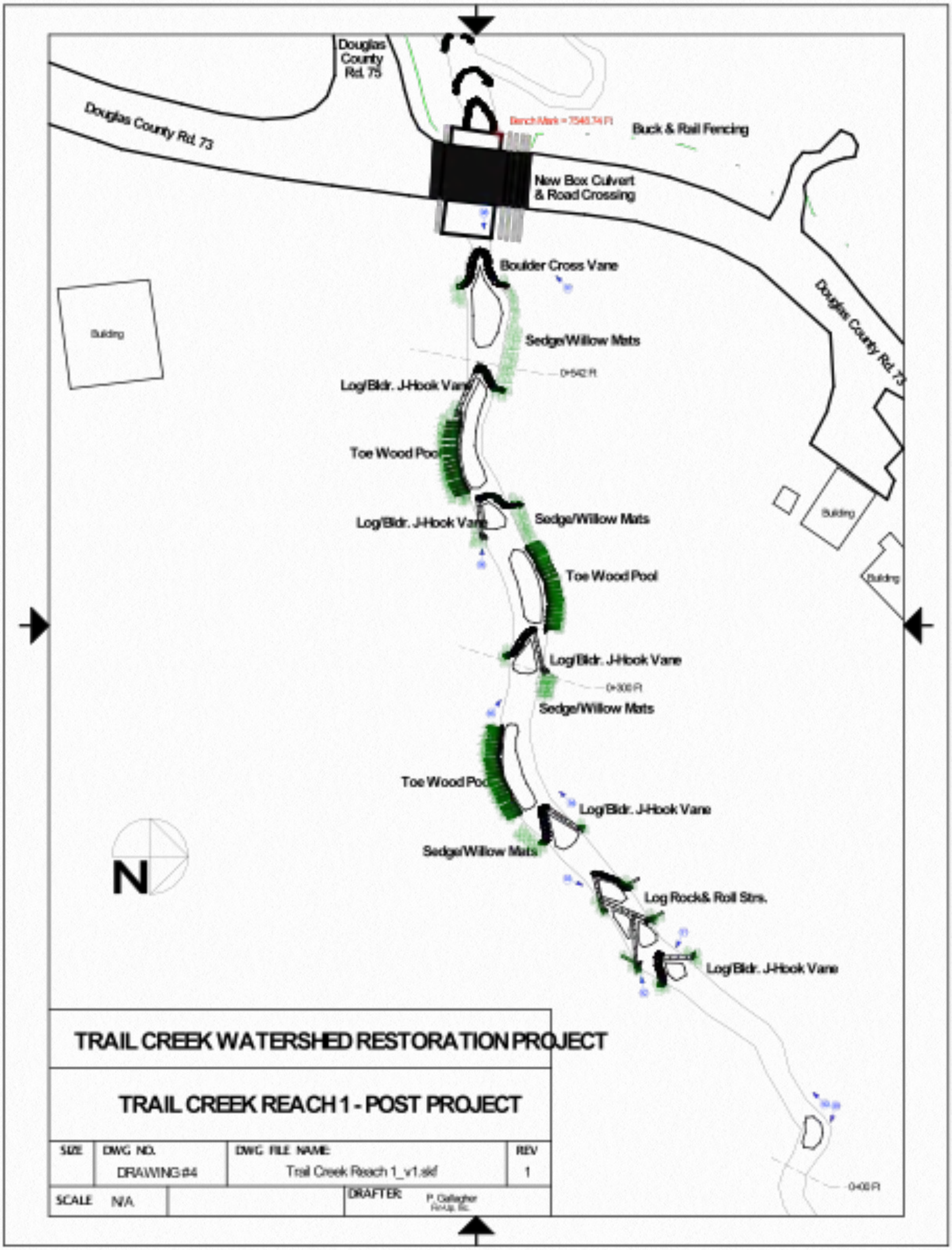


West Creek Reach 1

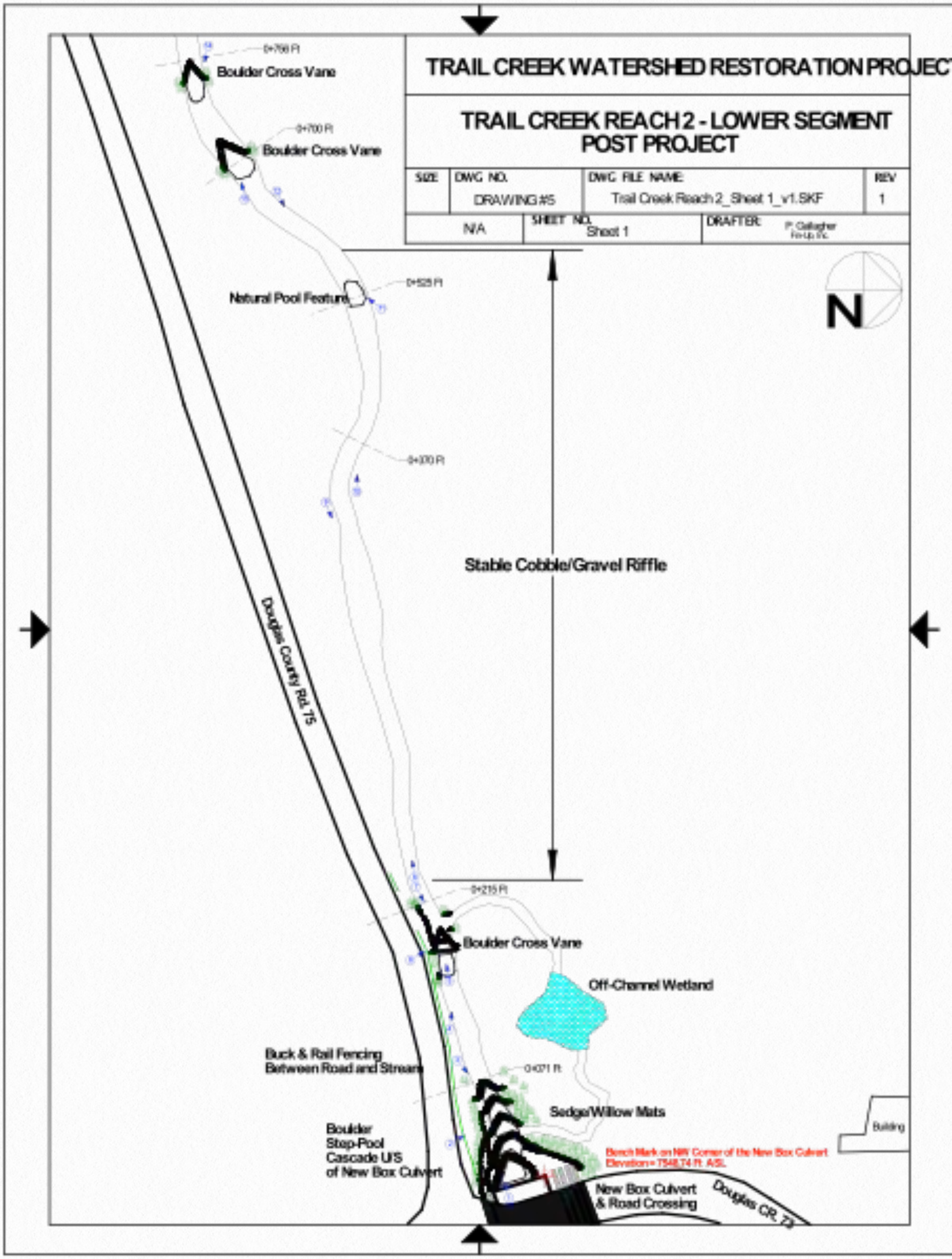


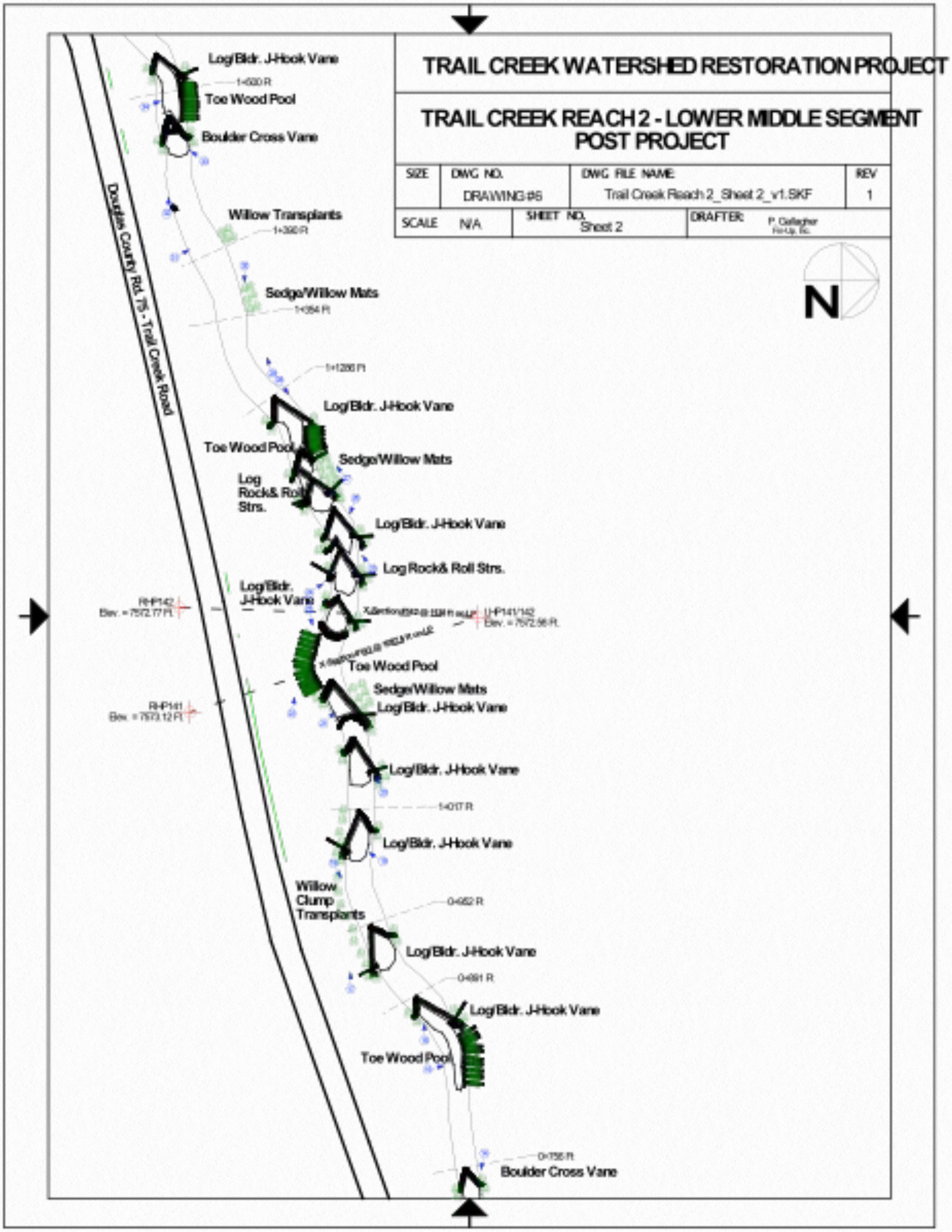

TRAIL CREEK WATERSHED RESTORATION PROJECT
WEST CREEK REACH 1 - UPPER SEGMENT
POST PROJECT
SIZE
DWG NO.
DRAWING #2
DWG FILE NAME
West Creek Reach 1_Upper Segment_v1.SKF
REV
1
SCALE
N/A
SHEET NO.
Sheet 2
DRAFTER
N
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
Toe Wood Pool
Boulder Cross Vane
Bld. X-Vane
RockVane
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
Toe Wood Pool
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
RockVanes
Log Rock& Roll Strs.
Toe Wood Pool
Boulder Rip-Rap Channel
West Creek Ephemeral Fan#1 Sediment Detention Basin
Convergence Boulders & Logs
Log/Bldr. J-Hook Vane
Toe Wood Pool
Boulder Step-Pool Cascade (Brandon Falls)
Pine Lake Road (Westcreek)
BRIDGE

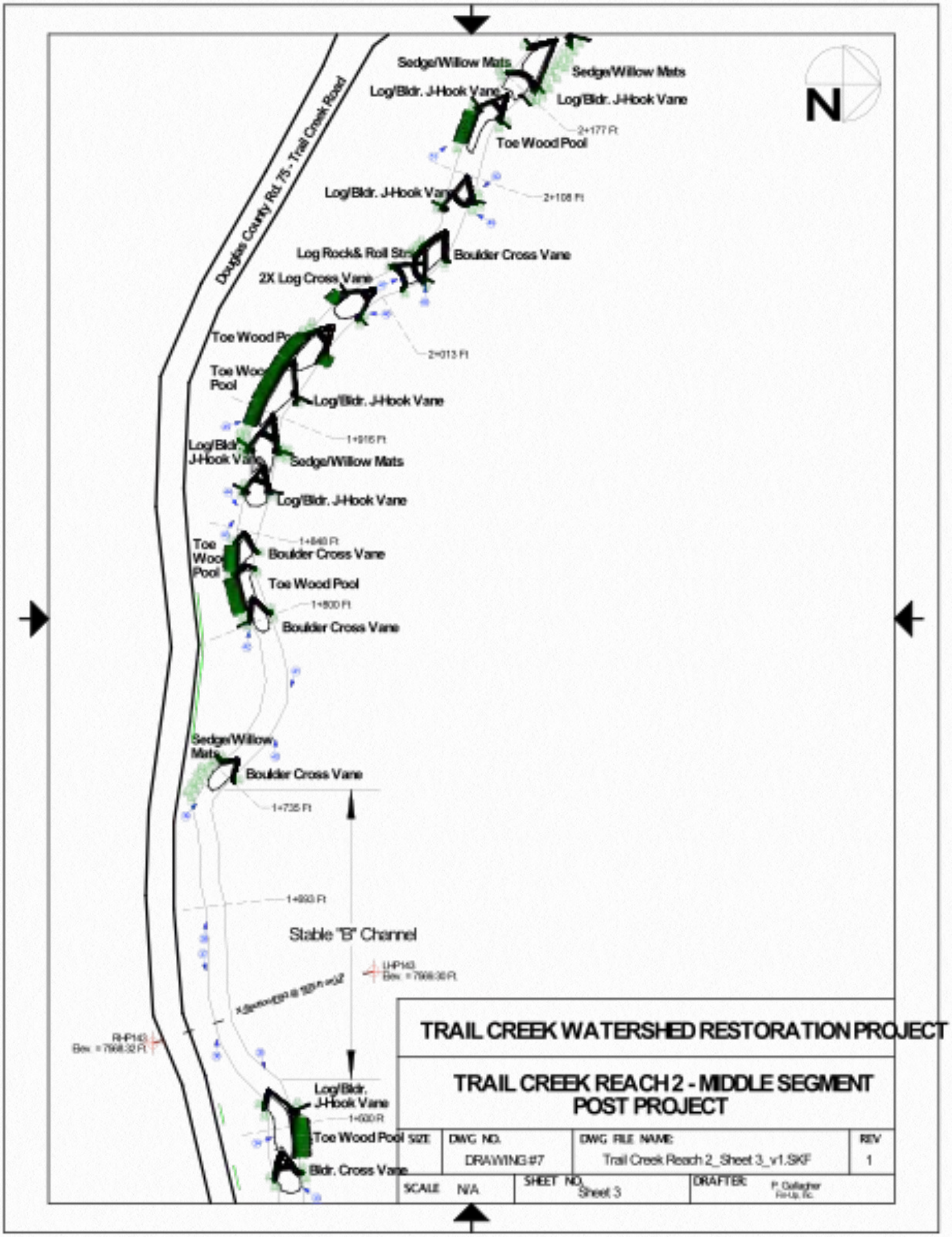
Trail Creek Reach 1



Trail Creek Reach 2

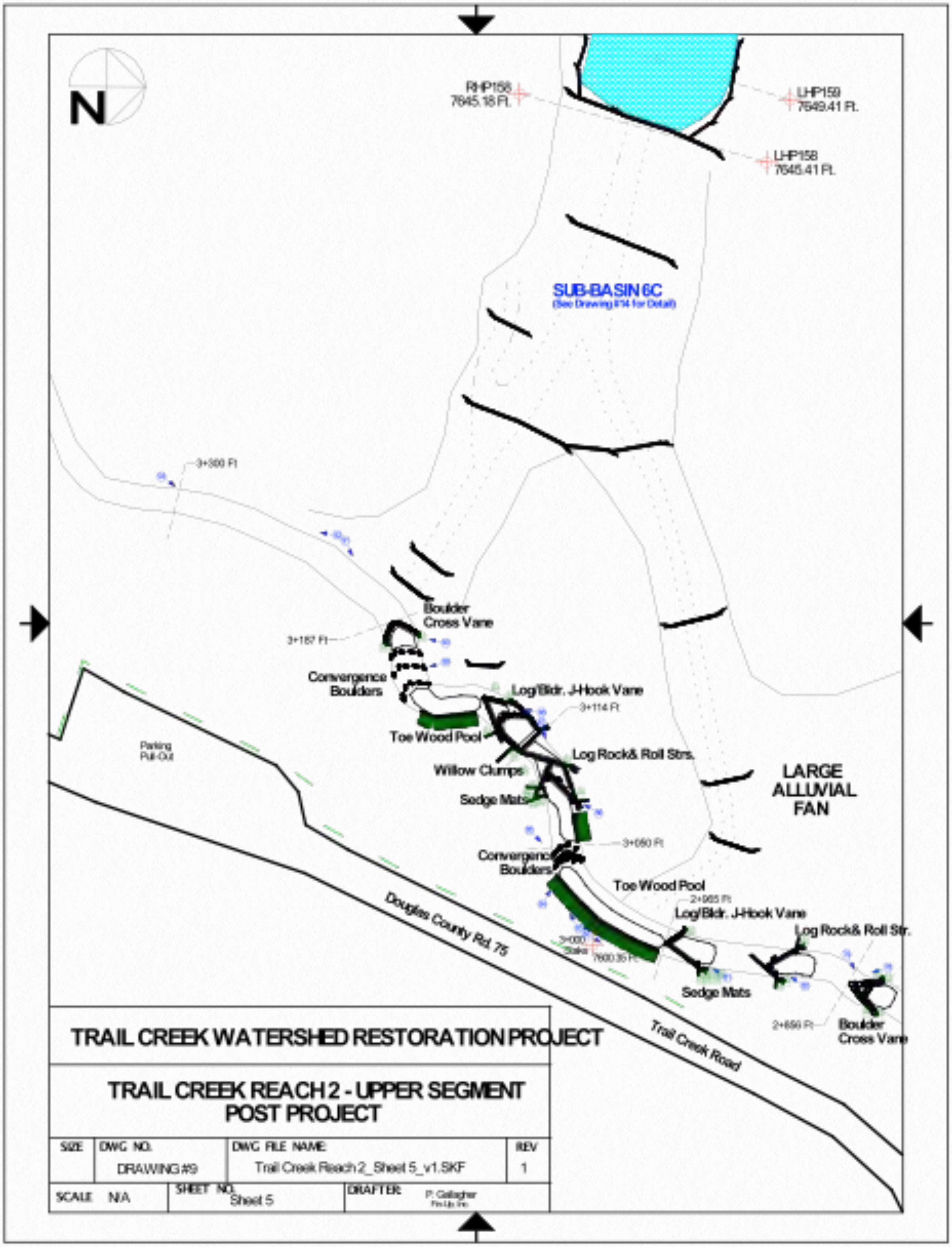



TRAIL CREEK WATERSHED RESTORATION PROJECT
TRAIL CREEK REACH 2 - LOWER MIDDLE SEGMENT POST PROJECT
SIZE
DWG NO.
DRAWING #6
DWG FILE NAME
Trail Creek Reach 2_Sheet 2_v1.SKF
REV
1
SCALE
N/A
SHEET NO.
Sheet 2
DRAFTER
N
Douglas County Rd. 75 - Trail Creek Road
Log/Bldr. J-Hook Vane
Toe Wood Pool
Boulder Cross Vane
Willow Transplants
Sedge/Willow Mats
Log/Bldr. J-Hook Vane
Toe Wood Pool
Sedge/Willow Mats
Log Rock& Roll Strs.
Log/Bldr. J-Hook Vane
Log Rock& Roll Strs.
Log/Bldr. J-Hook Vane
Toe Wood Pool
Sedge/Willow Mats
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
Willow Clump Transplants
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
Toe Wood Pool
Boulder Cross Vane

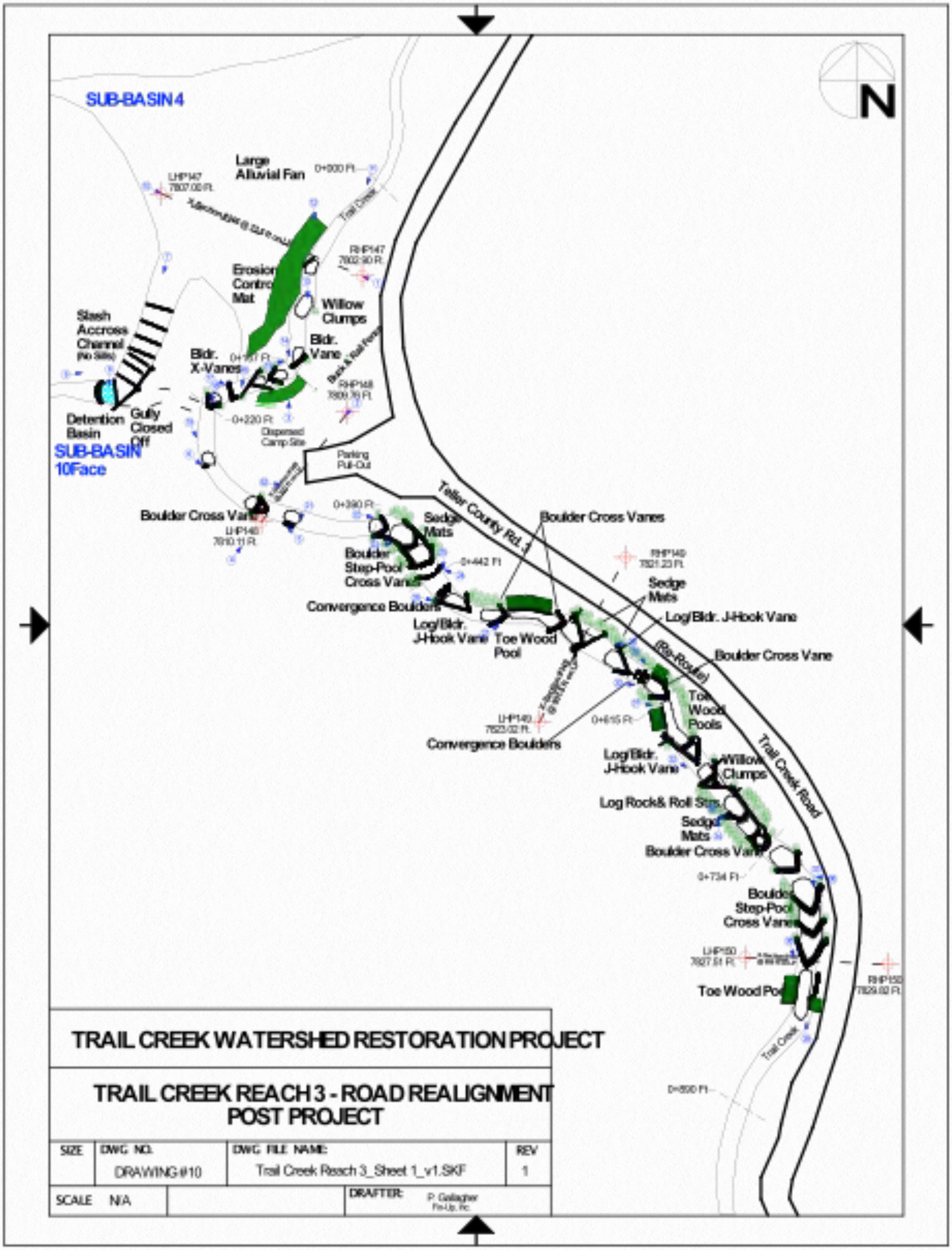


Douglas County Rd. 75 - Trail Creek Road
N
Sedge/Willow Mats
Sedge/Willow Mats
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
2+177 Ft
Toe Wood Pool
Log/Bldr. J-Hook Vane
2+108 Ft
Log Rock& Roll Str
Boulder Cross Vane
2X Log Cross Vane
Toe Wood Pool
2+013 Ft
Toe Wood Pool
Log/Bldr. J-Hook Vane
1+916 Ft
Log/Bldr. J-Hook Vane
Sedge/Willow Mats
Log/Bldr. J-Hook Vane
Toe Wood Pool
1+840 Ft
Boulder Cross Vane
Toe Wood Pool
1+800 Ft
Boulder Cross Vane
Sedge/Willow Mats
Boulder Cross Vane
1+735 Ft
1+693 Ft
Stable "B" Channel
Log/Bldr. J-Hook Vane
1+600 Ft
Toe Wood Pool
Bldr. Cross Vane
TRAIL CREEK WATERSHED RESTORATION PROJECT
TRAIL CREEK REACH 2 - MIDDLE SEGMENT
POST PROJECT
SIZE
DWG NO.
DRAWING #7
DWG FILE NAME:
Trail Creek Reach 2_Sheet 3_v1.SKF
REV
1
SCALE
N/A
SHEET NO.
Sheet 3
DRAFTER:
P. Gallagher

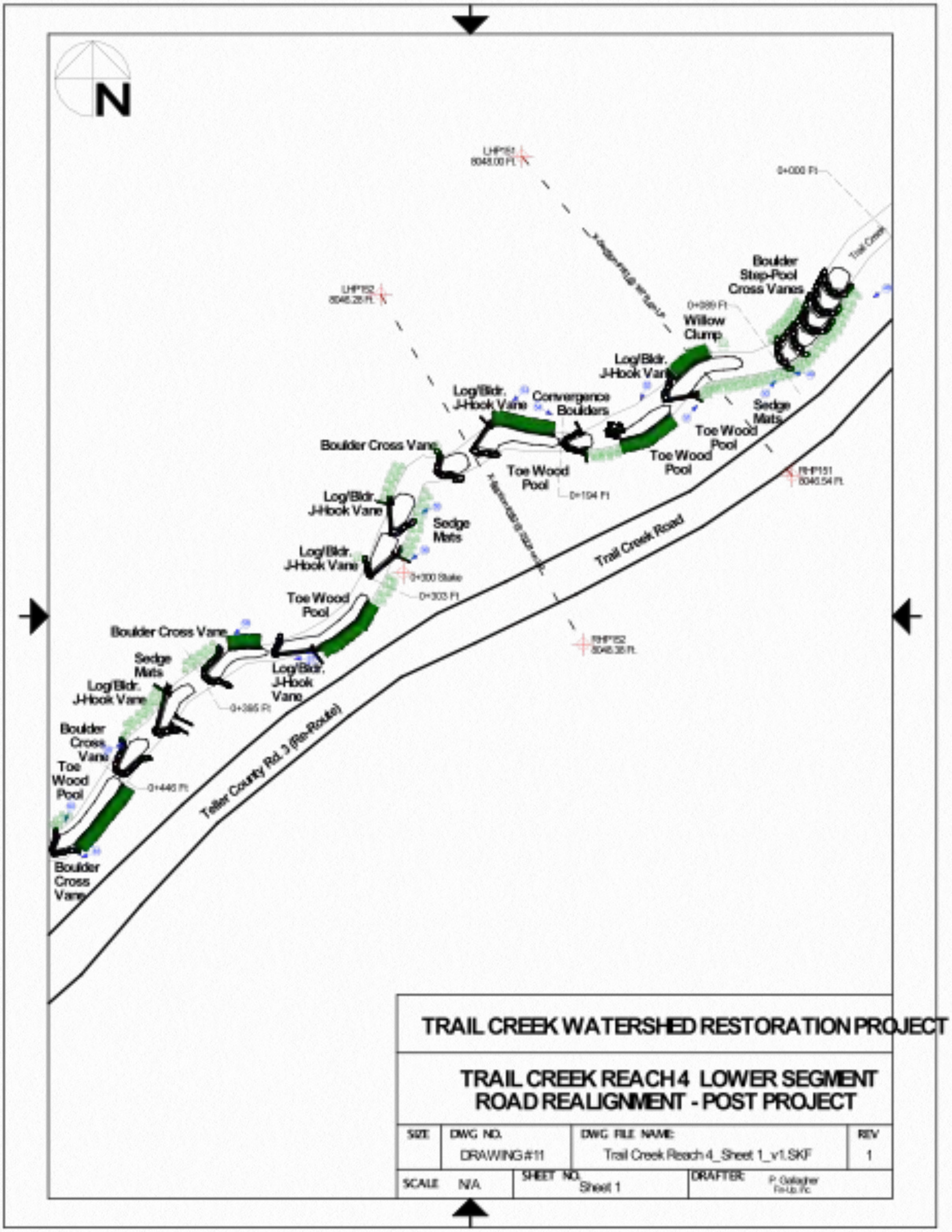

TRAIL CREEK WATERSHED RESTORATION PROJECT
TRAIL CREEK REACH 2 - UPPER MIDDLE SEGMENT
POST PROJECT
SIZE
DWG NO.
DRAWING #8
DWG FILE NAME
Trail Creek Reach 2_Sheet 4_v1.SKF
REV
1
SCALE
N/A
SHEET NO.
Sheet 4
DRAFTER:
N
Boulder Cross Vane
Log/Bldr. J-Hook Vane
Toe Wood Pool
Sedge Mats
Log Sill U/S of Ox-Bow Ponds
Bldr. Vane
Toe Wood Pool
Small Bld. Cross Vanes
Toe Wood Pool
Sedge Mats
Log/Bldr. J-Hook Vanes
Douglas County Rd. 75
Log Sills Along Road Fill Slope
Boulder Cross Vane
Log/Bldr. J-Hook Vanes
Sedge Mats
Toe Wood Pool
Log Rock& Roll Strs.
Trail Creek Road
Toe Wood Pool
Sedge Mats
Log/Bldr. J-Hook Vanes
Sedge Mats
Boulder Cross Vane
Toe Wood Pool
Parking Pull-Out
Log/Bldr. J-Hook Vanes
Sedge/Willow Mats
Log/Bldr. J-Hook Vane
Constructed D Channel w/ Divergent Rivulets
Constructed D Channel w/ Divergent Rivulets
SUB-BASIN 6
(See Drawing #13 for Detail)
Log Rock& Roll Strs.
Toe Wood Pool
Log Rock& Roll Strs.
Toe Wood Pool
Toe Wood Pool
Toe Wood Pool
Sedge/Willow Mats
Log/Bldr. J-Hook Vane

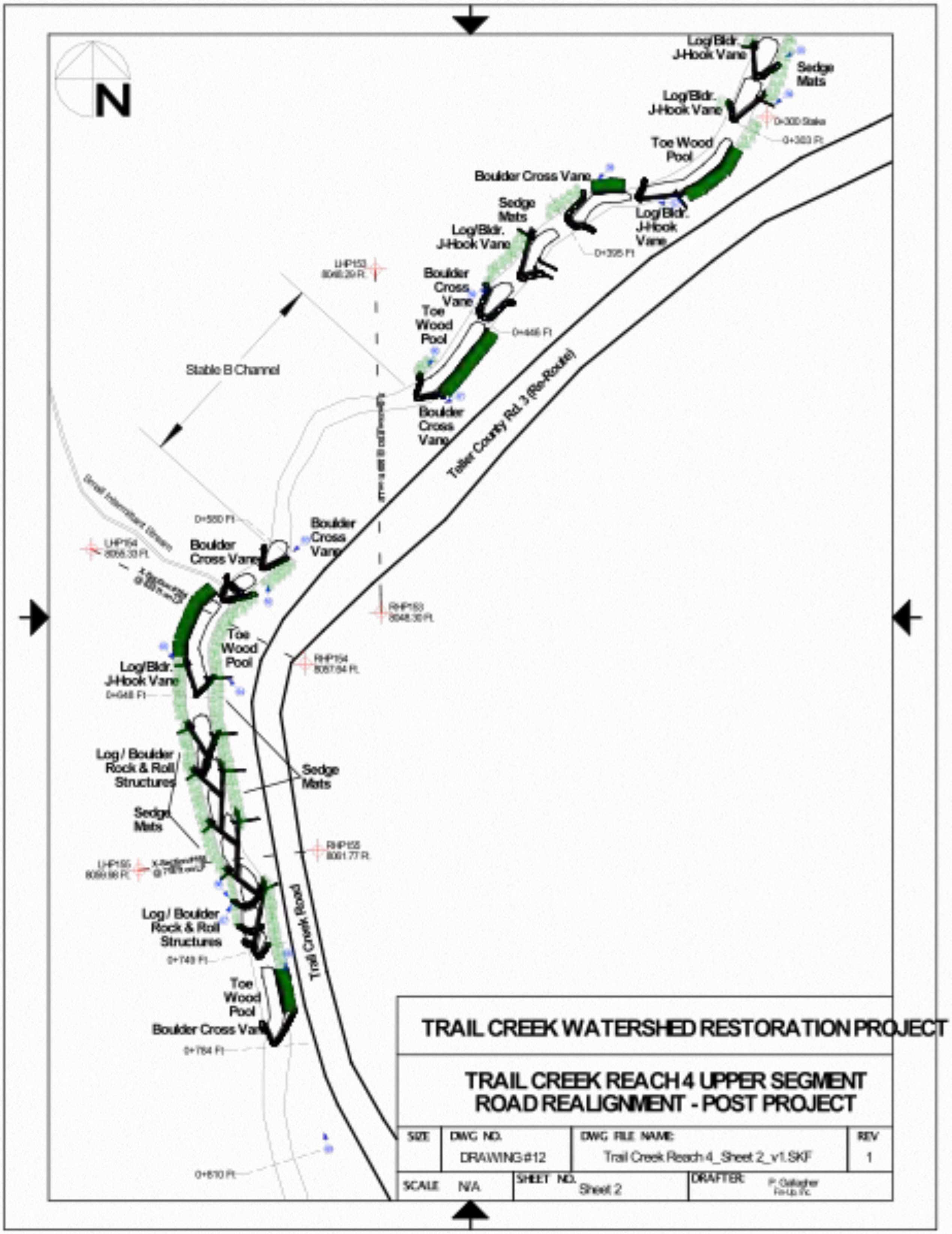

N
RHP158
7645.18 Ft.
LHP159
7649.41 Ft.
LHP158
7645.41 Ft.
SUB-BASIN 6C
(See Drawing #14 for Detail)
3+300 Ft
Boulder
Cross Vane
3+187 Ft
Convergence
Boulders
Log/Bldr. J-Hook Vane
3+114 Ft
Toe Wood Pool
Parking
Pull-Out
Log Rock& Roll Strs.
Willow Clumps
Sedge Mats
LARGE
ALLUVIAL
FAN
3+050 Ft
Convergence
Boulders
Toe Wood Pool
2+965 Ft
Log/Bldr. J-Hook Vane
Log Rock& Roll Str.
Douglas County Rd. 75
Sedge Mats
2+856 Ft
Boulder
Cross Vane
Trail Creek Road
TRAIL CREEK WATERSHED RESTORATION PROJECT
TRAIL CREEK REACH 2 - UPPER SEGMENT
POST PROJECT
SIZE
DWG NO.
DRAWING #9
DWG FILE NAME
Trail Creek Reach 2_Sheet 5_v1.SKF
REV
1
SCALE N/A
SHEET NO.
Sheet 5
DRAFTER
P. Gallagher

Trail Creek Reach 3

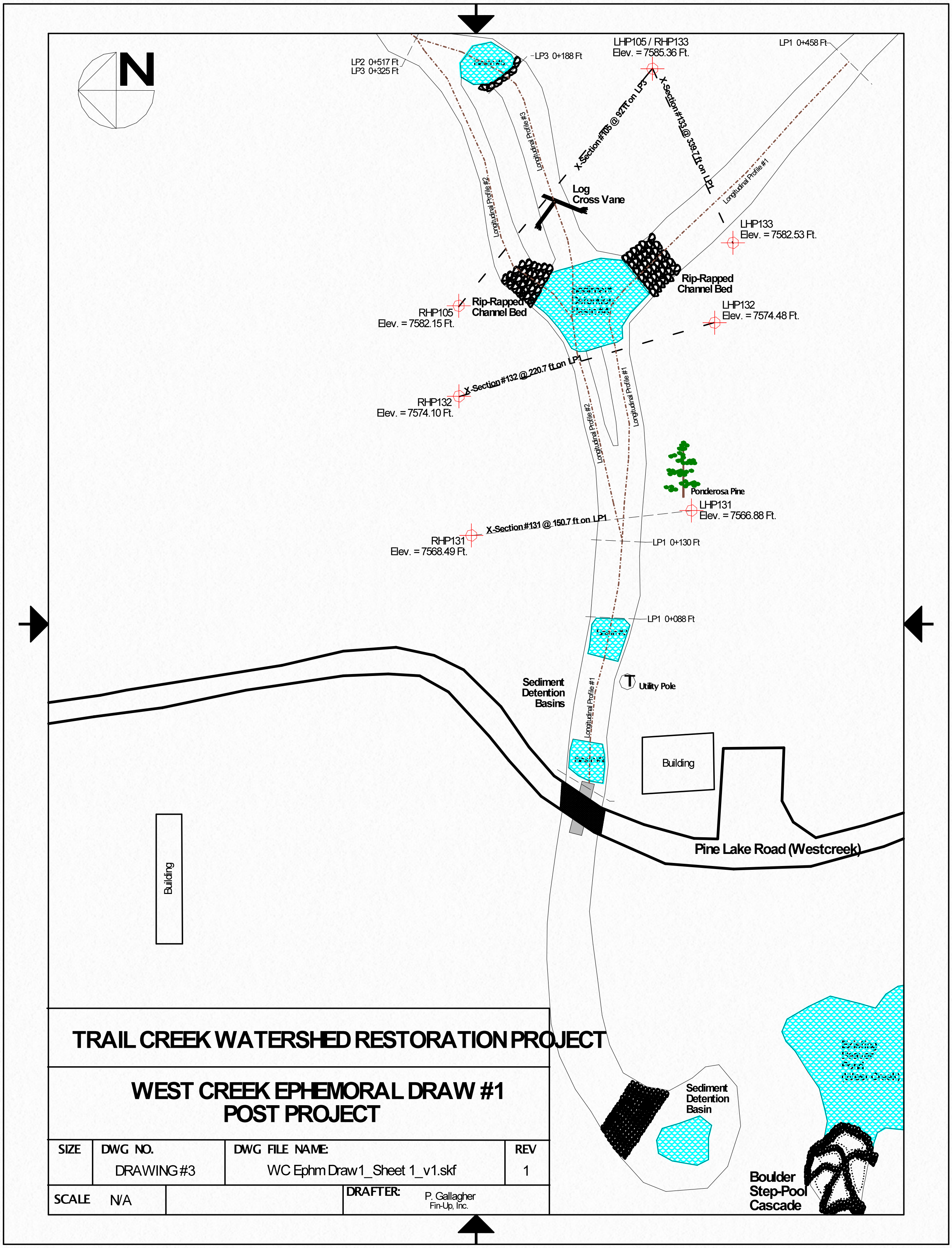


Trail Creek Reach 4

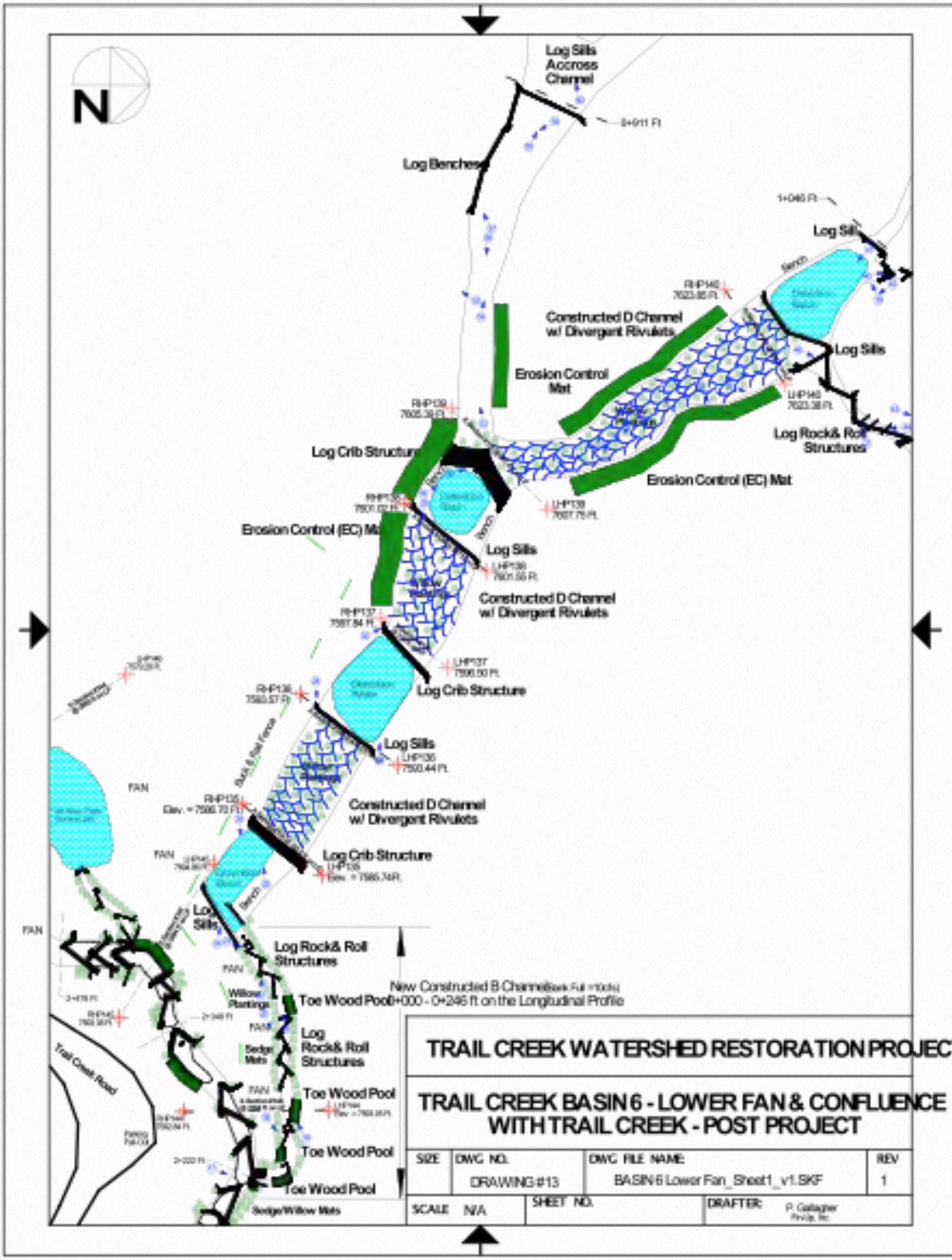



N
Log/Bldr. J-Hook Vane
Sedge Mats
Log/Bldr. J-Hook Vane
0+300 Stake
0+303 Ft
Toe Wood Pool
Boulder Cross Vane
Sedge Mats
Log/Bldr. J-Hook Vane
Log/Bldr. J-Hook Vane
0+395 Ft
LHP153 8048.29 Ft.
Boulder Cross Vane
Toe Wood Pool
0+446 Ft
Stable B Channel
Boulder Cross Vane
Teller County Rd. 3 (Re-Route)
Small Intermittent Stream
0+580 Ft
Boulder Cross Vane
LHP154 8058.33 Ft.
Boulder Cross Vane
RHP153 8048.30 Ft.
Toe Wood Pool
RHP154 8057.64 Ft.
Log/Bldr. J-Hook Vane
0+648 Ft
Log / Boulder Rock & Roll Structures
Sedge Mats
Sedge Mats
RHP155 8061.77 Ft.
LHP155 8059.98 Ft.
Log / Boulder Rock & Roll Structures
0+749 Ft
Trail Creek Road
Toe Wood Pool
Boulder Cross Vane
0+784 Ft
0+810 Ft
TRAIL CREEK WATERSHED RESTORATION PROJECT
TRAIL CREEK REACH 4 UPPER SEGMENT
ROAD REALIGNMENT - POST PROJECT
SIZE
DWG NO.
DRAWING #12
DWG FILE NAME:
Trail Creek Reach 4_Sheet 2_v1.SKF
REV
1
SCALE
N/A
SHEET NO.
Sheet 2
DRAFTER:

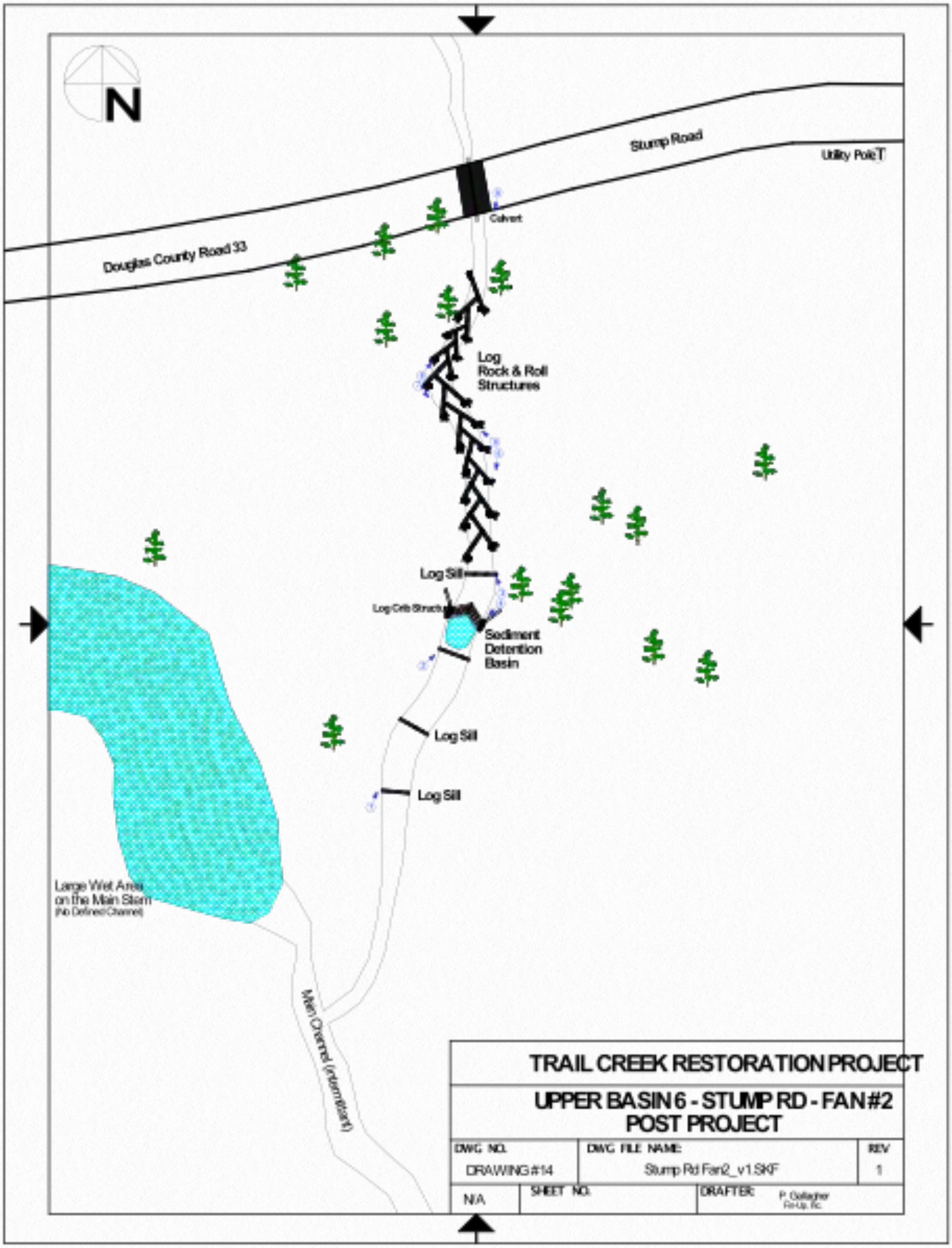
West Creek Ephemeral Draw #1



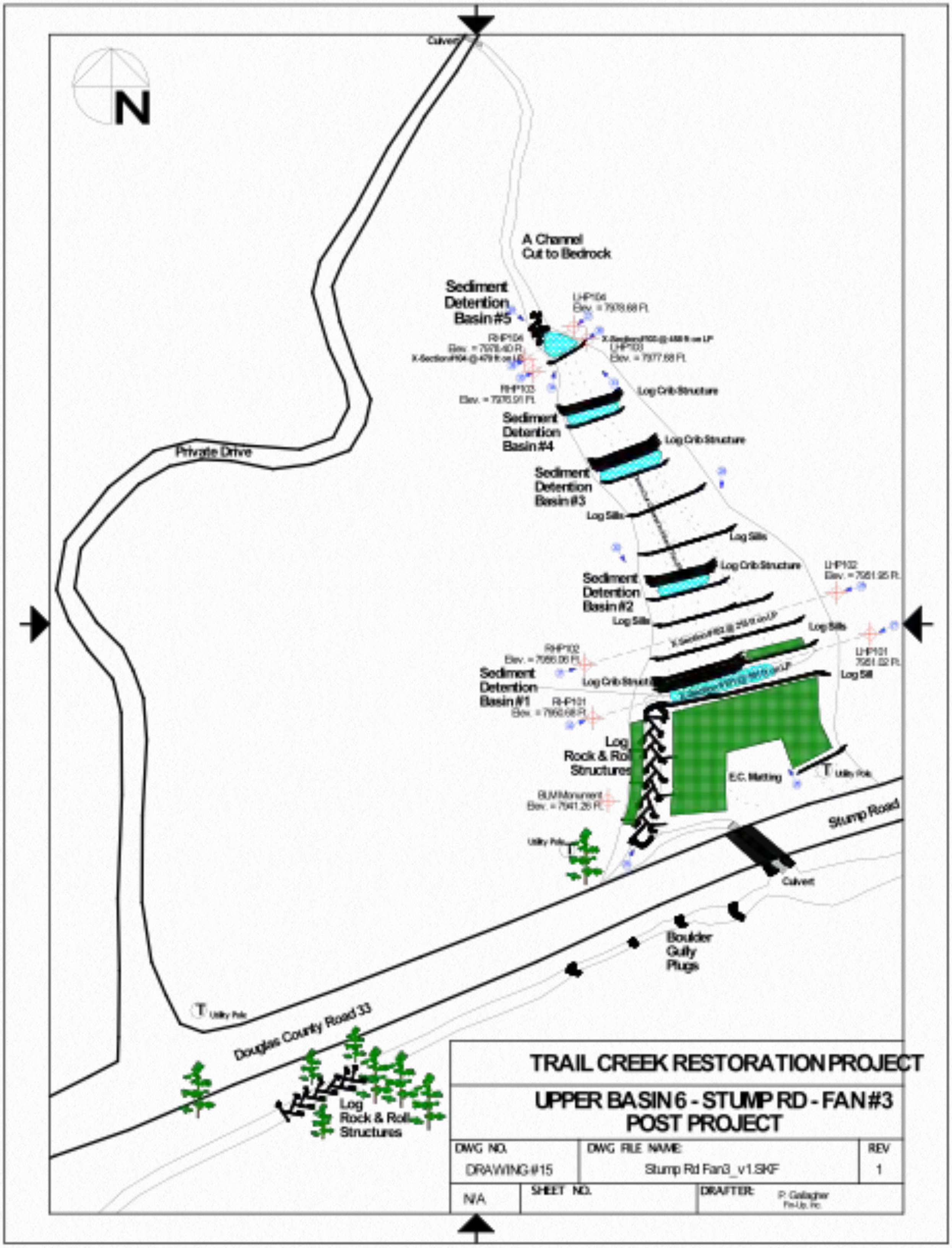
Trail Creek Basin 6 Lower Fan



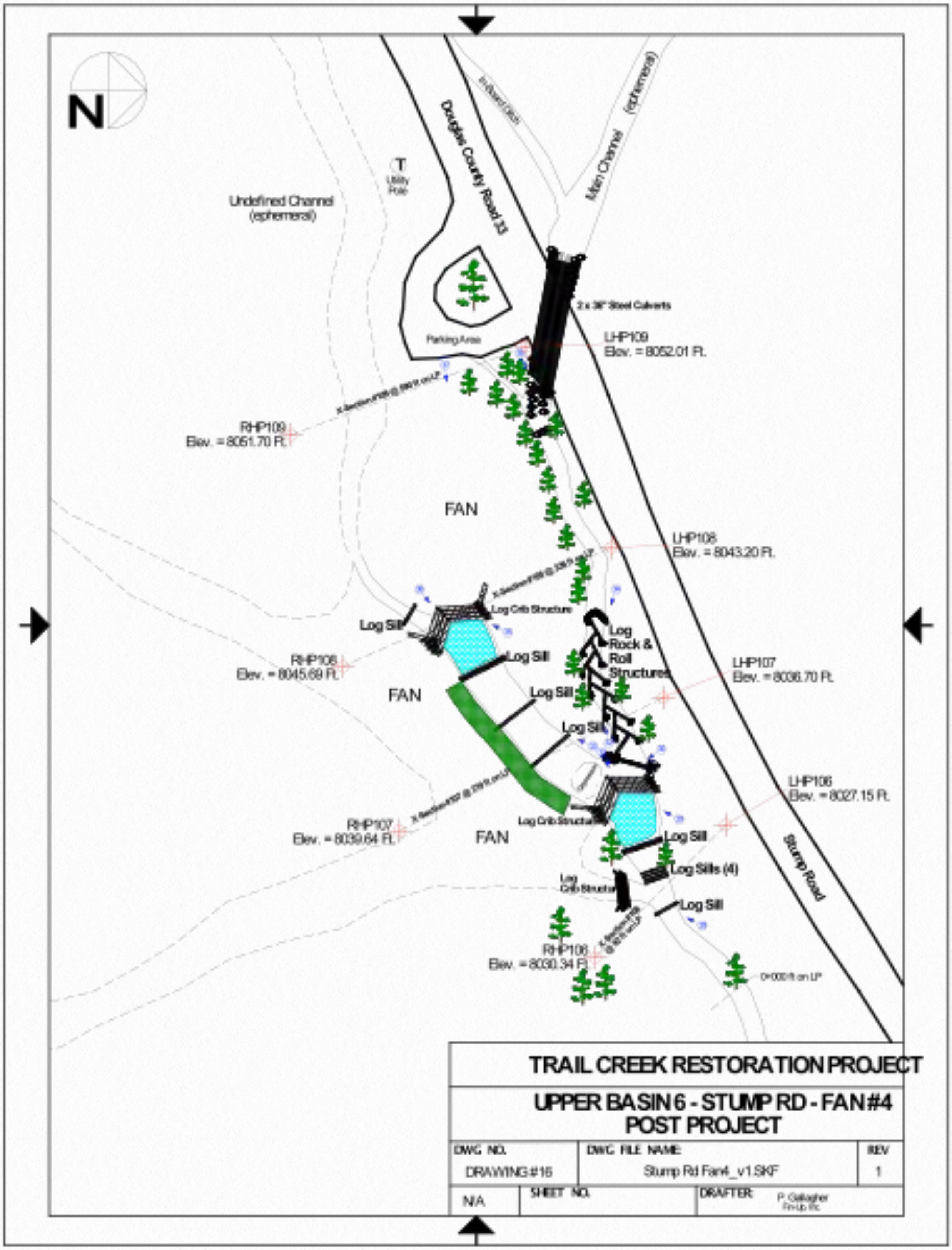
Trail Creek Basin 6 (Stump Road) Fan #2



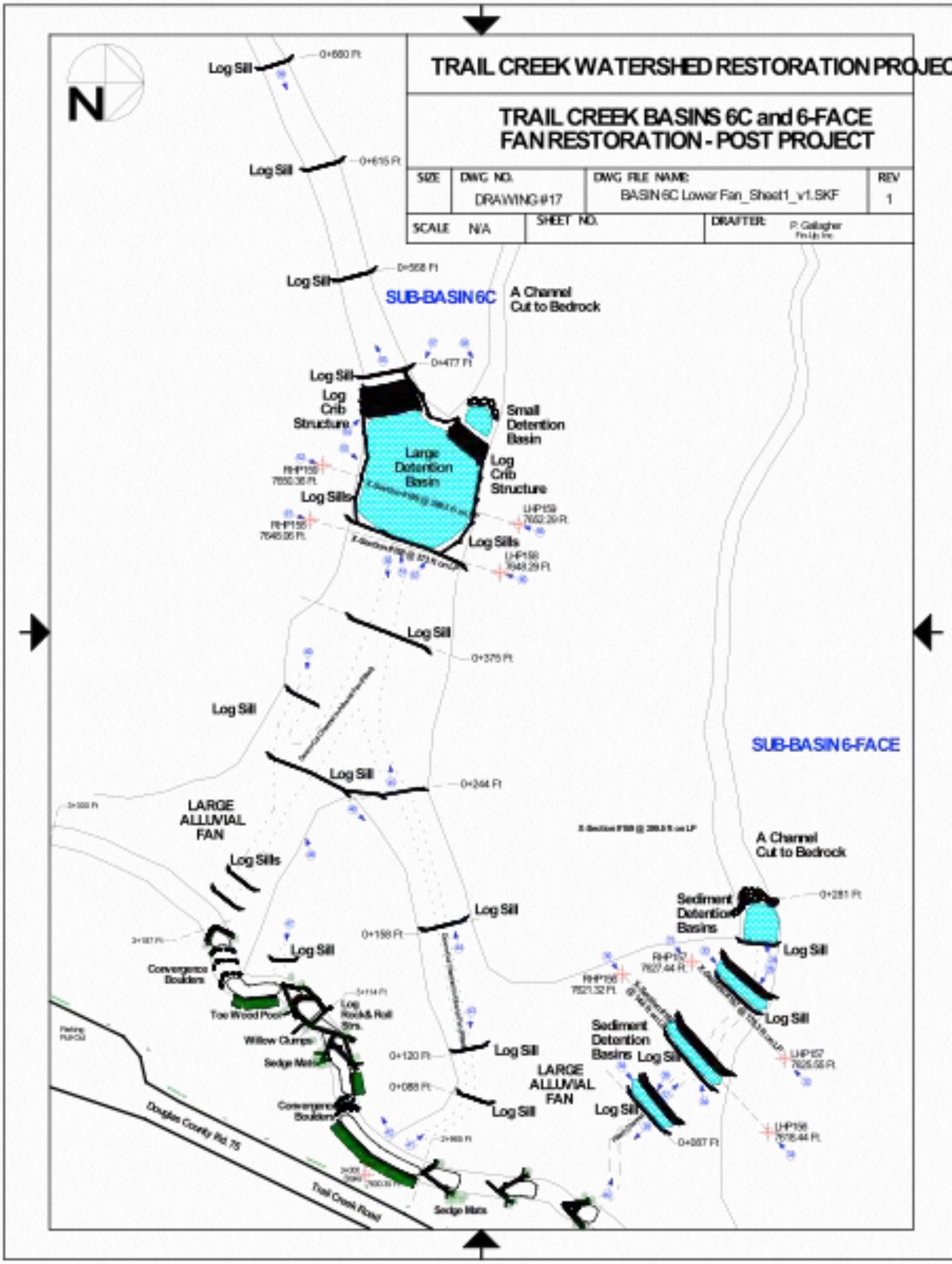
Trail Creek Basin 6 (Stump Road) Fan #3



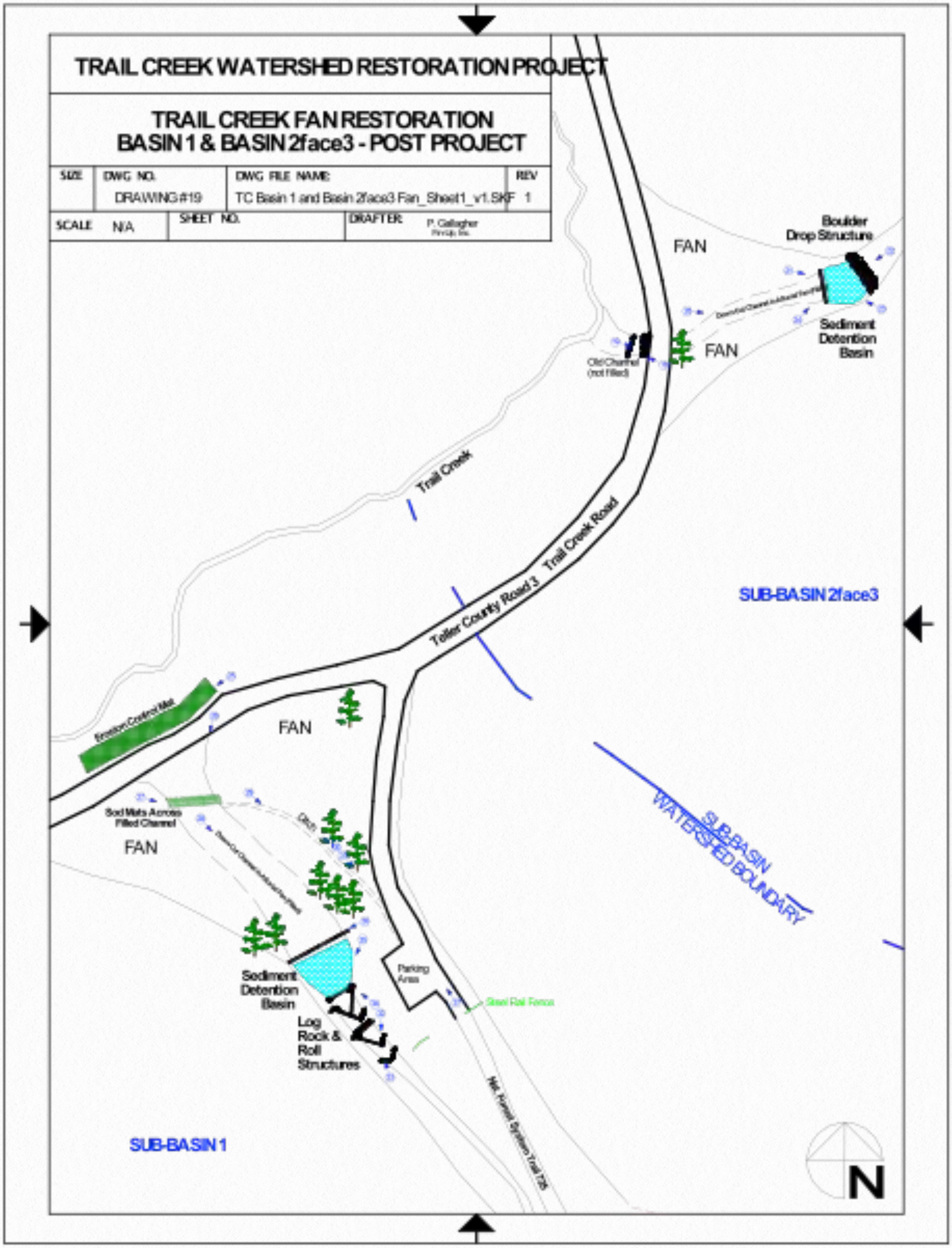
Trail Creek Basin 6 (Stump Road) Fan #4



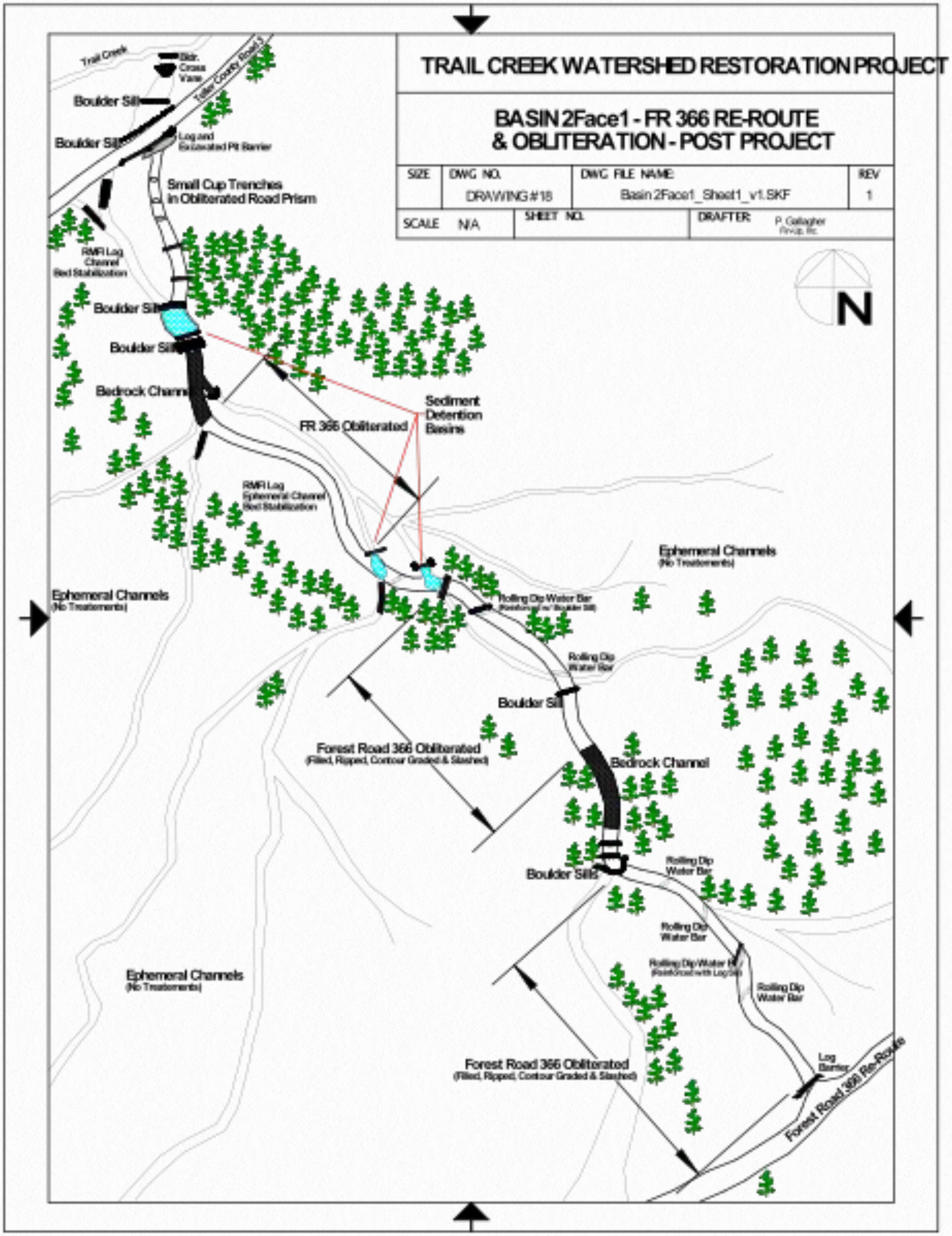
Trail Creek Basin 6Face Fan



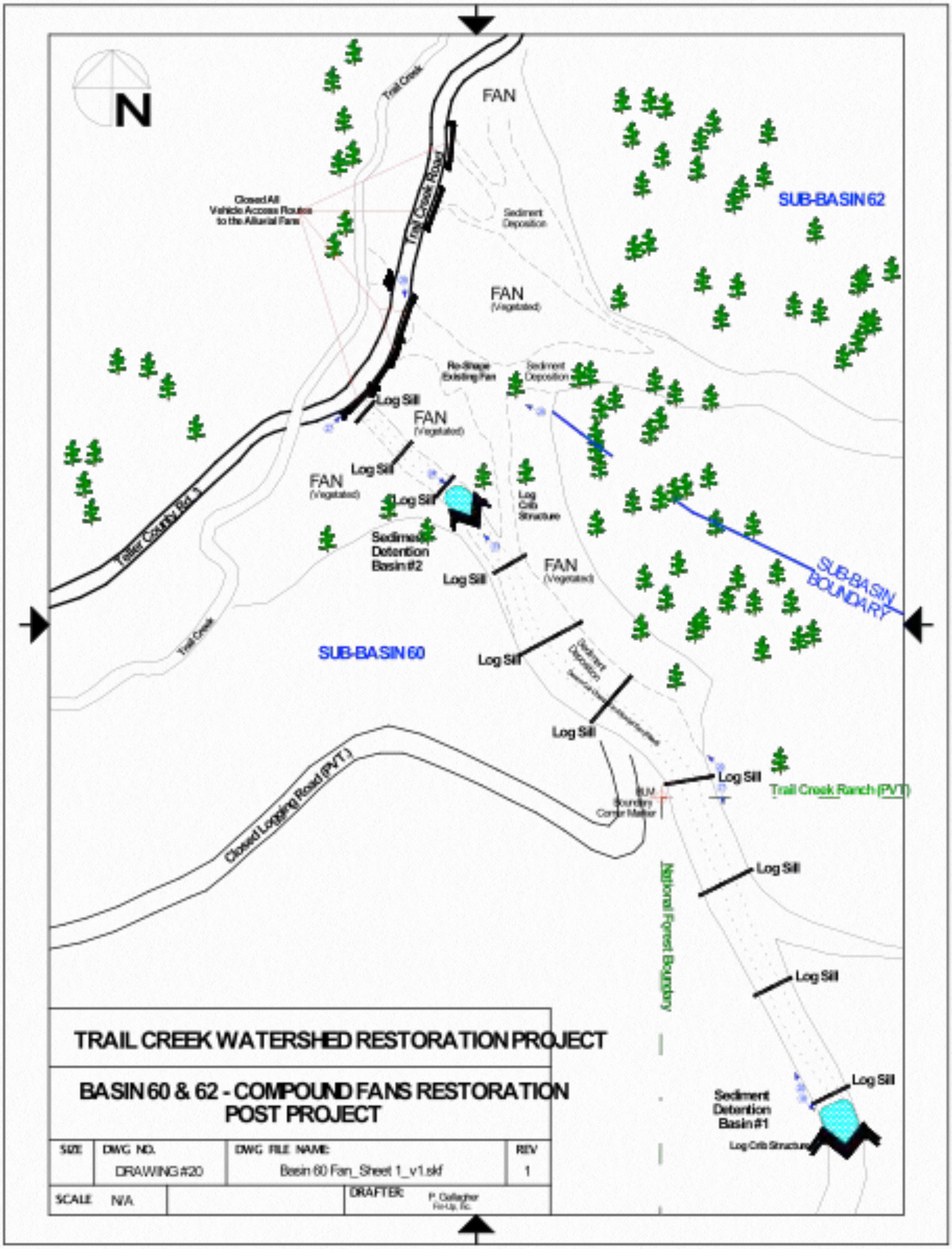
Trail Creek Basin 2Face3 & Trail Creek Basin 1



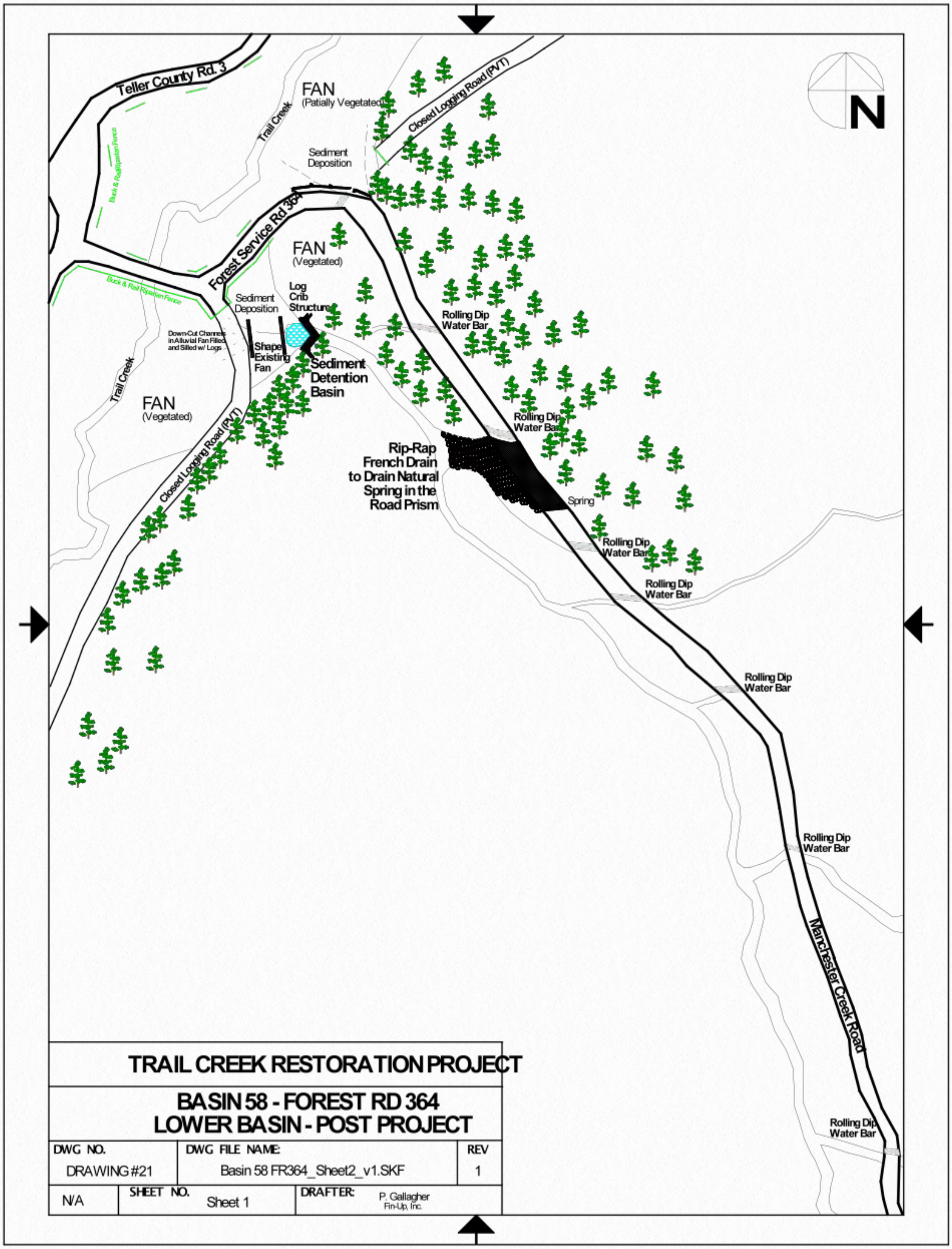
Trail Creek Basin 2Face1

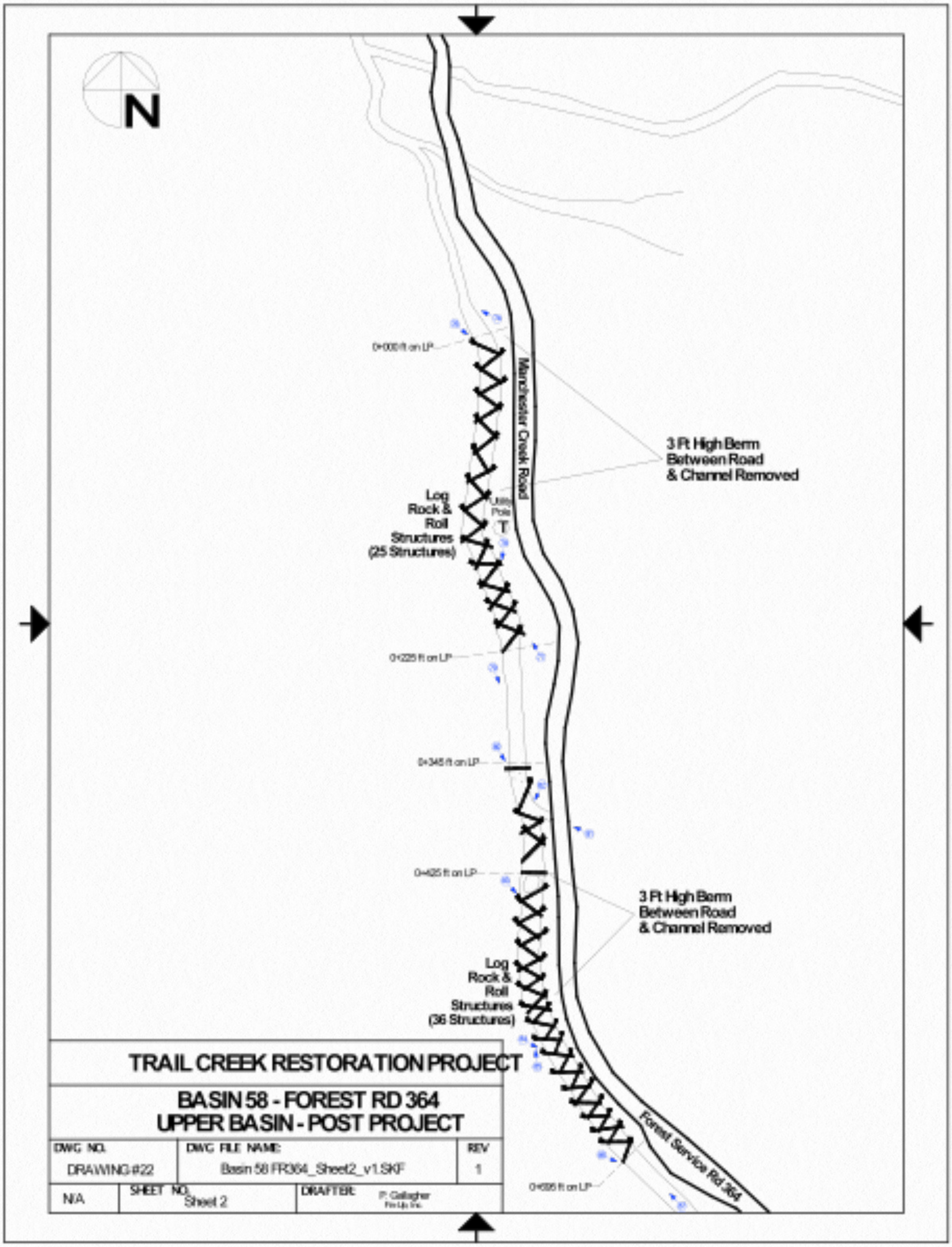


Trail Creek Basin 60 & 62

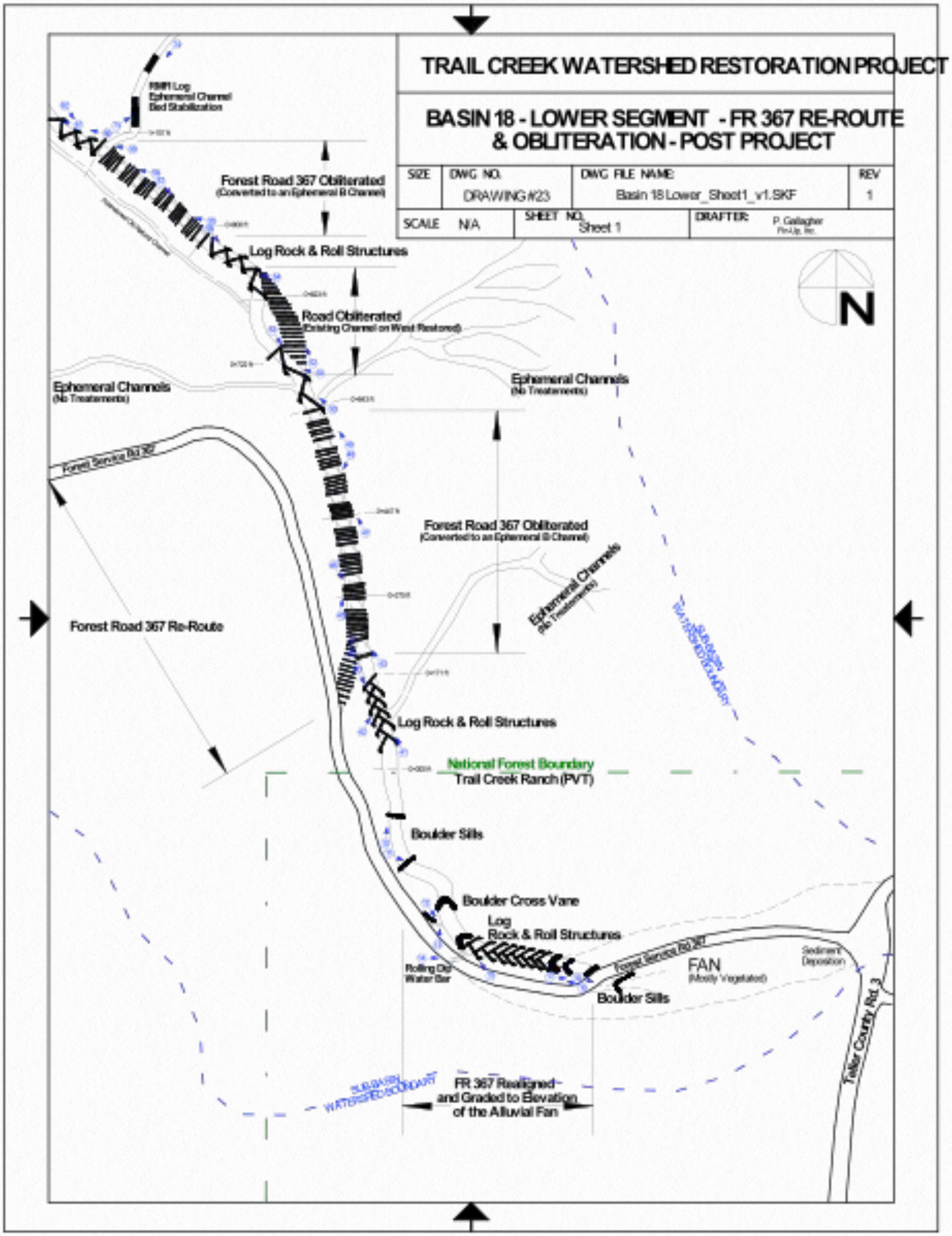


Trail Creek Basin 58




N
Manchester Creek Road
3 Ft High Berm
Between Road
& Channel Removed
0+000 ft on LP
Log
Rock &
Roll
Structures
(25 Structures)
0+225 ft on LP
0+345 ft on LP
0+425 ft on LP
3 Ft High Berm
Between Road
& Channel Removed
Log
Rock &
Roll
Structures
(36 Structures)
Forest Service Rd 364
TRAIL CREEK RESTORATION PROJECT
BASIN 58 - FOREST RD 364
UPPER BASIN - POST PROJECT
DWG NO.
DRAWING #22
DWG FILE NAME:
Basin 58 FR364_Sheet2_v1.SKF
REV
1
N/A
SHEET NO.
Sheet 2
DRAFTER:
P. Gallagher

Trail Creek Basin 18



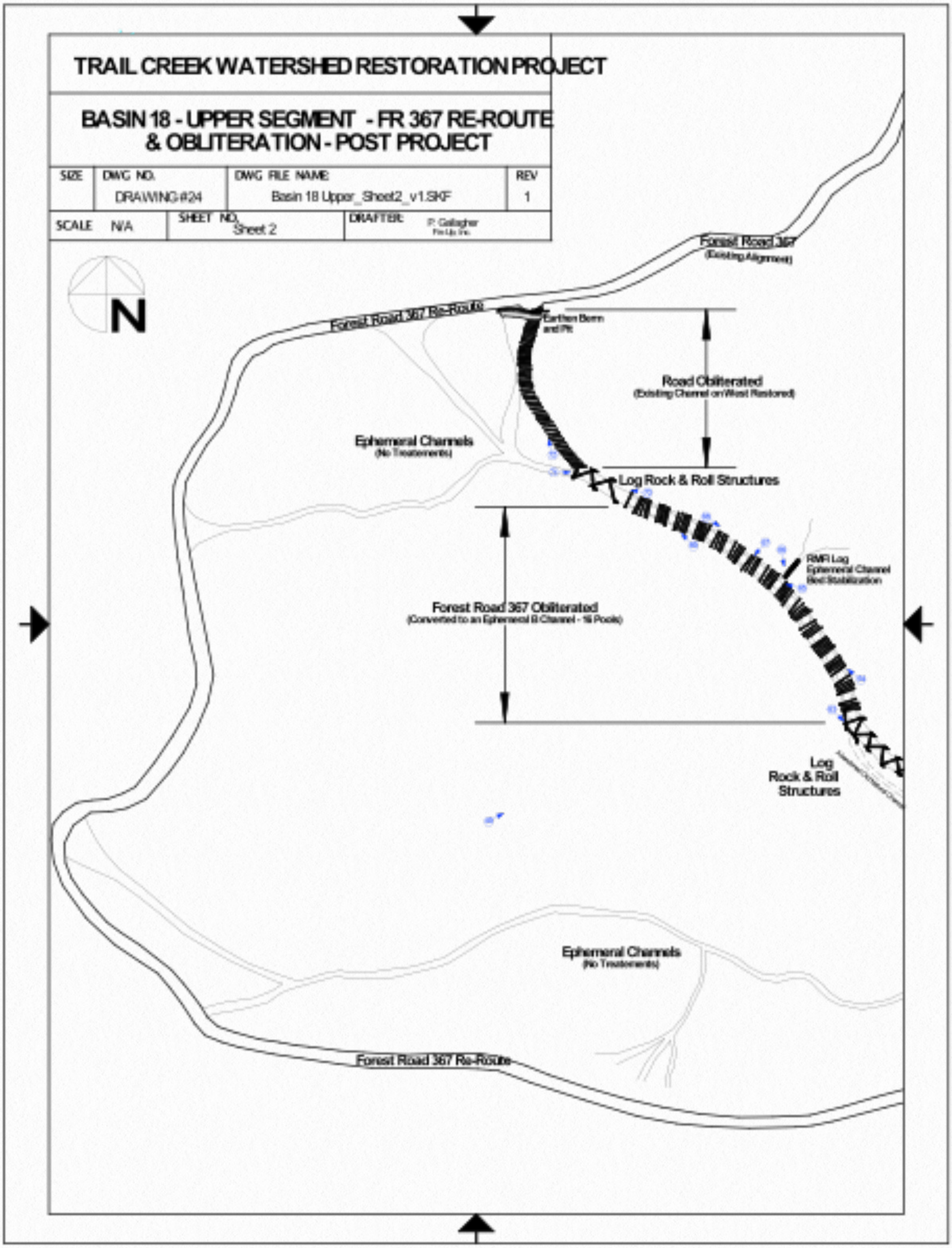

TRAIL CREEK WATERSHED RESTORATION PROJECT
BASIN 18 - UPPER SEGMENT - FR 367 RE-ROUTE & OBLITERATION - POST PROJECT
SIZE
DWG NO.
DRAWING #24
DWG FILE NAME
Basin 18 Upper_Sheet2_v1.SKF
REV
1
SCALE N/A
SHEET NO.
Sheet 2
DRAFTER
N
Forest Road 367
(Existing Alignment)
Forest Road 367 Re-Route
Earthen Berm and Pit
Road Obliterated
(Existing Channel on West Restored)
Ephemeral Channels
(No Treatements)
Log Rock & Roll Structures
RMR Log Ephemeral Channel Bed Stabilization
Forest Road 367 Obliterated
(Converted to an Ephemeral B Channel - 16 Pools)
Log Rock & Roll Structures
Ephemeral Channels
(No Treatements)
Forest Road 367 Re-Route

Photo Points

Headcut and incised F4b stream type at the mouth of Sub-watershed 6 showing Before vs. After comparison of sediment detention basin and braided, D4 stream type on raised surface constructed in November 2011.

Before vs. After comparison of conversion of a F4b to a braided (D4) stream type as constructed in November, 2011 at the Trail Creek confluence of this tributary draining sub-watershed 6. Material from excavated sediment detention basins was used to raise bed elevation 5 feet and eliminate the gully with convergence/divergence, multiple channels constructed to disperse flow energy and deposit sediment. A 2-year storm in 2002 produced no sediment transport or flows into Trail Creek as flood peaks were diminished and sediment was stored on the new surface and in the constructed basins.

Before vs. After comparison of restoration showing an eroding bank at previous location of the incised channel of Trail Creek against an alluvial fan that was converted to an oxbow lake; Trail Creek was relocated away from the fan and reconnected to its floodplain (restoration implemented in July, 2012).

Before vs. After comparison of an unnamed tributary to Trail Creek showing a gully that was filled to restore alluvial fan function using excavated material from sediment detention basins as implemented in July, 2012. Stormflow runoff following a 1-inch+ storm was dispersed on the new alluvial fan surface as observed in the lower photograph. This reduced the high sediment supply from the gully and dispersed flood waters.

Before vs. After comparison of aggrading reach of Trail Creek looking upstream from a buried box culvert (6 feet deep) that was converted to a lower width/depth ratio, step–pool channel constructed in October, 2012.

Before vs. After comparison of the conversion of an overwide, aggrading channel through the raised concrete box culvert on Trail Creek at the West Creek road crossing with relief flow culverts placed on a newly created floodplain as constructed in October, 2012. Flow is constricted at the approach and outlet sections of the box to emulate the width and depth of the bankfull discharge channel to maintain sediment transport capacity.

Before vs. After comparison of the downstream view of changes on Trail Creek at the West Creek road. The channel was converted from a braided (D4) to meandering (C4) stream type with removal of concrete barriers and re-establishment of floodplain as constructed in October, 2012. Aggrading channel was lowered 3 feet to match previous floodplain elevation behind the concrete barriers.

Before vs. After comparison of conversion of a braided (D4) to single-thread meandering (C4) stream type on West Creek showing the excavation and placement of toe wood with transplanted willow riparian vegetation as constructed in July, 2012. Beaver pond in background was reinforced for floodplain function and a raised water table.

Before vs. After comparison of converting a braided (D4) stream type to meandering (C4) stream type on West Creek using toe wood revetment and fish habitat as constructed in July, 2012.

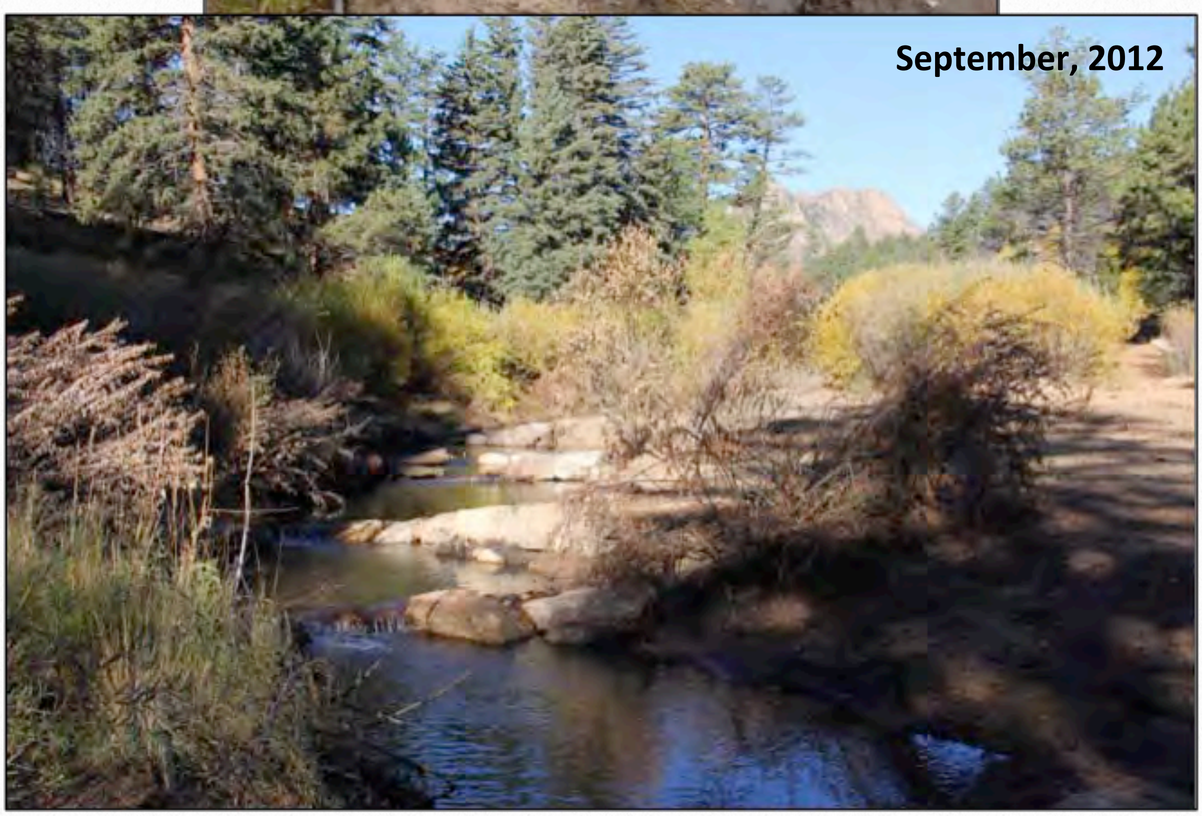
Before vs. After comparison of reach downstream of bridge on West Creek. Step–pool boulder structures were used to maintain beaver dam in place to prevent potential future headcut and breach. Toe wood was placed on bankfull bench in lateral scour pool created. Constructed in July, 2012.

Before vs. After comparison of step–pool boulder structure on West Creek to prevent future breach of existing beaver dam. Note beaver dam immediately above invert of structure. A bankfull bench was constructed at the base of road fill. This reach was constructed in July, 2012.

Before vs. After comparison below beaver dam on West Creek. A step–pool structure was used for fish migration, streambank erosion reduction, energy dissipation and grade control (constructed in July, 2012).

Before vs. After comparison of road and Trail Creek relocation that eliminated two ford crossings as constructed in October, 2012. Photographs are looking upstream.

Before vs. After comparison of road and Trail Creek relocation that eliminated two ford crossings as constructed in October, 2012. Photographs are looking downstream.



Before vs. After comparison of a reach on Trail Creek as constructed in September, 2012. Trail Creek was raised two feet in elevation to reconnect to previous floodplain at this location.

Before vs. After comparison of mainstem Trail Creek where the deeply entrenched stream type (G4 to F4) was converted to a stable B4, step–pool stream type as constructed in September, 2012.

Before vs. After comparison of conversion from a high width/depth ratio, entrenched (F4) stream type on Trail Creek that was converted to a stable, step–pool B4 stream type as constructed in September, 2012.

Before vs. After comparison of entrenched (F4) stream type converted to a step–pool B4 stream type as constructed in September, 2012. Note reduction in exposed streambanks and energy dissipation/grade control with use of a combination of log and rock structures.

Before vs. After comparison of restoration on lower Trail Creek (looking downstream) as the entrenched (F4) stream type was converted to a meandering C4 type as constructed in September, 2012.

Before vs. After comparison of newly constructed, meandering C4 stream type (September, 2012).

Before vs. After comparison looking downstream on Trail Creek showing log J-Hook Vane and Toe Wood structures as constructed in September, 2012.

Before vs. After comparison of lower Trail Creek looking upstream transitioning from a C4 to B4 step–pool channel as constructed in September, 2012.

Resources & Reports

Billmeyer, E. Lempit, H. Hassler, A. (2011) Upper South Platte/Hayman Effectiveness and Baseline Monitoring Year 1. Prepared for the South Platte Ranger District, United States Department of Agriculture.

Hayman Case Study, U.S. Forest Service: http://www.fs.fed.us/rm/pubs/rmrs_gtr114.pdf

Hayman Fire Research Summary, 2003-2012, Colorado Forest Restoration Institute & Colorado State University: http://coloradoforestrestoration.org/CFRIpdfs/2012_HaymanFireResearchSummary.pdf

Horse Creek Watershed RLA and RRISSC Assessments, Wildland Hydrology: http://cusp.ws/wp-content/uploads/2014/10/HorseCreekWatershedRLA_RRISSCReportComp.pdf

Post-Fire Watershed Recovery: Trail Creek Case Study, Colorado Riparian Association: http://coloradoriparian.org/post-fire-watershed-recovery-trail-creek-case-study/

Trail Creek and West Creek, Douglas County, Engineering & Hydrosystems, Inc.: http://uppersouthplatte.org/search/wp-content/uploads/2011/08/EH_Trail-Creek-Sediment-Yield-Report.pdf

Trail Creek Maps, Wildland Hydrology: http://cusp.ws/wp-content/uploads/2014/10/11x17_Maps_TrailCreek_MasterPlanComp.pdf

Trail Creek Watershed Assessment & Conceptual Restoration Plan: The WARSSS Results of the Hayman Fire, Wildland Hydrology: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5361902.pdf

Trail Creek Watershed Master Plan for Stream Restoration & Sediment Reduction, Wildland Hydrology:
http://cusp.ws/wp-content/uploads/2014/10/TrailCreek_MasterPlanComp.pdf

Treasured Landscapes Sites - Upper South Platte Watershed/Hayman Burn, CO, National Forest Foundation:
http://www.nationalforests.org/conserve/programs/conservation/upper-south-platte-watershedhayman-burn-co

Treasured Landscapes, Unforgettable Experiences: Hayman Restoration Partnership, National Forest Foundation:
https://www.nationalforests.org/assets/pdfs/Hayman-Final-Report_8_29_14_design.pdf

Waldo Canyon Fire Watershed Assessment of River Stability & Sediment Supply (WARSSS) & Final Waldo Canyon Fire Master Restoration Plan, Wildland Hydrology:
http://cusp.ws/wp-content/uploads/2014/10/FinalWaldoCanyonFireMasterRestorationPlanComp.pdf

Watershed Condition Class and Prioritization Information Map, USDA Forest Service:
http://apps.fs.usda.gov/WCFmapviewer/

Wildfire Restoration Handbook, Coalition for the Upper South Platte, Rocky Mountain Field Institute, & Volunteers for Outdoor Colorado:
http://cusp.ws/wp-content/uploads/2014/09/Fire-Restoration-HandbookDraft_2015_2.compressed.pdf

1,000-hour fuels

Represents the modeled moisture content (typically in dead fuels in the inch diameter class) and the layer of the forest floor about four inches b surface. The 1000-hr FM value is based on a running 7-day computed using length of day, daily temperature and relative humidity extremes (m and minimum values) and the 24-hour precipitation duration values. Va range from 1 to 40 percent. The term was based on the fact that it typi about 1,000 hours, or over 40 days, for these larger fuels to reach mois librium with soil moisture levels.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 1 - The Fire