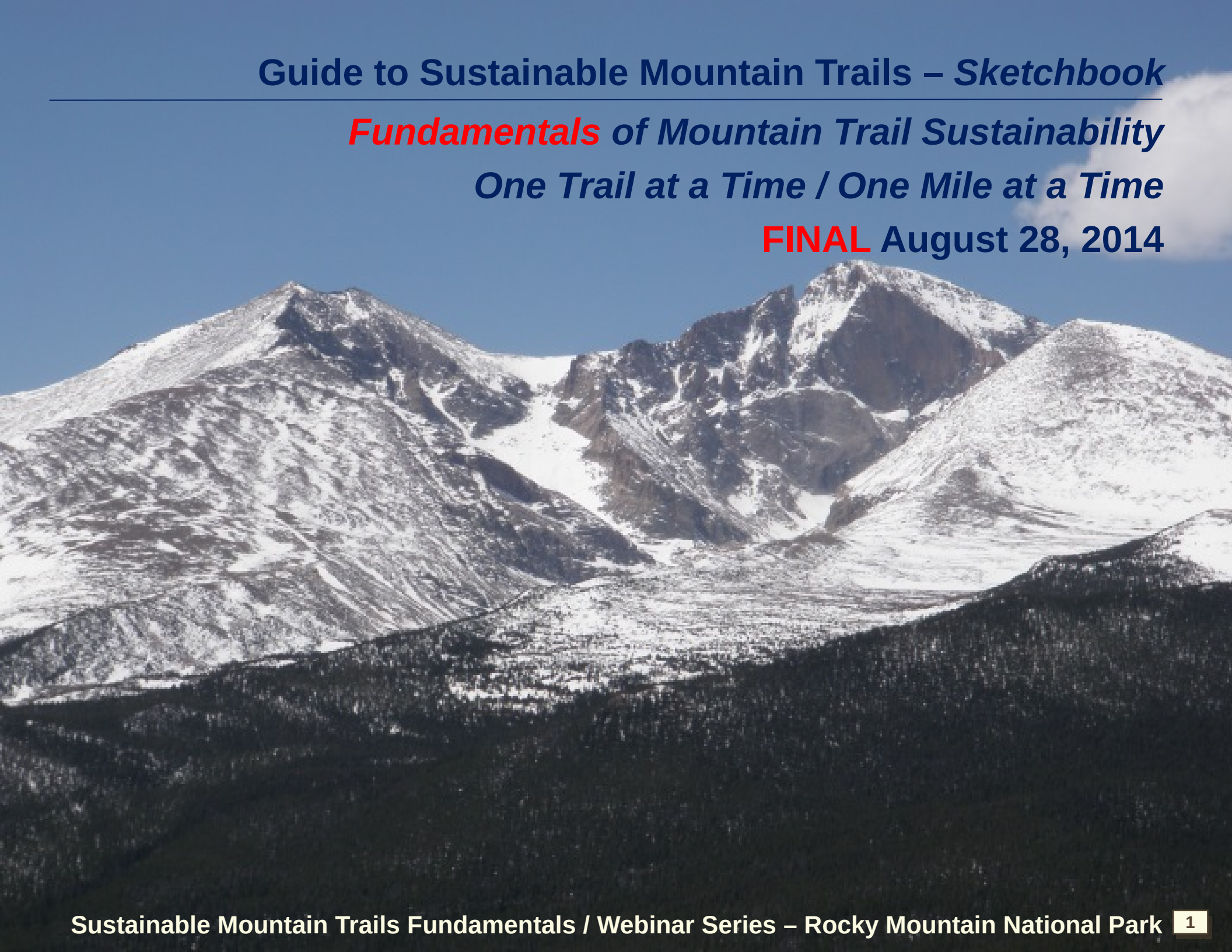
Guide to Sustainable Mountain Trails – *Sketchbook*

Fundamentals of Mountain Trail Sustainability

One Trail at a Time / One Mile at a Time

FINAL August 28, 2014



Fundamentals Webinar Interdisciplinary Team

… from Rocky Mountain National Park (RMNP), Estes Park, Colorado

- **Ian Brighton**
- **Danny Basch**

Also: Hugh Duffy

Danny

Hugh

Ian

Danny Basch – Background … Sustainable Mountain Trails

- Danny is an active trail user and enthusiastic advocate for outdoor-based recreation.
- His love for the woods was fostered as a youngster in what is now Cuyahoga Valley National Park and cemented when his family moved to Estes Park, Colorado, in 1983.
- Since then, he has gained over 20 years of experience maintaining and managing the trails in and around Rocky Mountain National Park and currently oversees the operations branch of facility management.
- Danny is a Master Instructor in the Outdoor Stewardship Initiative (OSI)

Danny Basch, Master Instructor, OSI
Title: Facility Management Specialist
Email: Danny_Basch@nps.gov
Phone: (970) 586-1231

Ian Brighton – Background … Sustainable Mountain Trails

- Ian began his trails career as a teenager working for the City of Boulder Open Space "Junior Ranger" program. He returned for 9 seasons and eventually became a Trails Foreman.
- 2010 – 2013 University of Colorado, Denver
  Masters of Landscape Architecture
  Wilderness Design Emphasis
- 2011 – Present Rocky Mountain National Park
  Facilities Management System Specialist
  Flood of 2013 Recovery Project Leader

Ian Brighton, MLA, ASLA, LEED® AP
Title: Facilities Management Specialist
Email: ian_brighton@nps.gov
Phone: (970) 586-1421

Hugh Duffy – Background … Sustainable Mountain Trails

- 1960's & 1970's – Exposed to the Appalachian Trail @ Bear Mountain State Park, New York
- 1970 – (first) Earth Day – Carman's Creek
- 1980 – Bachelor's of Landscape Architecture Syracuse University
- 1980 – 1983 USFS
  - Recreation Planning
- 1983 – 1985 Buffalo National River, Arkansas
  - Park Landscape Architect
- 1986 – Appalachian Mountain Stewardship Training, Boston, MA
- 1985 – 2014 Various NPS Projects
- 1997 – 2012 Various Professional Trail Consultations
- 2007 – Present – *Sketchbook* & Following Documents

Hugh Duffy, PLA, PMP, ASLA, LEED® GA, Master Instructor, OSI

Title: Project Manager

Email: Hugh_duffy@nps.gov; duffyfamily7@comcast.net

Phone: (303) 969-2452; Cell: (303) 981-5120

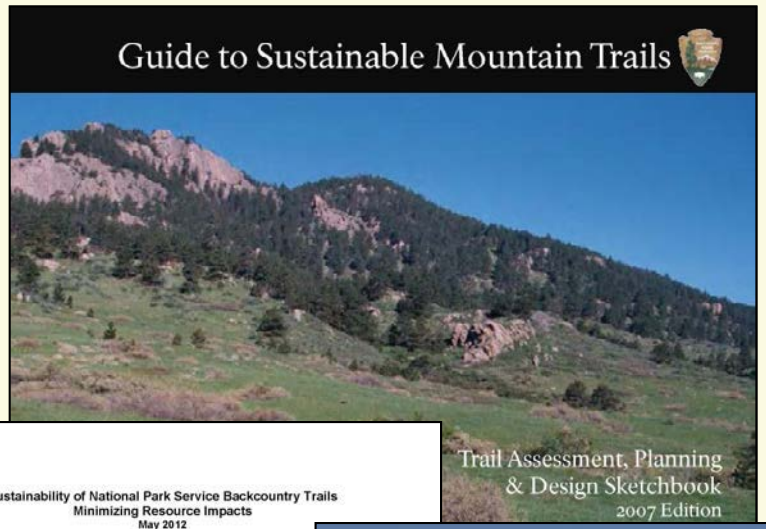
1. Overview of the *"Sketchbook"* process … emphasizing the entire *Trail Project Cycle, not just one cog*
2. Professional Landscape Architectural Ethics
3. Land Management Agency Missions & Policies
4. Key Trail Literature / Internet Research
5. Paramount & Subordinate landscape architectural criteria
6. Successful Tools & Techniques of the application of mountain trail sustainability on the ground
7. Gentle – Moderate Profile Grades on Gentle – Moderate Cross Slopes will result in the most sustainable trail corridor.

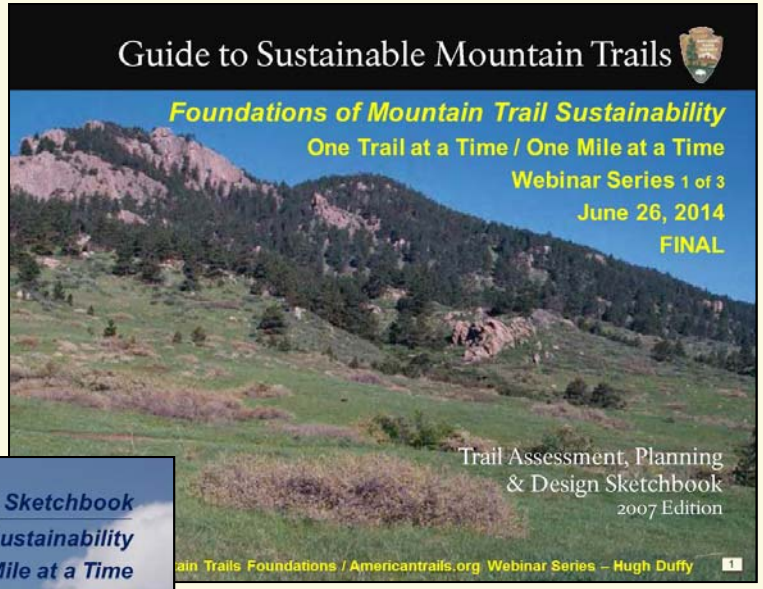
Webinar 2 – *Fundamentals* – Learning Objectives

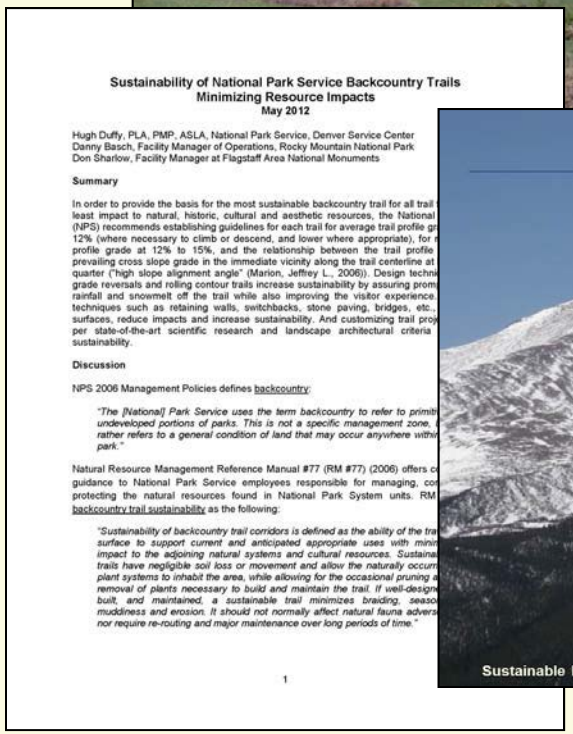
1. How a *Mountain Trail Sustainability Ethic* is helping the trails program at Rocky Mountain National Park (RMNP) respond to a natural disaster
   - General Trail Program Overview
   - Flood of 2013 summary
   - Flood Recovery Project and case studies
2. Interdisciplinary Team Leadership
3. Project Formulation Process
4. Stakeholder Management … How to Include Management & Compliance Staff, and the public
5. Choosing by Advantages Example
6. Trail Planning, Landscape Architectural and Project Management Tools & Techniques Customized for RMNP

Questions? Please note the slide #

Overview *Sketchbook & Following* Documents







Sustainability of National Park Service Backcountry Trails
Minimizing Resource Impacts
May 2012

Hugh Duffy, PLA, PMP, ASLA, National Park Service, Denver Service Center
Danny Basch, Facility Manager of Operations, Rocky Mountain National Park
Don Sharlow, Facility Manager at Flagstaff Area National Monuments

Summary

In order to provide the basis for the most sustainable backcountry trail for all trail
least impact to natural, historic, cultural and aesthetic resources, the National
(NPS) recommends establishing guidelines for each trail for average trail profile gr
12% (where necessary to climb or descend, and lower where appropriate), for
profile grade at 12% to 15%, and the relationship between the trail profile
prevailing cross slope grade in the immediate vicinity along the trail centerline at
quarter ("high slope alignment angle" (Marion, Jeffrey L., 2006)). Design techni
grade reversals and rolling contour trails increase sustainability by assuring prom
rainfall and snowmelt off the trail while also improving the visitor experience.
techniques such as retaining walls, switchbacks, stone paving, bridges, etc.,
surfaces, reduce impacts and increase sustainability. And customizing trail proj
per state-of-the-art scientific research and landscape architectural criteria
sustainability.

Discussion

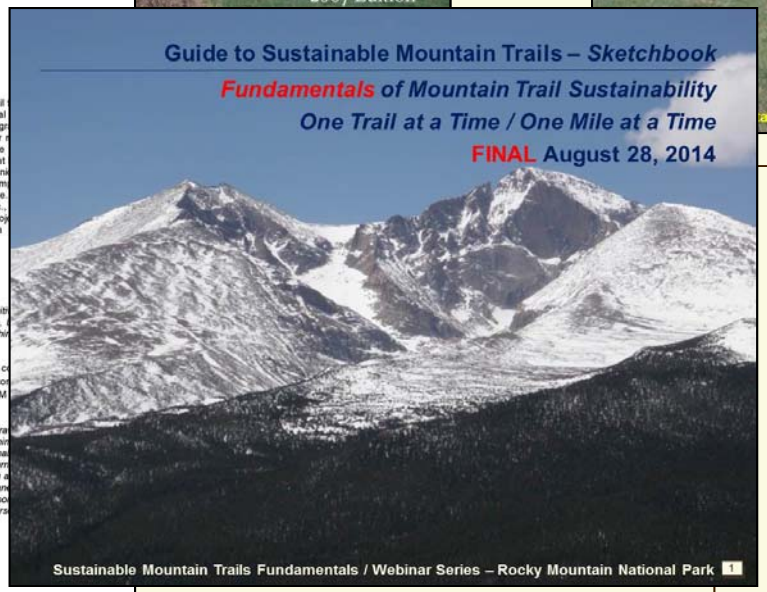
NPS 2006 Management Policies defines backcountry:

> *"The [National] Park Service uses the term backcountry to refer to primiti
> undeveloped portions of parks. This is not a specific management zone,
> rather refers to a general condition of land that may occur anywhere withi
> park."*

Natural Resource Management Reference Manual #77 (RM #77) (2006) offers c
guidance to National Park Service employees responsible for managing, co
protecting the natural resources found in National Park System units. RM
backcountry trail sustainability as the following:

> *"Sustainability of backcountry trail corridors is defined as the ability of the tra
> surface to support current and anticipated appropriate uses with minim
> impact to the adjoining natural systems and cultural resources. Sustaina
> trails have negligible soil loss or movement and allow the naturally occurri
> plant systems to inhabit the area, while allowing for the occasional pruning a
> removal of plants necessary to build and maintain the trail. If well-design
> built, and maintained, a sustainable trail minimizes braiding, seaso
> muddiness and erosion. It should not normally affect natural fauna adversa
> nor require re-routing and major maintenance over long periods of time."*

1



Towards a Mountain Trail Sustainability Ethic …
Webinar #3

All Meant to Build on the *Sketchbook*!

What is the *Sketchbook* Process?

Customized Tools & Techniques …

… for successfully implementing …

Sustainability of Mountain Trails …

"A New Model"

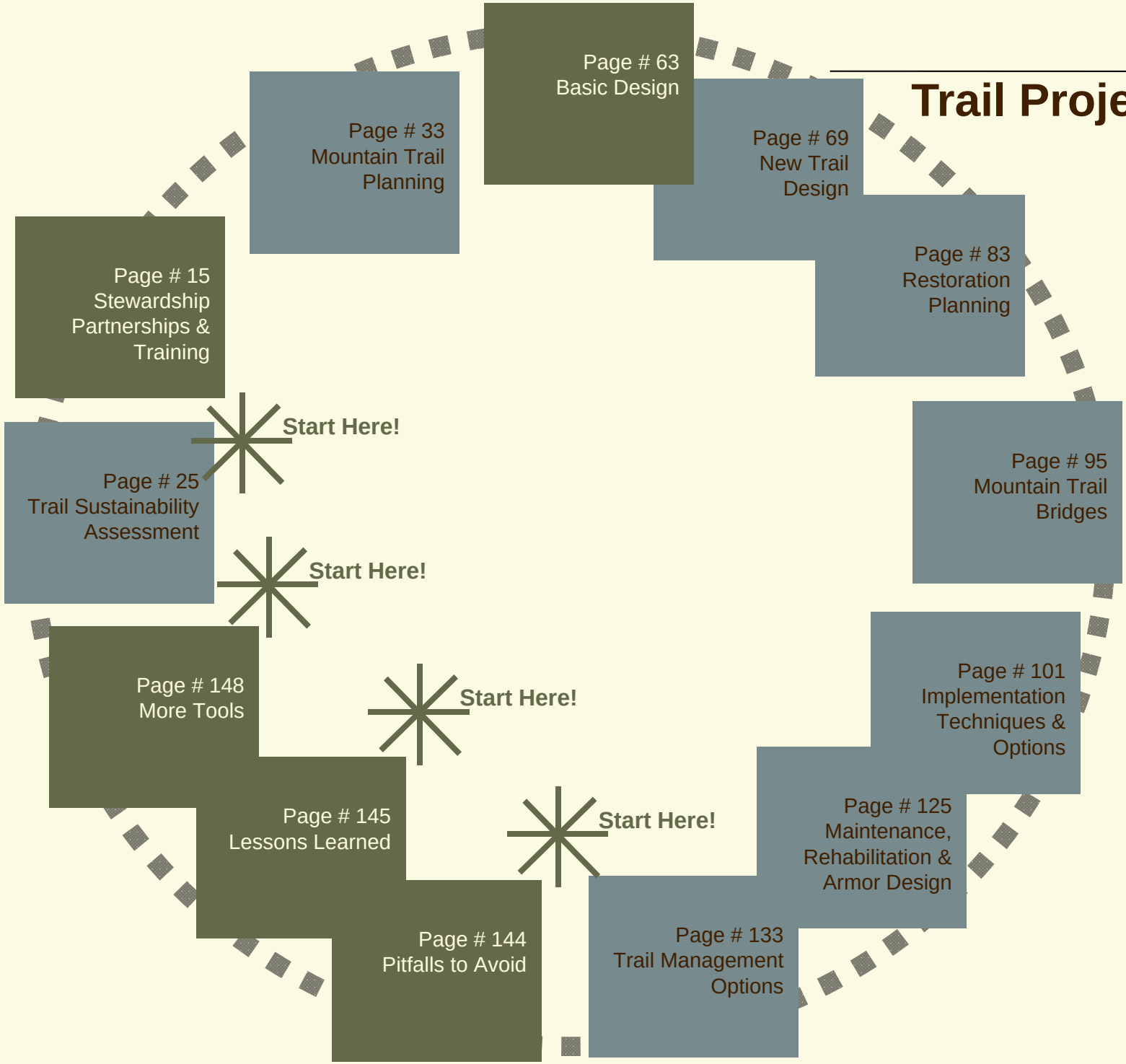
…. not to overwhelm you … orderly process …

… Art & Science …

… What Is … & … What Can Be …

Review 2 of 3

Trail Project Cycle Tool



Partnerships with conservation nonprofit agencies are required, now more than ever, to ensure continued success of recreational trails on public lands.

All cogs of the trail project cycle would benefit from such support!

Review 3 of 3 Popular Literature Research – Internet

Jump to …

NPS Sustainable Trails website

- http://www.nps.gov/dsc/trails.htm

Key National Park Service Trail Literature (New Link)

- http://www.nps.gov/dsc/trails-literature.htm

American Trails / Resources website

- http://www.americantrails.org/resources/index.html

University of Minnesota Forestry Libraries

- http://www.lib.umn.edu/cgi-bin/forestry/index.cgi

Google.com

Posting of Key U.S. Forest Service Trail Literature
… is in process … Stay tuned!

Rocky Mountain NP – Customized Tools & Techniques

Inputs

- Typical Inputs
- Foundations

Tools & Techniques

- Typical Tools & Techniques
- Lessons Learned Technique
- Trail Project Cycle Tool

Outputs

- Typical Summary Package Outputs
- Draft for Review; Final

Typical Inputs

- Foundations
- Stakeholder Analysis & Summary
- Popular Literature
- Aerial Photos, Annotated Aerial Photos
- Maps, Annotated Maps
- Data Bases

Typical Tools & Techniques

- Assemble Interdisciplinary Trail Team
- Popular Literature Review – Internet & More Tools
- Research / Science
- Field Work, i.e.: Field Notes, Design Notes, Thumbnail Sketches
- Drawings, Examples, Photo Collages, Photomontages
- GPS, GIS, Analytical Techniques
- Choosing by Advantages
- Estimating Tools
- Stakeholder Analysis
- Charette Techniques
- Management Team Review
- Compliance Review

Typical Summary Package Outputs

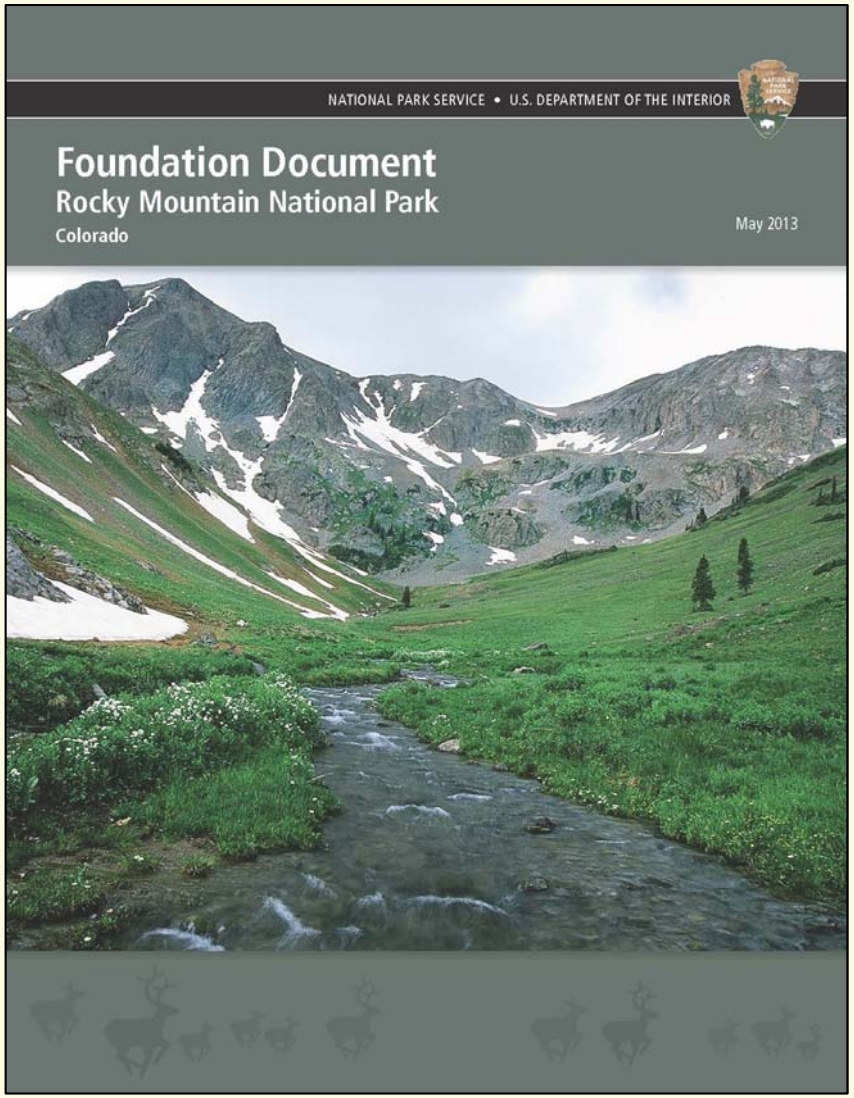
- Written Summary
- Plans Set
- Thumbnail Sketches / Drawings
- Stakeholder Summary
- Photographs
- *Lessons Learned* Summary
- Trail Management Techniques
- Actions Sequences
- Checklists

Rocky Mountain NP Foundations

- Enabling Legislation
- Purpose Statement
- Significance Statements
- Fundamental Resources & Values
- Wilderness

Customizing ***Tools & Techniques*** that apply to *"most projects, most of the time"* will increase achievement of sustainability on mountain trail projects.

Rocky Mountain National Park – 2013 Foundation Document



Components

Enabling Legislation

Purpose

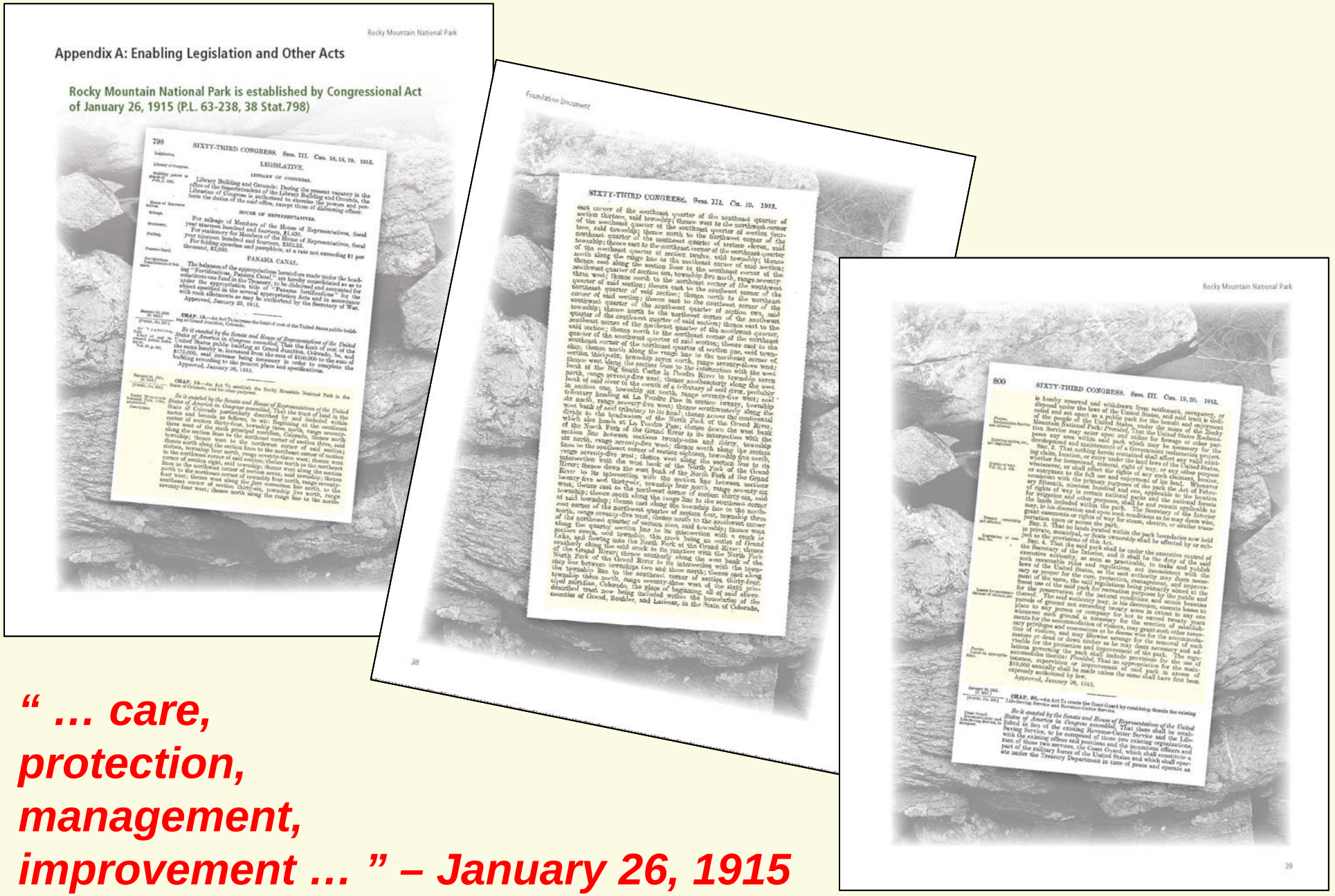
Significance Statements

Fundamental Resources & Values

Wilderness Character

… RMNP Is primarily a wilderness park

Rocky Mountain National Park – Enabling Legislation



" … care, protection, management, improvement … " – January 26, 1915

National Park Organic Act of 1916

The *purpose* of the National Park Service is …

"... to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

– NPS Organic Act of 1916

Rocky Mountain National Park – Purpose Statement

"The purpose of Rocky Mountain National Park…

… is to preserve the high-elevation ecosystems and wilderness character of the southern Rocky Mountains within its borders and to provide the freest recreational use of and access to the park's scenic beauties, wildlife, natural features and processes, and cultural objects."

– Rocky Mountain National Park Foundation Document, 2013

Rocky Mountain National Park – Significance Statements 1 of 2

1. RMNP provides exceptional access to wild places for visitors to recreate and experience solitude and outstanding scenic beauty …

1. Fragile alpine tundra encompasses one-third of Rocky Mountain National Park, one of the largest examples of alpine tundra ecosystems protected in the contiguous United States.

1. Glaciers and flowing fresh water carved the landscapes of Rocky Mountain National Park. The park is the source of several river systems, including the Colorado River and the Cache la Poudre, Colorado's first and only designated wild and scenic river.

– Rocky Mountain National Park
Foundation Document, 2013 (excerpts only)

Rocky Mountain National Park – Significance Statements 2 of 2

4. The dramatic elevation range … allows for diverse terrestrial and aquatic ecosystems, varied plant and animal communities and a variety of ecological processes … with portions of the park's montane, subalpine, and alpine ecosystems managed as research natural areas for scientific and educational purposes.

5. Visitors can see remnants of the different ways people have used this land over time, ranging from prehistoric big game drives to dude ranching to recreational tourism.

– Rocky Mountain National Park
Foundation Document, 2013 (excerpts only)

Rocky Mountain NP – Fundamental Resources & Values

Fundamental resources and values (FRVs) are those features, systems, processes, experiences, stories, scenes, sounds, smells, or other attributes determined to warrant primary consideration during planning and management because they are critical to achieving the park's purpose and maintaining its significance.

1. **Access to Wild Places …**
2. **High Elevation Ecosystems …**
3. **Wilderness Character …**
4. **Headwaters of the Continental Divide …**
5. **Ability to Experience a Wide Variety of Recreation Opportunities …**
6. **Trace Human Footprints on the Landscape …**

– Rocky Mountain National Park Foundation Document, 2013 (excerpts only)

Rocky Mountain National Park – 2009 Wilderness Legislation

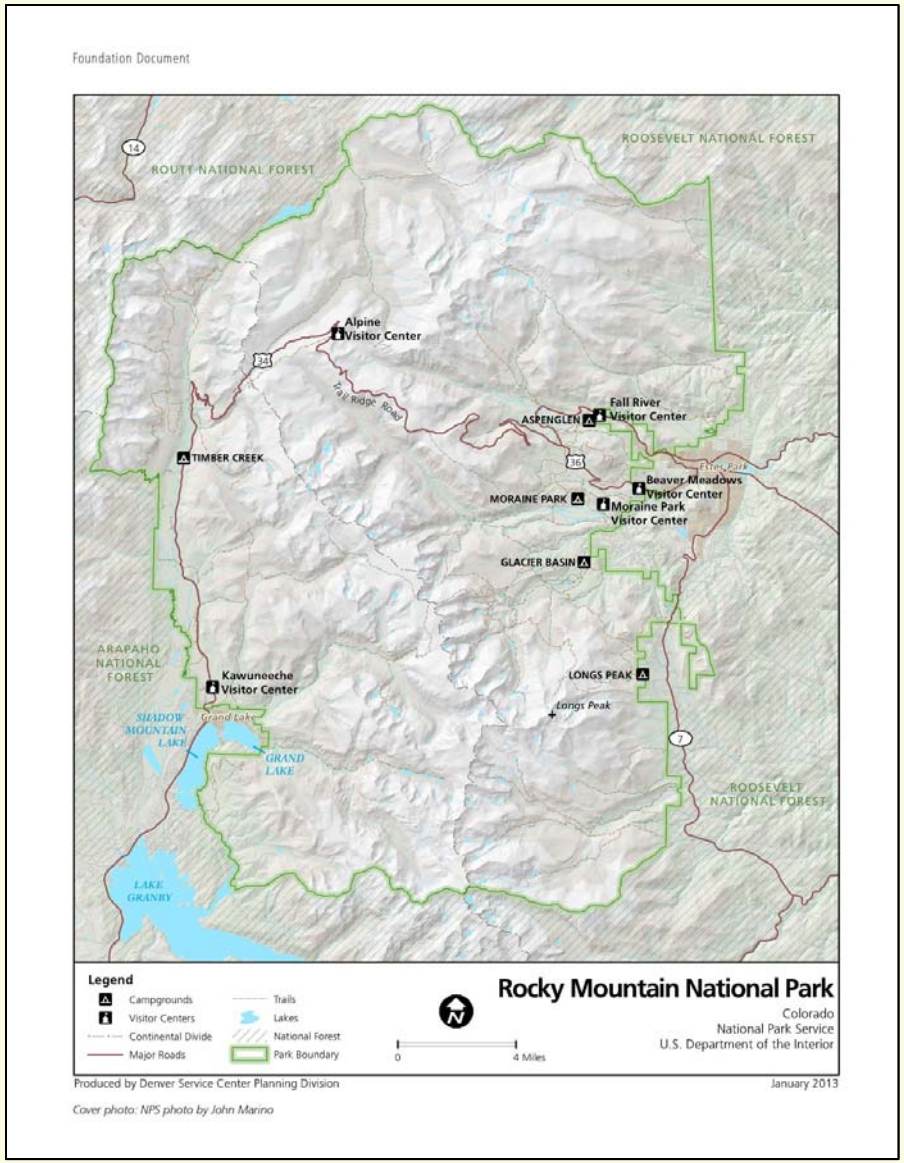
"In 2009, Congress designated the Rocky Mountain National Park Wilderness Area, covering about 252,085 acres, or about 95% of the park."

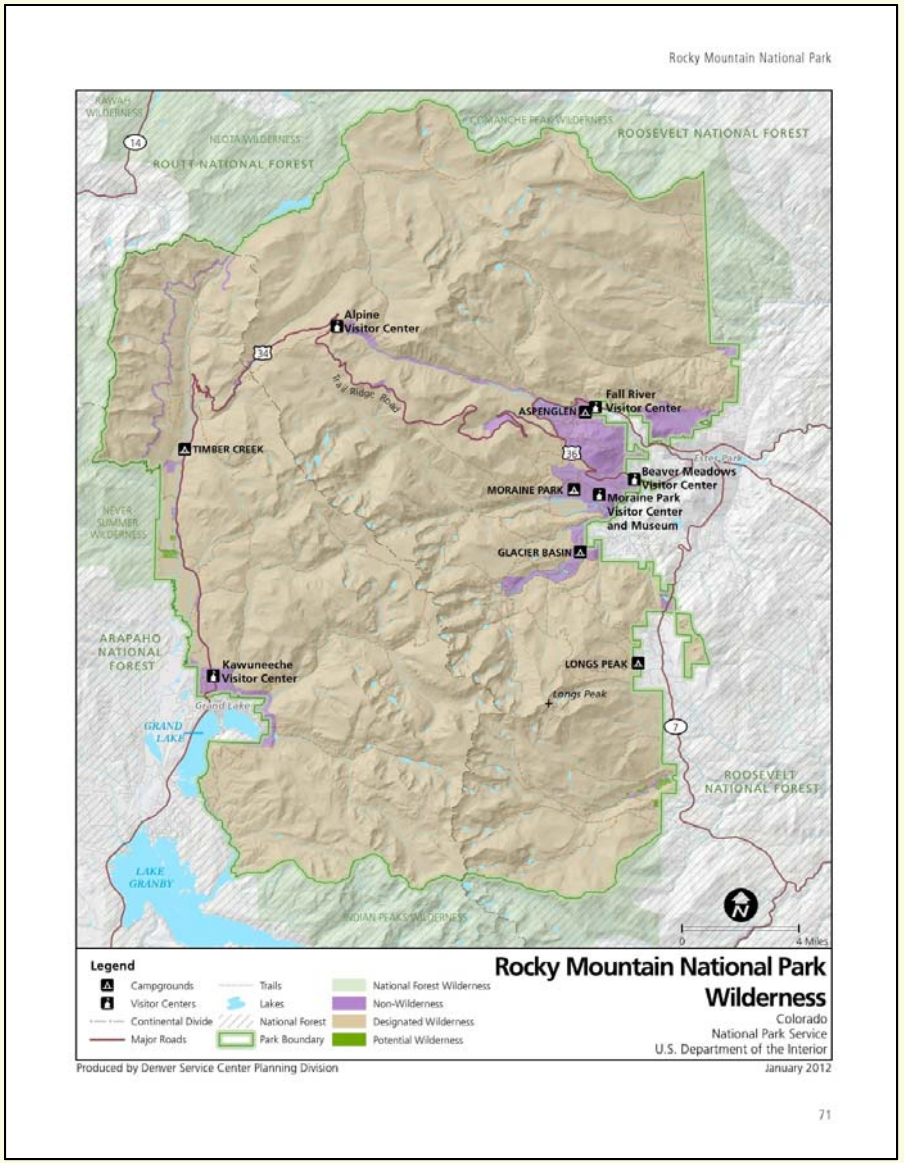
"Wilderness designation protects the land's wilderness character, natural, untrammeled and undeveloped conditions, opportunities for solitude and primitive recreation, and scientific, educational, and historical values."

– Rocky Mountain National Park Foundation Document, 2013

… Minimum Task / Minimum Tool Guideline …

Rocky Mountain National Park – Base Map / Wilderness

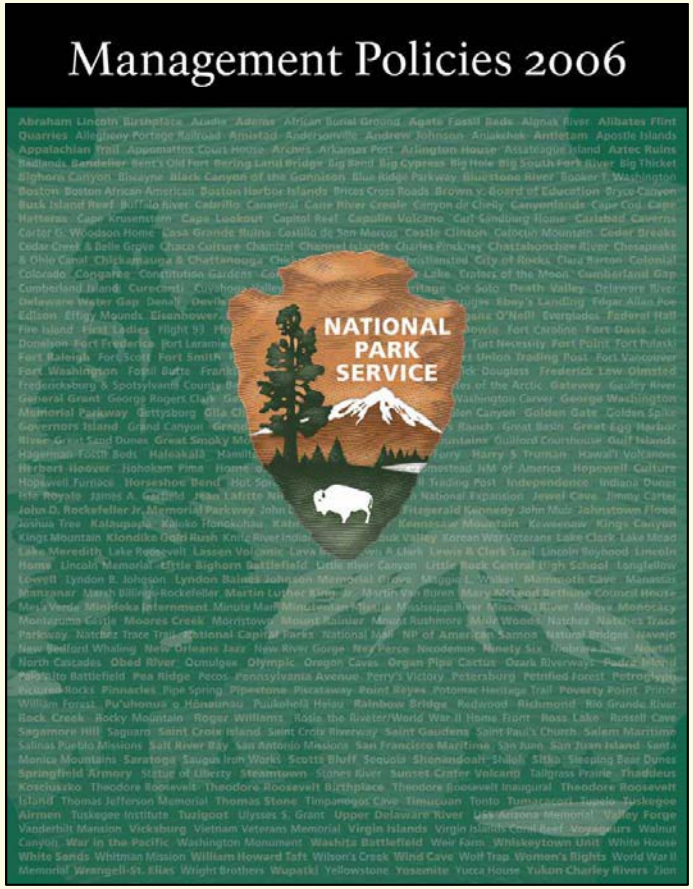




Note: Rocky Mountain NP is 95% designated wilderness.

RMNP – Other Guidance Documents

- *Wilderness Act of 1964 as amended*
- *National Historic Preservation Act of 1966 as amended*
- *National Wild & Scenic Rivers Act as amended*
- *National Environmental Protection Act (NEPA) as amended*
- *ABAAS (Accessibility Standards for the Federal Government)*
- *2006 NPS Management Policies*



Rocky Mountain National Park – Topography & Ecosystems

Topography

- 7,600 to over 14,200 elevation
- Peaks – 72 named peaks over 12,000’ elevation

Ecosystems

- Montane Forest
- Mountain Grasslands & Meadows
- Alpine Tundra (25% of park is above tree line)

Ecosystems – *Sketchbook* Overview

- Elevation Ranges
- Common Soils
- Common Vegetation
- Vegetation – Soil Type Indicators
- Trail Considerations

Ecosystems 1 of 3 – Mountain Grasslands & Meadows

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Interspersed in intermountain basins. 7,300 feet – 10,000 feet elevation.	Deep and fine-textured. Wet meadows may have large amounts of accumulated organic matter.	Dry meadows: grasses and forbs. Shrubby Cinquefoil is common. Wet meadows: sedges, rushes, Willow, Bog Birch, Shrubby Cinquefoil and forbs.	Mountain Greasslands and Meadows are interspersed throughout the Montane Forest and Subalpine Forest Ecosystems. Wet meadows are dominated by sedges and rushes, not grasses.	◆ Wet meadows usually require armor improvements. ◆ Gentle profile grades recommended. ◆ Management issues such as with trail braiding, widening or short-cutting may arise. ◆ Meadows offer excellent opportunities for memorable visitor experiences, including changes of scenery and wildlife viewing. ◆ Prevalence of weeds in these ecosystems may spread into trail corridors. ◆ Restoration is generally quickly accomplished.

The Green Ranch Property at Golden Gate Canyon State Park offers spectacular views towards the south, including Mt. Evans. Trails here will be designed to not impact these Mountain Meadows.

These ecosystem recommendations inform trail-side decisions at RMNP!

Ecosystems 2 of 3 – Montane Forests

Montane forests provide richness and diversity to the landscape.

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Throughout mountainous regions of Colorado. 5,500 feet – 9,000 feet elevation.	Coarse (sandy), rocky, can be fine-textured.	Ponderosa Pine, Douglas-fir, Rocky Mountain Juniper, Aspen and Lodgepole Pine.	Pine species and Juniper are more dominant on dry sites and slopes. Douglas-fir and Aspen typically occupy cool, moist sites.	◆ Soils are typically good for locating sustainable trail corridors. ◆ Gentle to moderate profile grades recommended.

Ecosystems 3 of 3 – Alpine Tundra

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
High mountain ridge tops and peaks. Greater than 11,500 feet elevation.	Coarse soils, can be fine-textured in low-lying wet areas or wet mountain ranges (San Juan Mountains).	Cushion plants, forbs, grasses, sedges and low shrubs (at lower elevations).	Lush alpine meadows can have fine-textured soils and remain wet well into the summer. Vegetation height is a good indicator of soil moisture (taller plants usually equate to higher soil moisture levels).	◆ Gentle profile grades recommended. ◆ Seasonal snowpack can last well into the summer (observe over several seasons), creating muddy conditions. ◆ Improvements which mitigate sometimes continuous snowmelt are recommended. ◆ Alpine plants are slow to establish and grow in disturbed areas. Limit trail activities to the trail surface. ◆ Waterbars are discouraged due to the potential for sediment build up over neighboring alpine plants. If waterbars are needed, drain into talus or Willows. ◆ Few physical barriers exist above timberline to prevent trail short cutting. ◆ Scree fields are best avoided. ◆ Talus fields are difficult sites to implement trails, but provide a sustainable trail surface. ◆ Restoration is difficult due to short growing season and harsh growing conditions.

Environments of an extremely fragile character (i.e.: marshy and alpine areas) require special attention in order to protect their sensitive natural uniqueness. Thus it is essential that the delicate balance be maintained between maximizing hiking opportunities and the environmental carrying capacity of the ecosystem. Overuse can destroy the natural environment, which is an essential segment of the hiking experience. – William G. King, 1984.

Images from Rocky Mountain National Park

Longs Peak

Lawn Lake

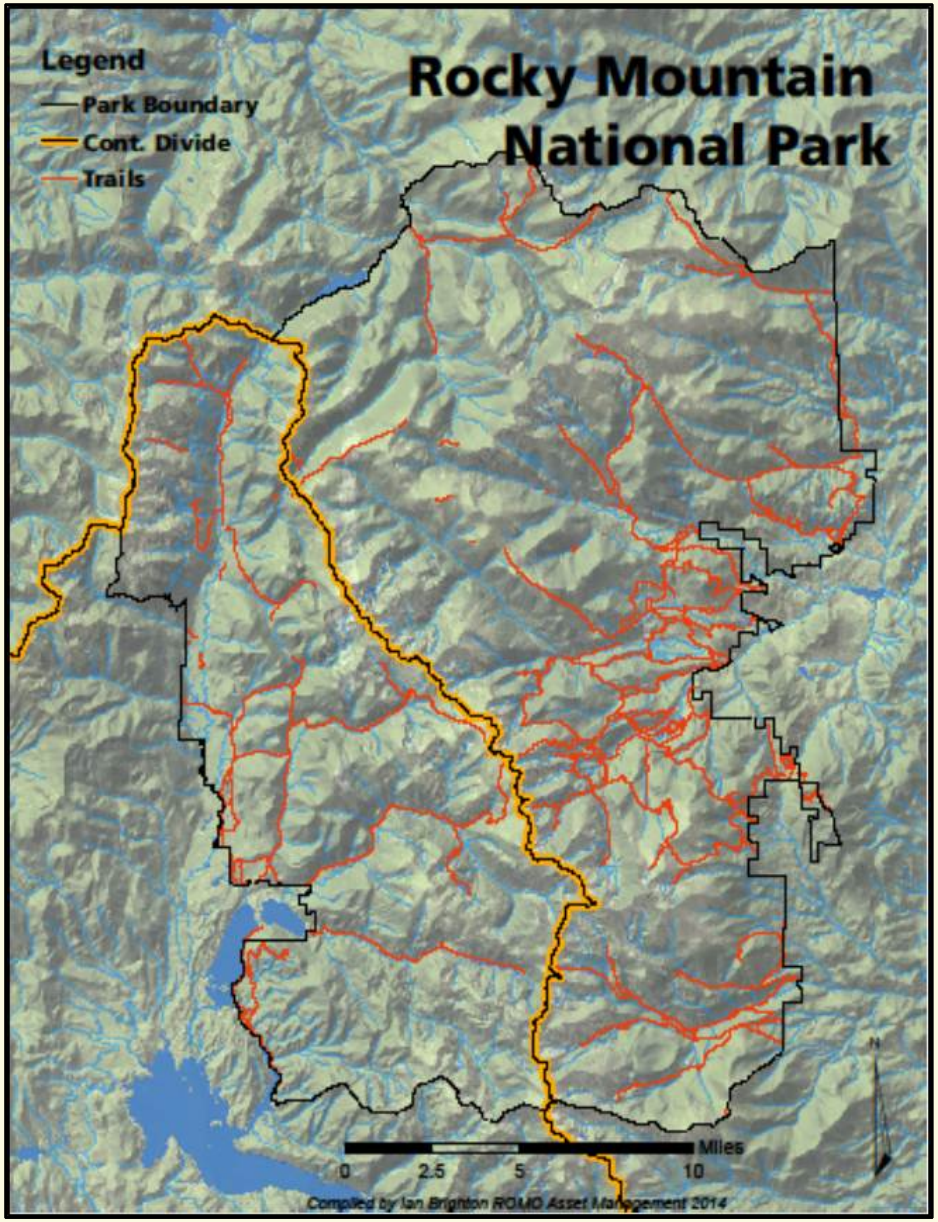
Longs Peak from Lawn Lake Trail

Longs Peak

Chiefs Head

McHenry's Peak

Rocky Mountain National Park – Trail Program Overview



- 355 miles of official (system) trails
- Average 3 million visitors per year
- Elevations range from approximately ~8000’ to over 14,000’
- Ecosystems range from Montane to Sub-Alpine
- 25 Liveries (commercial horse tour operations) located in and around the park
- The Trails Program consists of 4 permanent, 10 term and 35 seasonal employees.
- Approximately $1 million annual budget for the Trails Program.

Rocky Mountain National Park – Bridge Palette / Samples

Mountain Trail Bridges fall into the general framework shown on the right developed at Rocky Mountain National Park, and the photographs 1 – 5 below display options used there.

1. **Simple Foot Log Bridge.** For light to medium foot traffic only across small and/or intermittent water. Minimal dimensions, tools, time and labor required. Appropriate in the frontcountry, middle country and backcountry zones. No vertical-drop of more that 5 feet anywhere along the span. Local materials typical.
2. **Simple Foot Log Bridge With Handrail.** Light to medium pedestrian use without horse or multi-accessible fords. Medium complexity of tools, labor and skills required due to the possible size and weight of materials. May incorporate an 'island,' pier or abutment within the water channel to support center posts for longer spans. Utilization of local native materials is common.
3. **Foot Traffic Only Bridge.** Frontcountry to backcountry distance zones with medium to heavy volume of use. May be multiple-member foot log or decked stringer type. Approach and abutment need to accommodate ford for light to heavy horse and / or multiple users. May require additional skills and tools for harvesting, moving and assembling materials for larger structures.
4. **Multiple Use Access Bridge with Handrail.** Medium to heavy volume of use. Frontcountry to backcountry distance trail zones. Decked multiple stringer design with steel super-structure preferred. Design may include mixed materials for optimum strength, life cycle and aesthetics. Will require complex logistics, skills and tools, and material handling techniques.
5. **Boardwalk.** Many design variations and definitions vary from region and agency. Basic design elevates the corridor or walking surface over wet, unsustainable tread areas. Common designs and names include turnpike, puncheon, corduroy and gadbury. Kick-rails are common with many designs.
6. **Suspension or Box-Frame Design Bridge (Not Shown).** Usually for crossing long spans or gorges. The most challenging and complex type of bridge structure. Significant cost, skills and complex tools like helicopters and high-lines will very likely be necessary for these more complex designs.

Images from Rocky Mountain National Park

Mill Creek Trail

Upper Poudre River Trial

Mummy Mountain

Ypsilon Lake

Flood of 2013

- On September 12th, major flooding occurred in the foothills northwest of Denver, CO.
- 13.15” of rain fell during the storm in Allenspark, CO.
- Main roads following mountain rivers washed away cutting off access to the RMNP. Trail Ridge Road which climbs to 11,000’ was the only intact access.

Flood Impacts at Rocky Mountain National Park

Unprecedented damage …

Impacts to Trails – From Rivers Expanding Banks

Bank Failure on the Lawn Lake Trail

Bridge damage on the Ouzel Falls Trail

Impacts To Trails – From 1,000-Year-Frequency Storm

Collapsed Tread on the Aspen Brook Trail

Landslide at the Twin Sisters Trail

Rocky Mountain National Park – Trail Recovery Plan

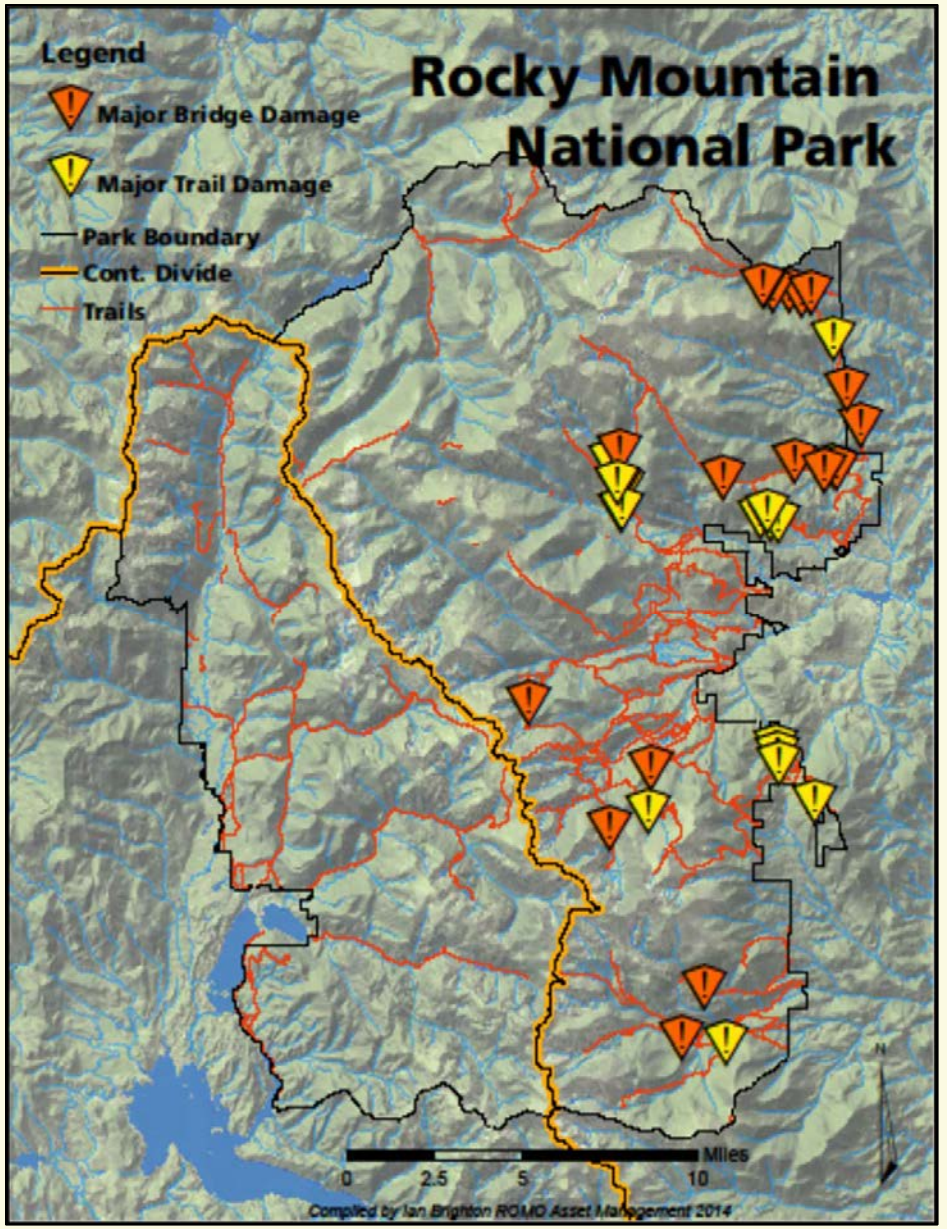
Rapid Assessment Team

5 teams surveyed all flood impacted trails in a three week period (finished just before government shutdown!)

What we found …

- **15 bridges washed out.**
- **Portions of 6 trails destroyed by landslides.**
- **Portions of 4 trails destroyed by riverbank failure.**
- **Large portions of the trail system subjected to severe erosion in general.**
- **However … some of the most popular areas lightly impacted (yeah!)**

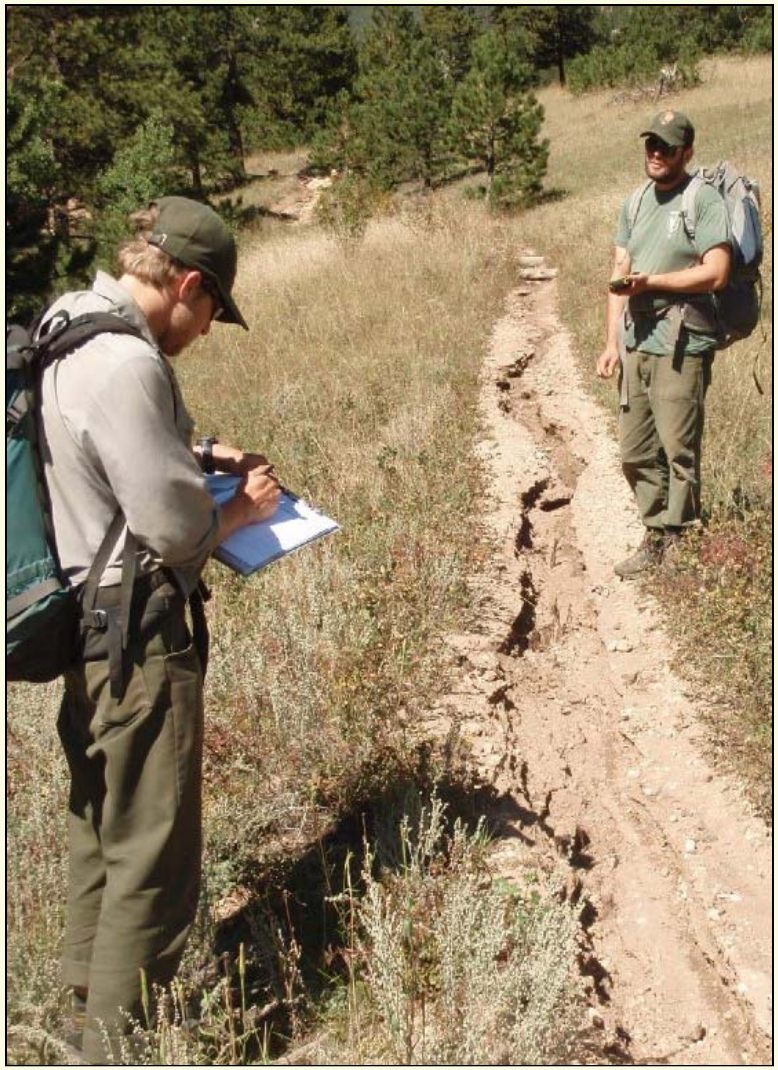
GIS linked photos can be found here:
http://www.nps.gov/romo/planyourvisit/map-showing-flood-impacts.htm



NPS Response to Natural Disasters Process

1 – 2 Days **1 – 2 Weeks** **2 Weeks – Present**

Tools & Techniques for Flood Recovery Assessment



Identify and follow safety protocols

- Job Hazard Analysis (JHA)
- NPS Operational Leadership Green Amber Red (GAR)

Inventory of conditions *prior* to event

- GIS-linked photos
- Measurements and specifications
- Year built
- Overall tread conditions

Documentation equipment

- GIS units (Trimble, Garmin etc.)
- Range finders
- Cameras
- ArcGIS mapping software

Small flexible teams with team leader ideally having trail design experience

RMNP Trail Recovery Planning & Compliance Process 1 of 3

Classify damage and evaluate work required to restore trail to pre-flood or minimally functional levels.

Urgent and / or minor repair work

- **Debris removal**
- **Bridge replacement**
- **Tread work through small landslides**
- **Repair damaged but intact structures (walls, steps, drains etc.)**

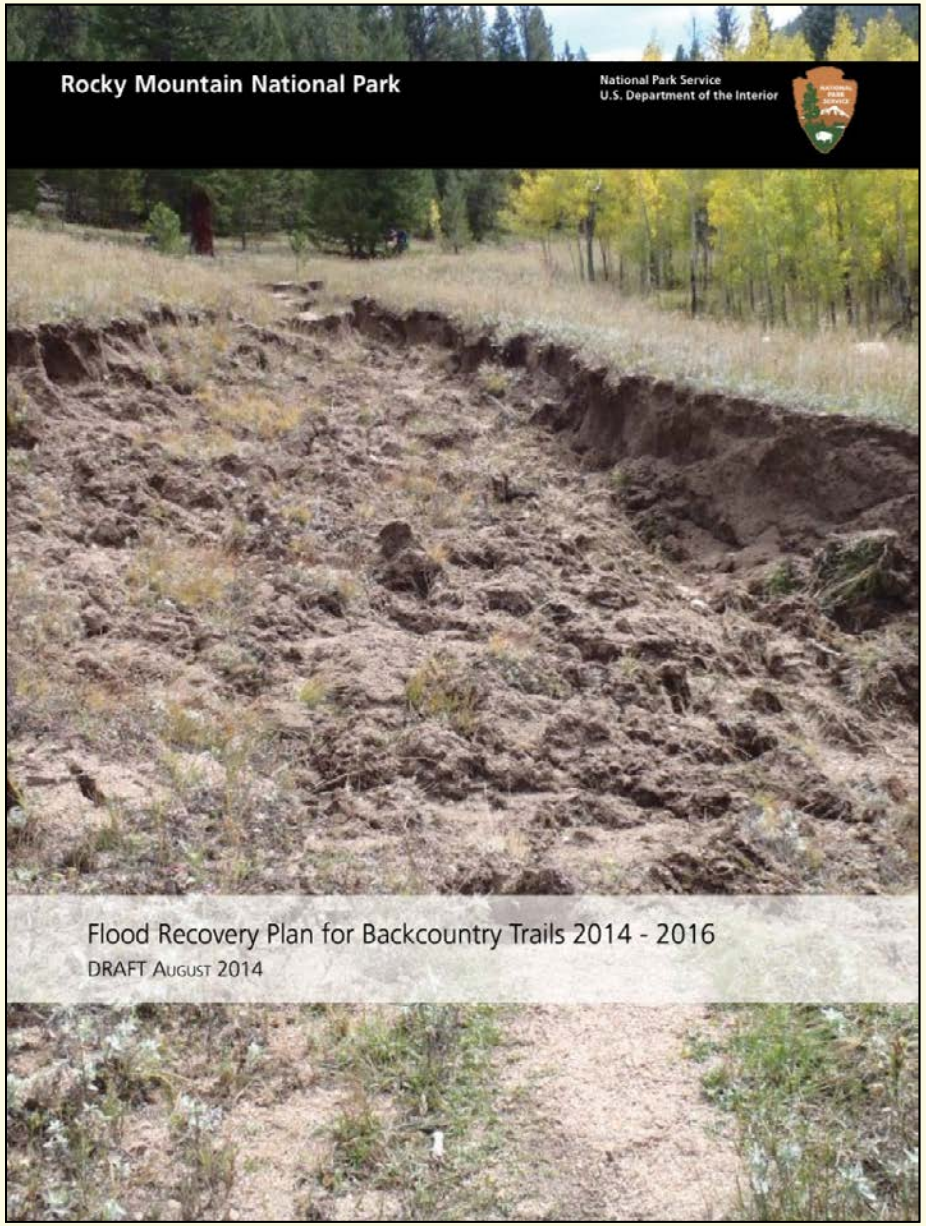
Fiscal Year 2014 Trails Work Plan

Severe and complex work

- **Large landslides**
- **Major bank failure / river re-direction.**
- **Severe trenching and sloughing**

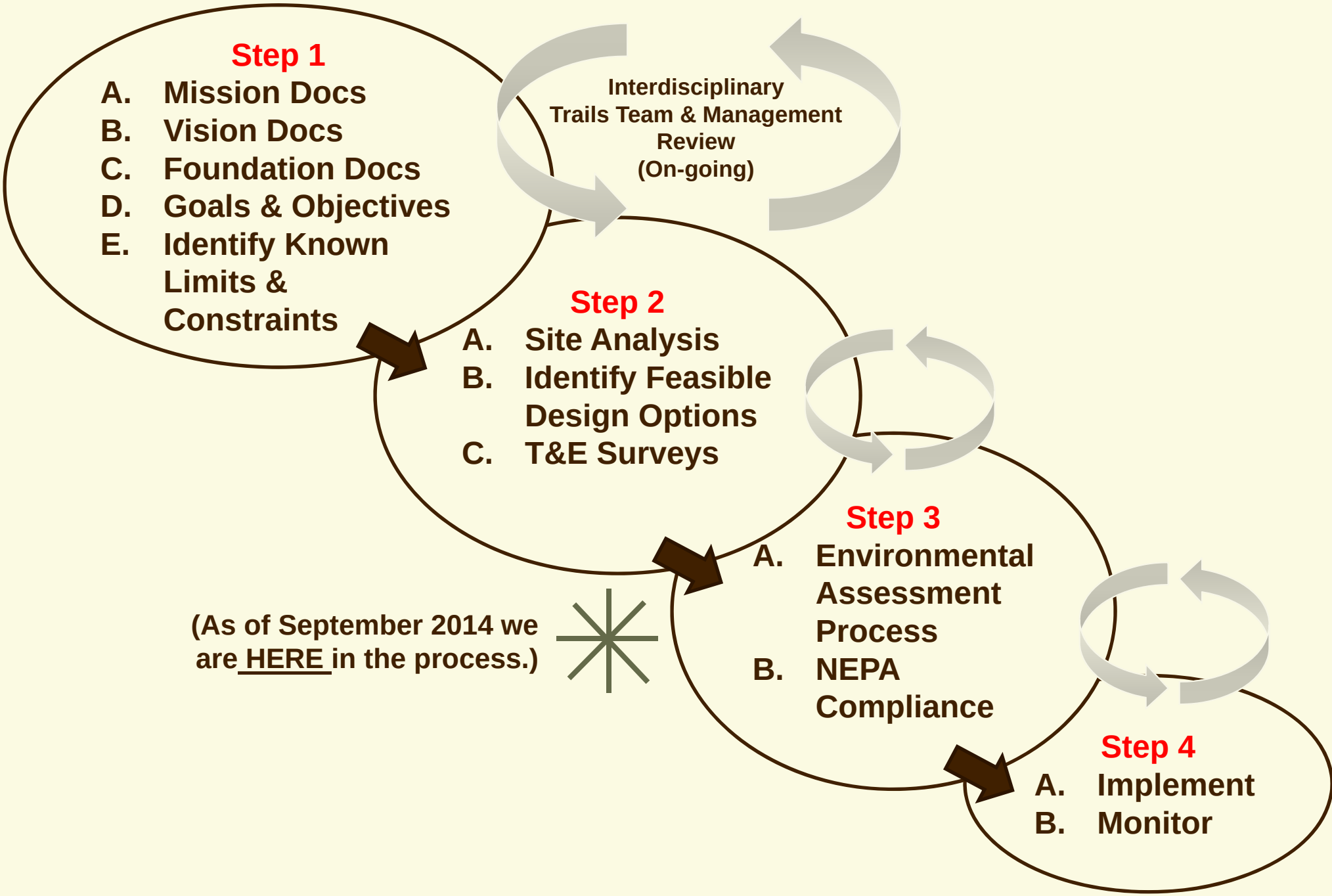
RMNP Trails *Sketchbook* Process

RMNP Trail Recovery Planning & Compliance Process 2 of 3



- 2014 Trails Working Group began process of evaluating recovery projects requiring additional compliance
- Utilized the *Sketchbook* as a basis for trail design guidelines (the "why" for each reroute proposal).
- Formed feasibility team to …
  - Identify viable options for severely impacted trail corridors
  - Identify and record Threatened and Endangered (T&E) species for the NEPA process

RMNP Trail Recovery Planning & Compliance Process 3 of 3



RMNP Trail Recovery Planning & Compliance Process 1 of 3

NPS Sustainable Mountain Trails definition Customized for RMNP …

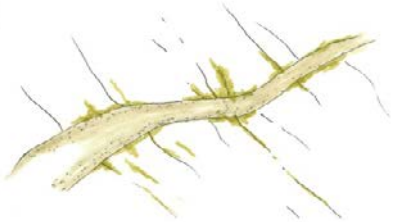
Does the trail …

- **Support current and anticipated uses?**
- **Have minimal impact to adjoining natural systems and cultural resources?**
- **Adversely natural fauna?**
- **Have minimal braiding, muddiness and erosion?**
- **Require rerouting and major maintenance over long periods of time?**
- **Comply with the Wilderness Act as appropriate?**

RMNP Flood Recovery Plan – Choosing by Advantages 1 of 2

Trail Asset Profiles

Rolling Contour Tread



TYPICAL SPECS
- 3' wide on 40% cross slope
- Unpaved tread
- Moderate brush understory

COST
$9 SF*

EXPECTED LIFESPAN
50+ years

Turnpike

TYPICAL SPECS
- 4' wide 1' tall
- Native timber easy gather factor.
- Crushed stone sub-base native soil surface.

COST
$ 36 sf*

EXPECTED LIFESPAN
10 years
(may need periodic resurfacing)

Causeway

TYPICAL SPECS
- 4' wide 1' tall
- Native stone medium gather factor.
- Crushed stone sub-base native soil surface.

COST
$43 sf*

EXPECTED LIFESPAN
50+ years
(may need periodic resurfacing)

Rock Retainer Bars

TYPICAL SPECS
- 3'x 3' x 6"
- Native stone
- Medium gather factor (within 100')

COST
$430 ea*

EXPECTED LIFESPAN
50+ years

Native Log Retainer Bars

TYPICAL SPECS
- 3'x 3' x 6"
- Easy gather factor.

COST
$370 ea*

EXPECTED LIFESPAN
10 years

Treated Log Retainer Bars

TYPICAL SPECS
- 3'x 3' x 6"
- One day stock support with 5 animal team.

COST
$480 ea*

EXPECTED LIFESPAN
20 years

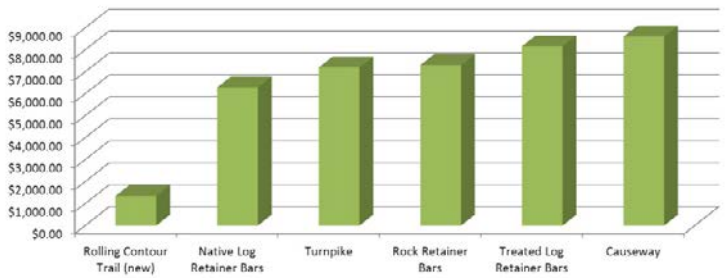
*Estimates based on 2014 CESS data specific to ROMO east side labor and material rates.

RMNP Flood Recovery Plan – Choosing by Advantages 2 of 2

Comparative Analysis

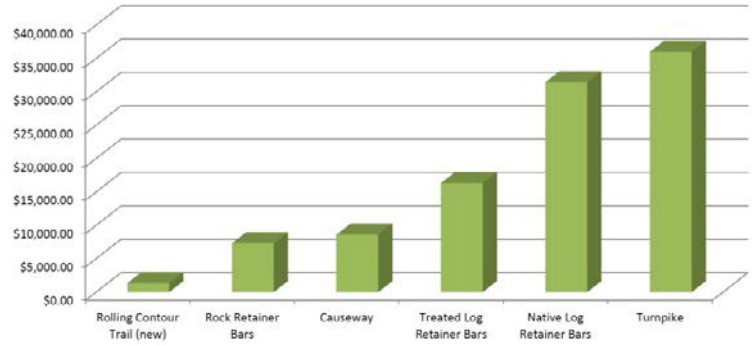
Initial construction costs
(based on constructing 50lf of trail)

Rolling Contour Trail	$1,350
Native Log Retainer Bars	$6,290
Turnpike	$7,200
Rock Retainer Bars	$7,310
Treated Log Retainer Bars	$8,160
Causeway	$8,600



50 year lifecycle cost
(based on 50lf of trail using 2014 dollars)

Rolling Contour Trail	$1,350
Rock Retainer Bars	$7,310
Causeway	$8,600
Treated Log Retainer Bars	$16,320
Native Log Retainer Bars	$31,450
Turnpike	$36,000



RMNP Flood Recovery Plan – Design Parameters 1 of 2

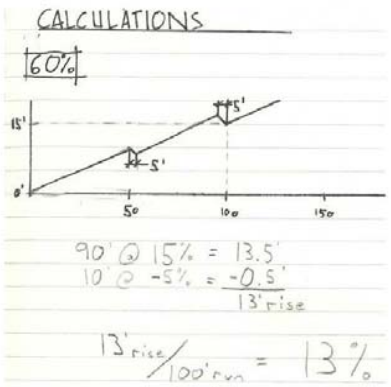
Design parameters

CROSS SLOPE	QUARTER RULE GRADE	DIP FREQ	OPTIMUM PROFILE GRADE
60%	15%	50'	13%
40%	10%	100'	9.25%
32%	8%	200'	7.68%
20%	5%	N/A*	5%

Optimum profile grade incorporates grade dips at various intervals and is therefore slightly less than the Quarter Grade Guideline (see figure 1). After the trail corridor is established and approved, grade dips can be added when construction notes are generated.

*Grade dips are ineffective at such low crosslope grades.

Figure 1



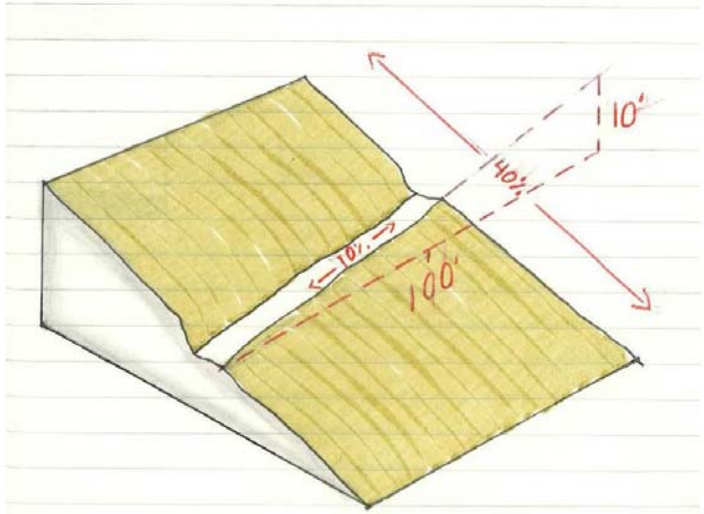
Compiled Trail Profile Grade Guidelines:

X Slope	Ideal Cond.	Less-than-Ideal Cond.
60%<	13%	10%
55%	12%	9%
50%	11%	8%
45%	10%	7%
40%	9%	6%
35%	8%	5%
30%	7%	4%
25%	6%	3%
20%>	5%	2%

Principles of Optimum Trail Grades for Natural Surface Trails

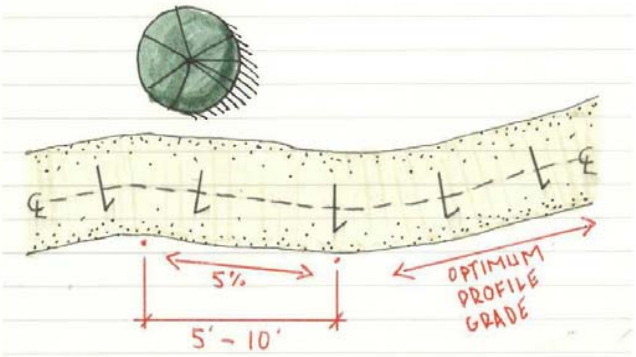
- In ideal conditions, optimum trail grade is achieved by adhering to the quarter guideline (trail profile grade is 1/4 of prevailing cross slope) while incorporating periodic grade dips to facilitate natural drainage.
- Factors that contribute to an increase in the erosion potential of the natural tread surface (fryable soil, poor drainage, northern aspects, heavy visitor use, adverse climate, etc.) may require a reduction in grade and the use of structures.

The Quarter Guideline

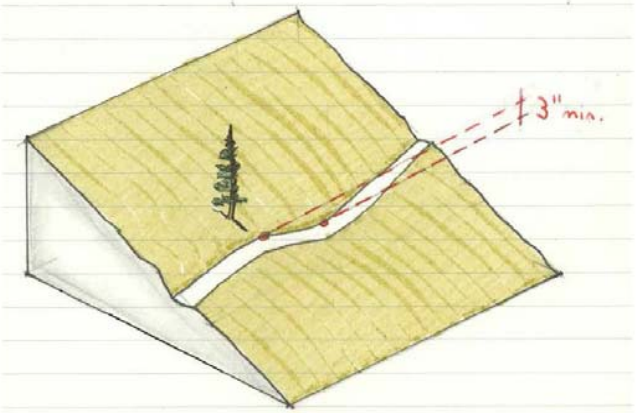


RMNP Flood Recovery Plan – Design Parameters 2 of 2

Rolling Grade Dips

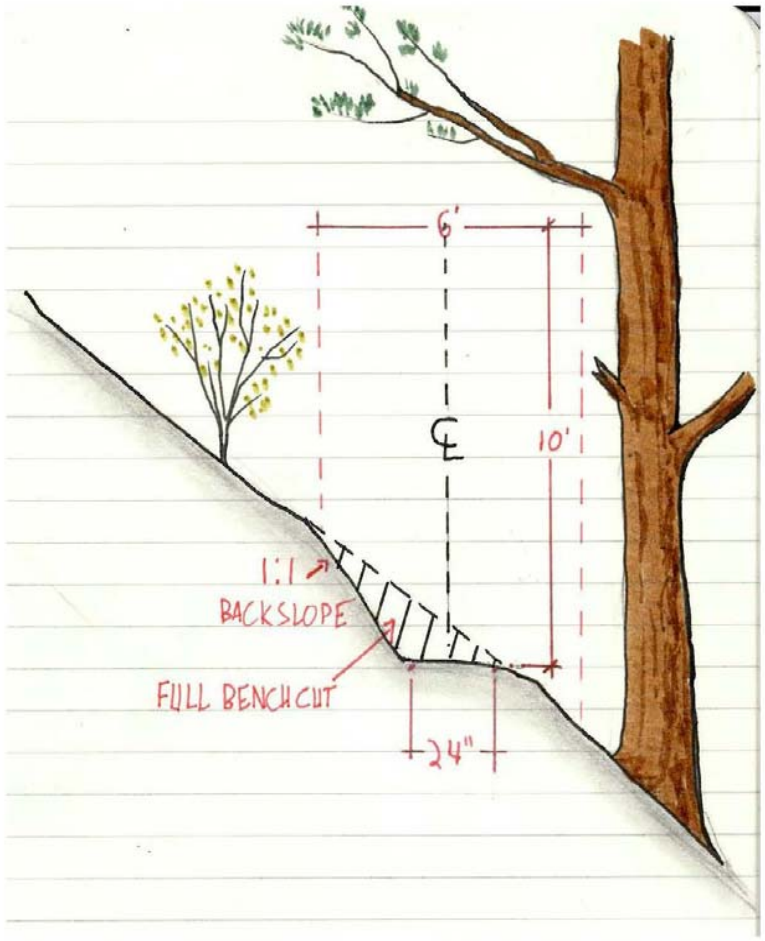


(PLAN VIEW)



DESIGN PARAMETERS CONT.

Typ. Cross Section



RMNP Trail Recovery Planning & Compliance Process 2 of 3

OPTIONS we considered for each area in the Flood Recovery plan

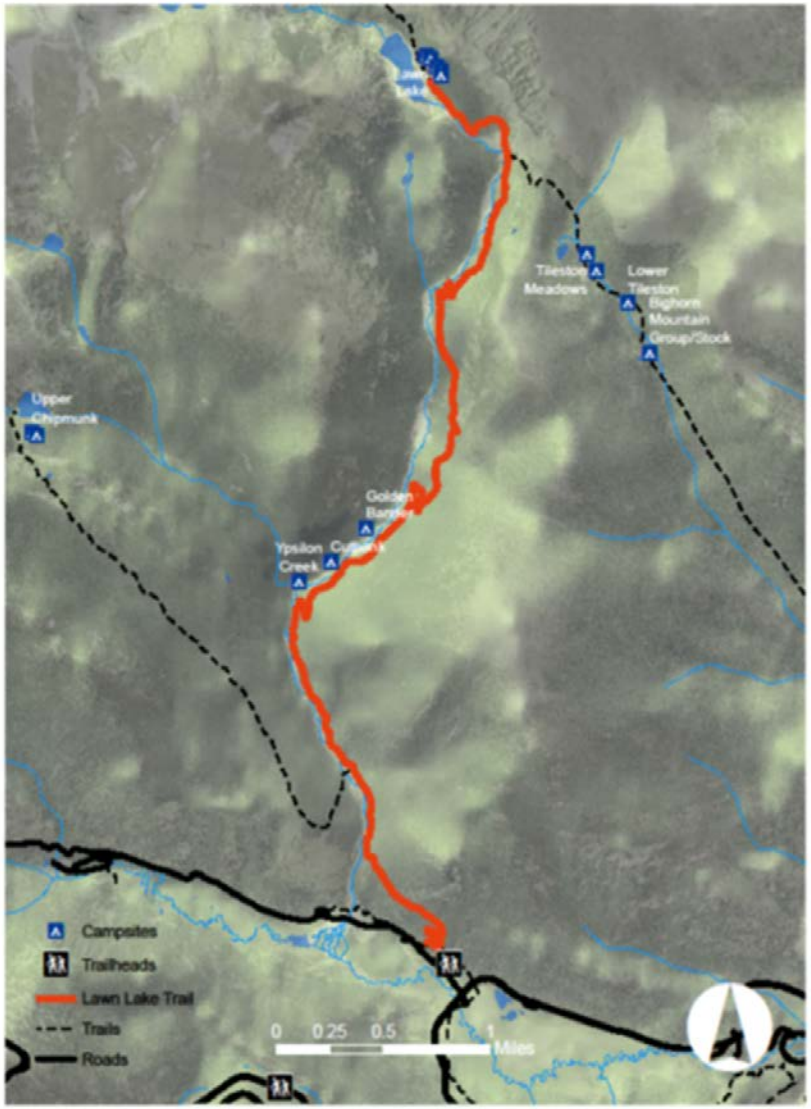
- Do Nothing
- Do “Little” (stabilize)
- Repair in Place
- Reroute and Ecologically Restore Corridor
- Close, Abandon, Ecologically Restore Corridor

✳ **Keep in mind not all of these options may be *feasible* given the type of damage, use levels etc.**

Flood Recovery Plan GOALS

- **Identify the feasible options for both the long-term and short-term recovery of the trail system**
- **Document potential impacts to natural & cultural resources due to flood damage and altered visitor use patterns**
- **Identify sustainable trail corridors using Optimum Trail Profile Grades outlined in the NPS *Sketchbook***
- **Inventory all rare, threatened and endangered (T&E) plant species for incorporation into the NEPA process**
- **Generate cost estimates and preliminary project plans for comparison purposes**
- **Provide streamlined analysis for management review**

Case Study # 1 – Lawn Lake Trail 1 of 5



RR-01 Lawn Lake Trail	
DESIGN STANDARD	CLASS III
PERMITTED USES	EQUESTRIAN/HIKER
DISTANCE	5.3MI
ASSET PRIORITY INDEX	100
FACILITY CONDITION INDEX	0.191 (POOR)
CURRENT REPLACEMENT VALUE	$4,112,870
COST PER LINEAR FOOT	$147

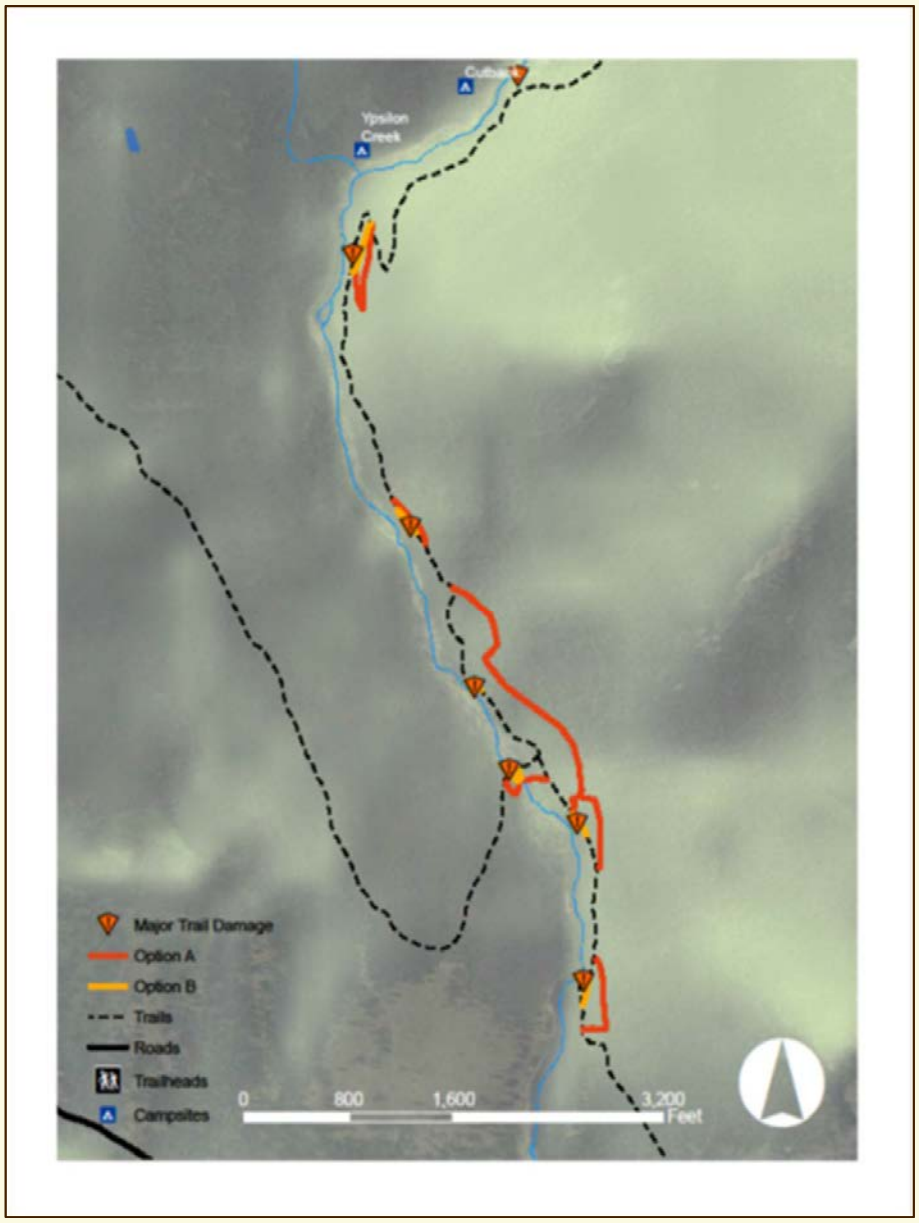
TRAIL SUMMARY

RR-01 covers the first portion of Lawn Lake and ends at the junction with the Black Canyon Trail. RR-02 continues to the lake. The combined trail segment climbs for 6.2 miles with an elevation gain of 2,249 feet. Lawn Lake sits at 10,789 feet. Lawn Lake was the site of a dam failure in 1982. Following the dam failure, the dam was removed and the trail was rebuilt.

DAMAGE SUMMARY

The lower half of the Lawn Lake Trail closely follows the bank of the Roaring River, which saw significant erosion during the flood. In several areas the bank completely collapsed, taking the trail with it. In addition, backcountry camping access trails to the Golden Banner Site and the Cutbank Site were washed out and a bridge was significantly damaged.

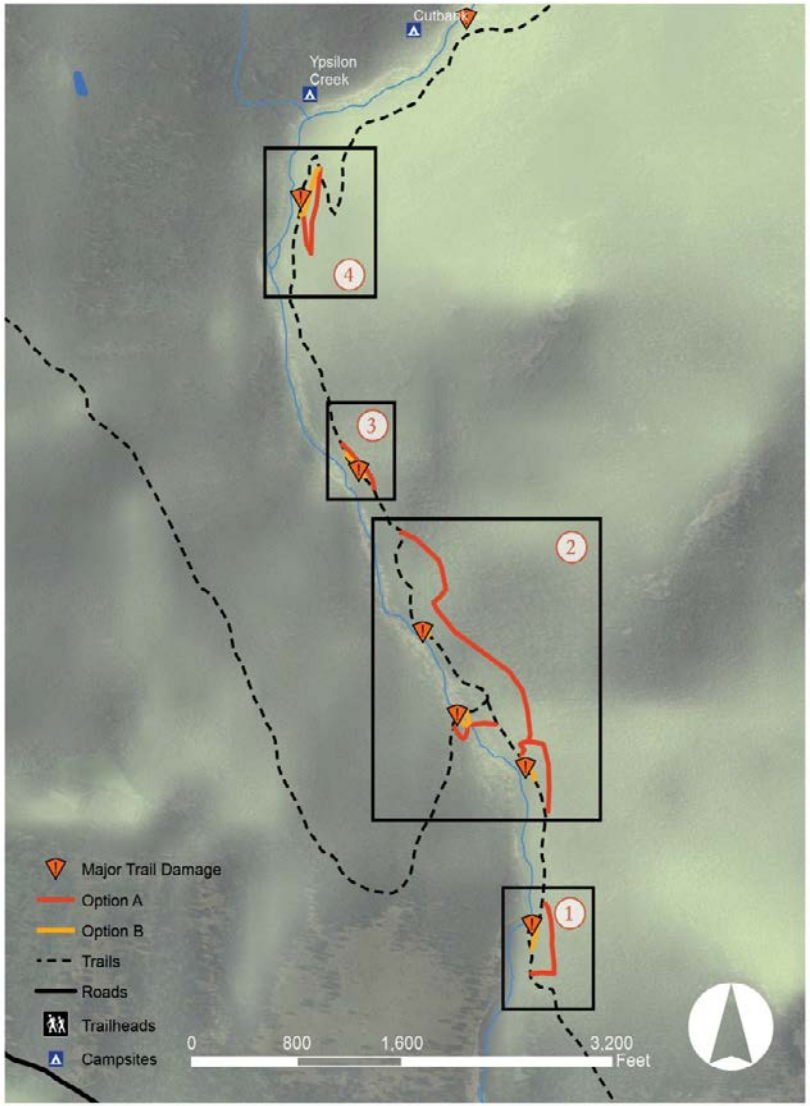
Case Study # 1 – Lawn Lake Trail 2 of 5



The Problem

- River bank collapsed in several areas taking the trail with it.
- Erosion was severe on sections of trail that followed fall-line orientation and used old “carriage roads” routes.

Case Study # 1 – Lawn Lake Trail 3 of 5



Impacted Sections

Option A (Sustainable Reroute)
Option A utilizes optimum trail profile grades for long-term sustainability and ease of maintenance.

Option B (Minimal Reroute)
Option B represents the shortest and easiest-to-implement reroute.

Section 1
The trail runs adjacent to a section of river bank that appears to be in danger of failure.

Section 2
Multiple sections of river bank have failed and the Ypsilon Lake Trail bridge has been washed out necessitating the need for full or partial reroutes.

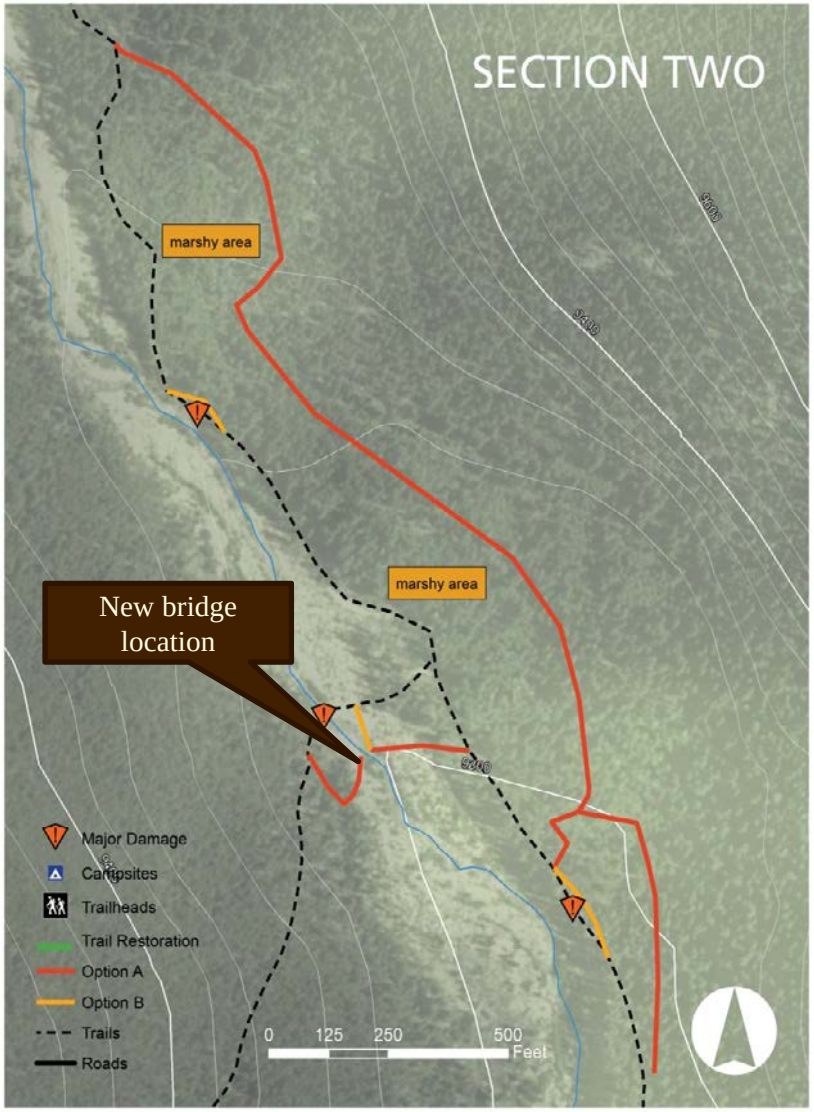
Section 3
A section of river bank has failed necessitating the need for a short reroute.

Section 4
A steep section of river bank has failed and taken approximately 100' of existing trail with it.

2 … Trail Planning and Design Strategy

When multiple areas of damage occur during a major weather event along a single trail, break it down into sections and treat each as its own "project" to evaluate the merits of a minimal reroute vs. a major reroute.

Case Study # 1 – Lawn Lake Trail 4 of 5

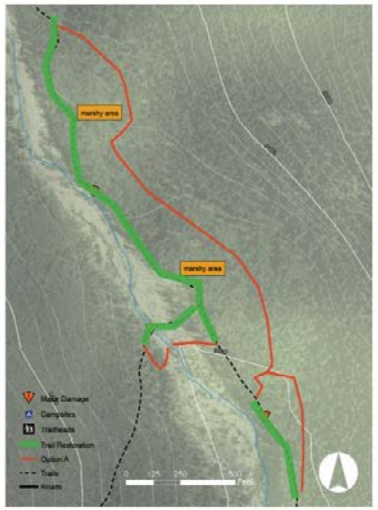


Option A

TOTAL DISTANCE	2710LF (LAWN) 610LF (YPSILON)
RESTORATION	1927LF (LAWN) 352LF (YPSILON)
EST. TIME FRAME	6 MONTHS
EST. COST	$75,180(LAWN) $40,516(YPSILON)

SUMMARY

Option A, the Lawn Lake trail would move approximately 100'-300' to the east. The junction with Ypsilon Lake Trail would be relocated, as well as the bridge approaches across the Roaring River.

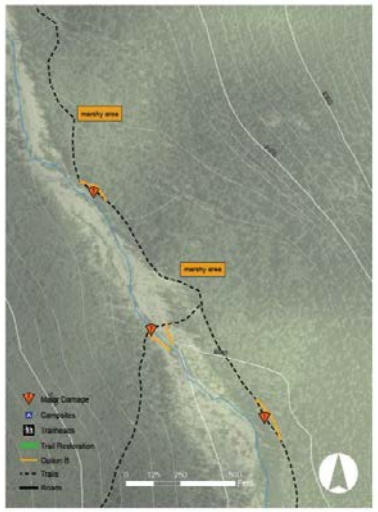


Option B

TOTAL DISTANCE	375LF (LAWN) 210LF (YPSILON)
RESTORATION	352LF (LAWN) 100LF (YPSILON)
EST. TIME FRAME	3 MONTHS
EST. COST	$31,800 (LAWN) $27,350 (YPSILON)

SUMMARY

Option B would involve smaller reroutes around impacted areas. Some reroutes would cross perennially wet areas that are ill-suited for trails. Significant structures such as causeways or boardwalks would be required.



Case Study # 1 – Lawn Lake Trail – What We Discovered! 5 of 5

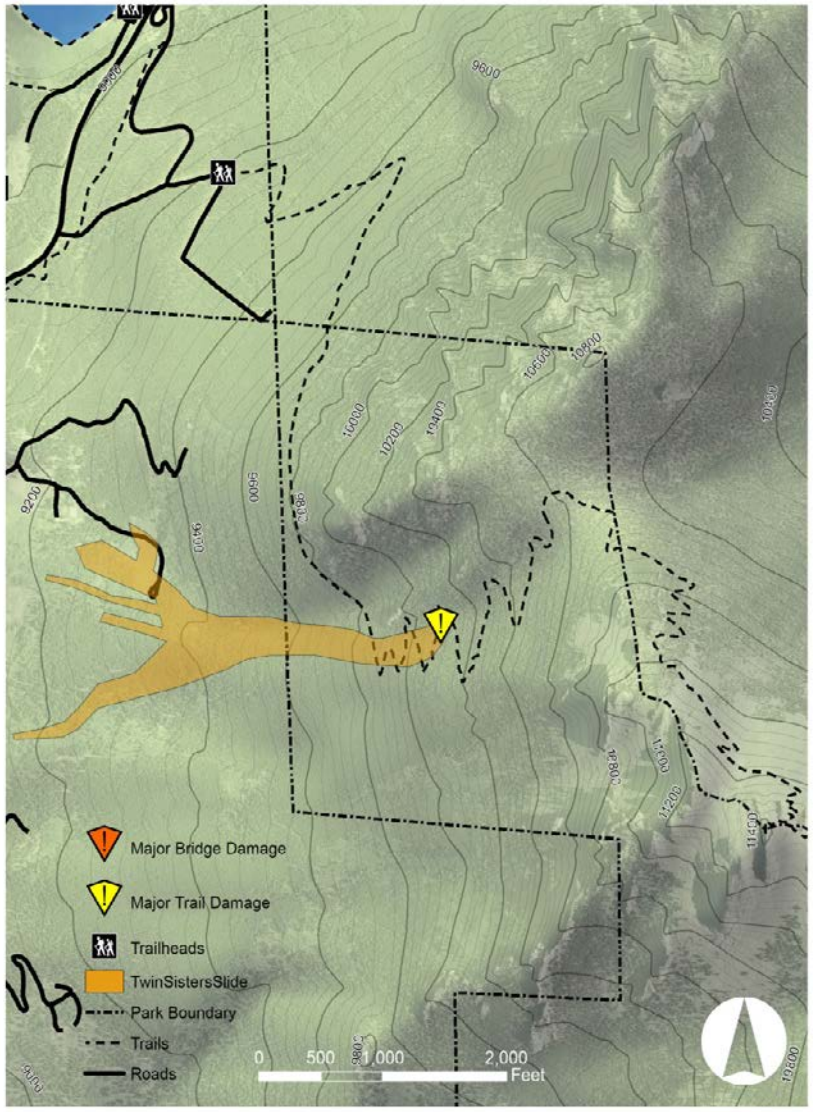
High-value Ecological Resources

Difficult Terrain for Construction

Undocumented Cultural Resources

Some Impacts from New Visitor Patterns

Case Study # 2 – Twin Sisters Trail 1 of 6



LP-14 Twin Sisters Trail

DESIGN STANDARD: CLASS III

PERMITTED USES: EQUESTRIAN/HIKER

API: 64*

CRV: $508,485.66

FCI: 0.610 (SERIOUS)

DEFERRED MAINTENANCE: $310,121.04

TRAIL SUMMARY

The Twin Sisters trail begins east of Lily Lake and accesses north Twin Sister Peak.

In the 1990's the trail was rerouted in order to move the old trailhead and access road off of private property.

DAMAGE SUMMARY

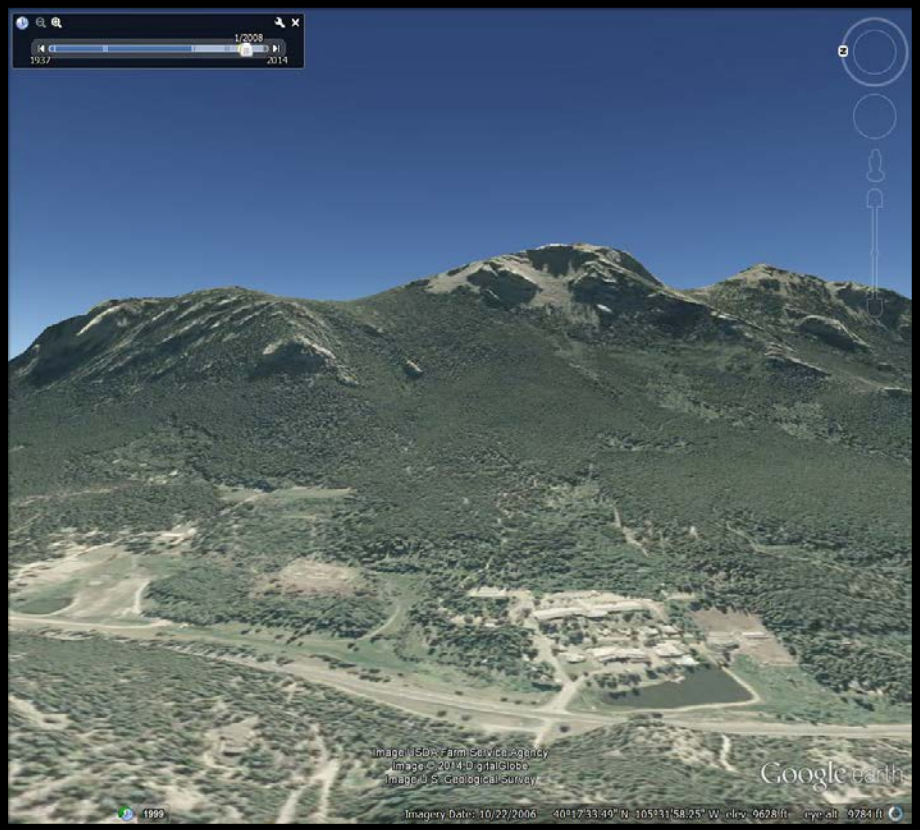
The Twin Sisters Trail experienced massive damage due to a large landslide that removed approximately 2,110' of trail and 5 switchbacks.

Based on a 2002 study approximately 70 Estimated 8,600 people June-September,

"Trail counters used on Twin Sisters and Storm Pass trails indicate there are a total of 13,928 and 10,219 visitors respectively between June 1 and October 13 each year." (DIRECT QUOTE FROM HWY 7 EA)

*FMSS data current as of May, 2014

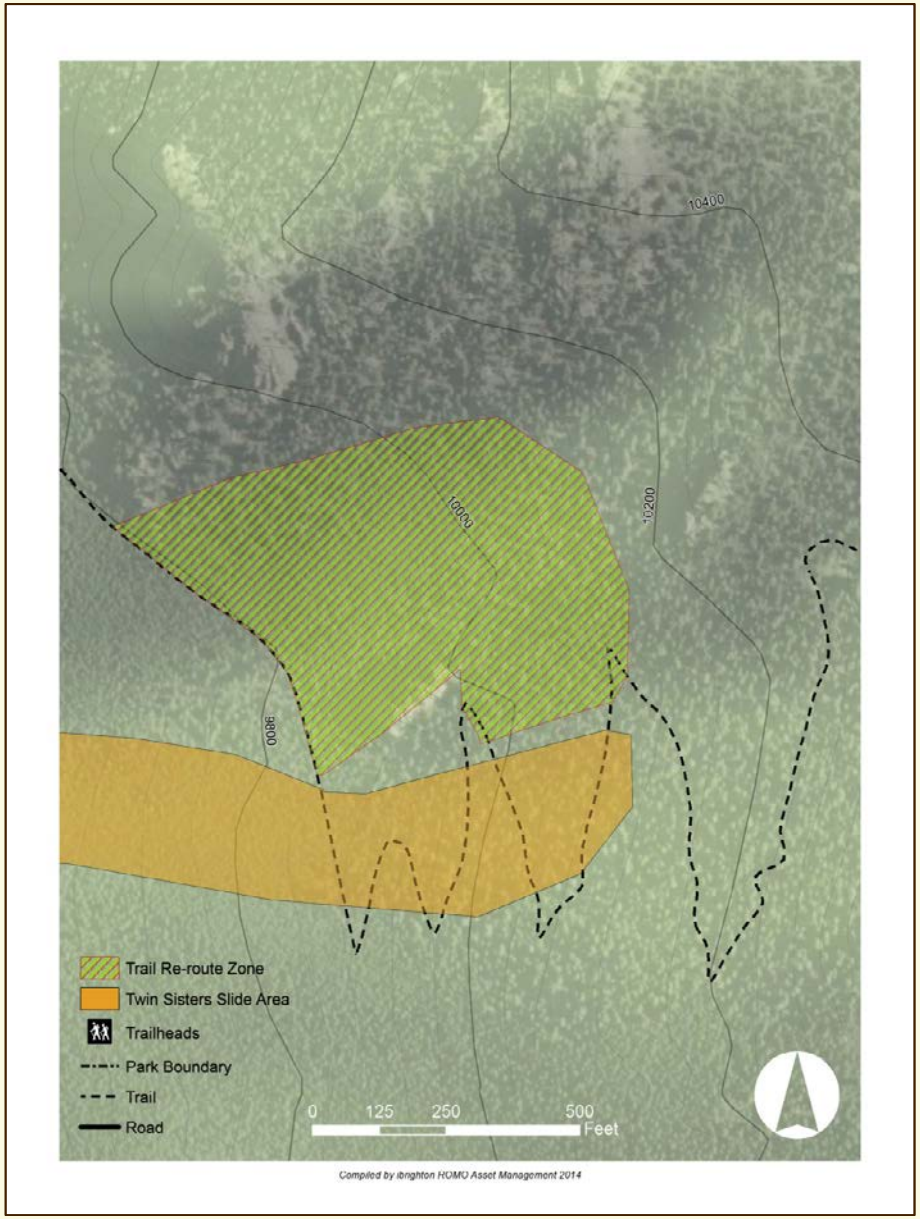
Case Study # 2 – Twin Sisters Trail 2 of 6



Pre-Great Flood of 2013 Google Earth Image

Post-Great Flood of 2013 Google Earth Image

Case Study # 2 – Twin Sisters Trail 3 of 6



The Problem

- A major landslide removed approximately 2,110 LF of trail and five switchbacks.
- Social Trails are occurring along both sides of the slide – an unacceptable occurrence.
- Small landslides are occurring to the south of the existing slide. Mitigation likely required, to be determined.

Case Study # 2 – Twin Sisters Trail 4 of 6

Twin Sisters Slide (Looking East)

Twin Sisters Slide (Looking South)

Twin Sisters Slide (Looking West)

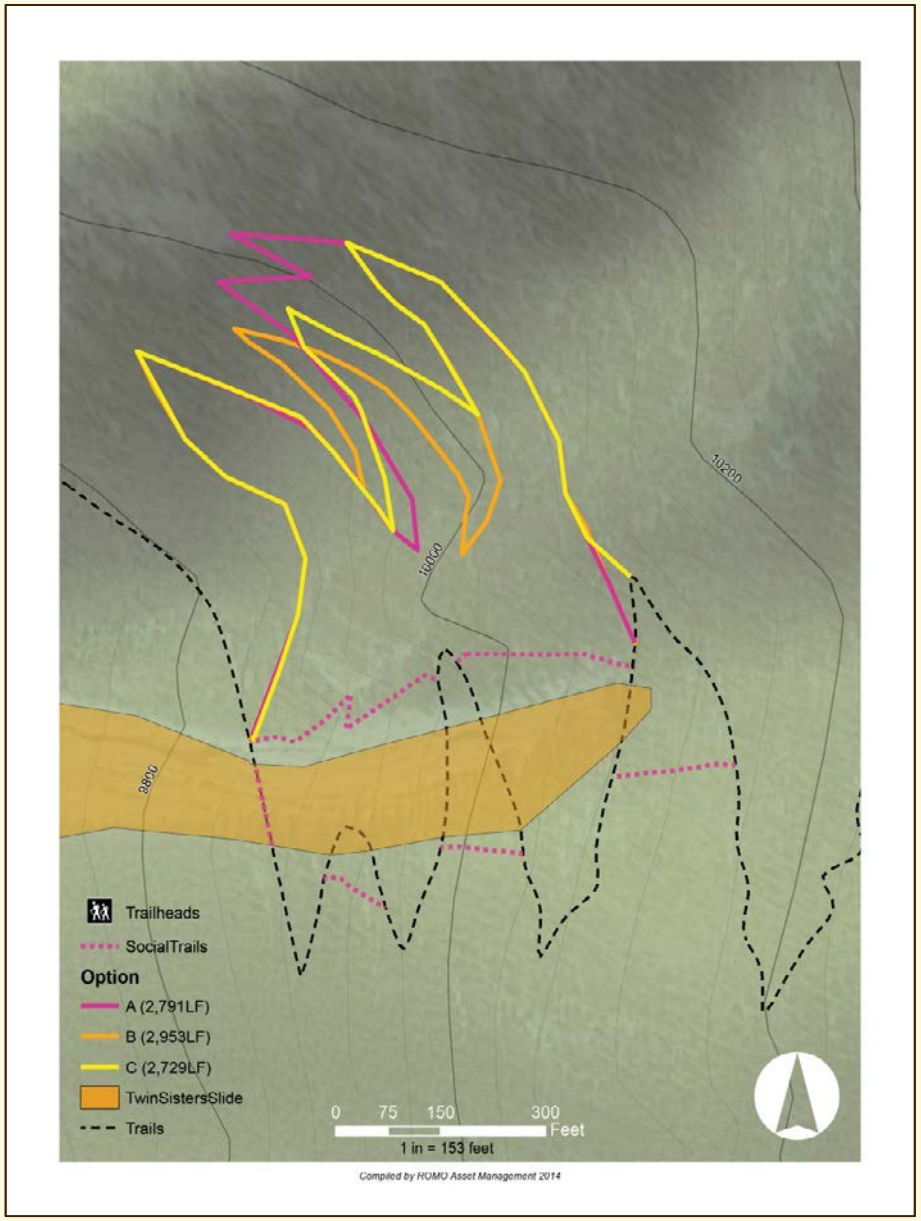
Evidence of Unstable Slopes

Case Study # 2 – Twin Sisters Trail 5 of 6

Lessons Learned

- Review an existing structure in similar terrain and in excellent condition for ideas of what is feasible.
  - Profile grades for this staircase is 30% for approximately 50’
  - Dimension of each riser approximately:
    8” height x 3’ w. x 3’ tread
- ***This example could be utilized with the expectation for similar results.***

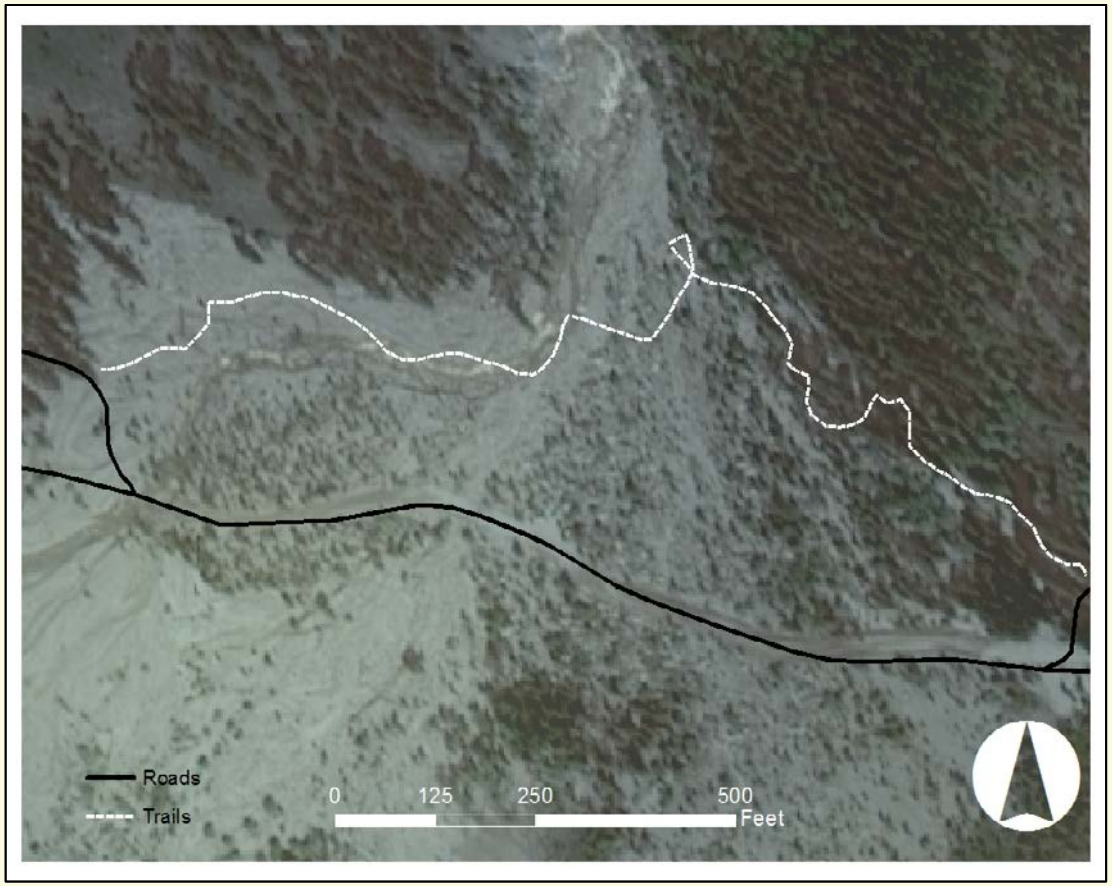
Case Study # 2 – Twin Sisters Trail 6 of 6



Options Framework

- Option A
  - 2,791 LF of New Trail Design
  - Improvements
    - Stairs
    - 6 Switchbacks
- Option B
  - 2,953 LF of New Trail Design
  - Improvements
    - Stairs
    - 6 Switchbacks
- Option C
  - 2,729 LF of New Trail Design
  - Improvements
    - Stairs
    - 6 Switchbacks
- ***Summary – Many Iterations of the Same Concept Possible.***

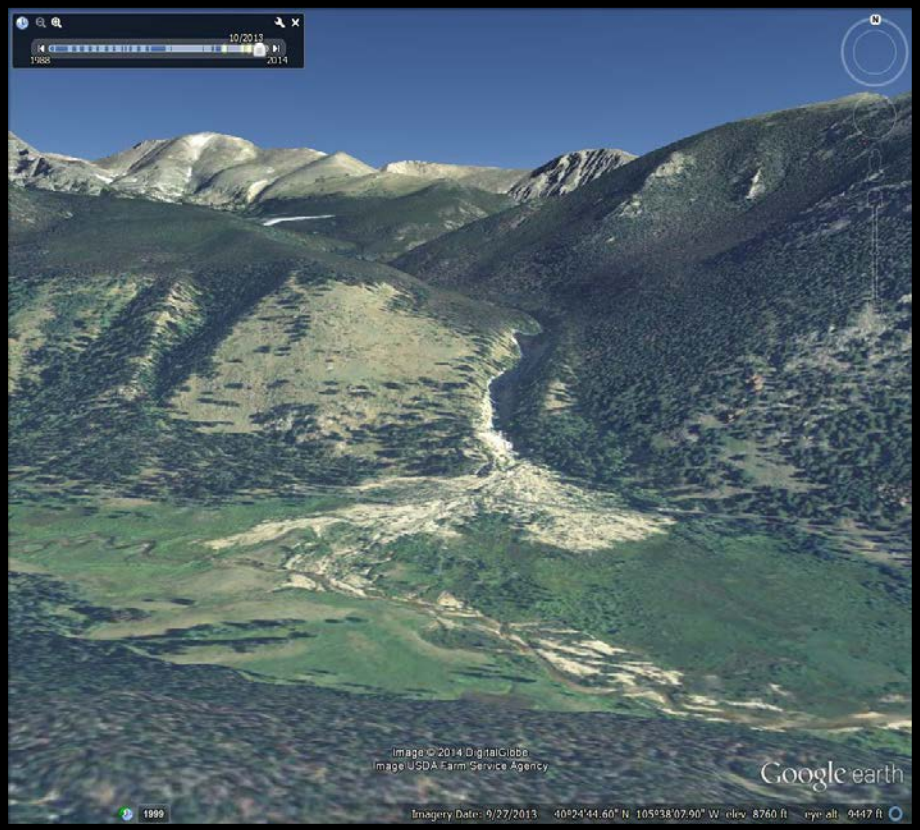
Case Study # 3 – Alluvial Fan 1 of 6



Overview

- Originally flooded in 1981
- Short “Frontcountry” paved trail with a waterfall overlook.
- Very popular area flanked by complementary parking and picnic facilities on both the east and west sides of the trail.

Case Study # 3 – Alluvial Fan 2 of 6



Before Great Flood of 2013

After Great Flood of 2013

Case Study # 3 – Alluvial Fan 3 of 6

The Problem

- Roaring River jumped its banks and moved the channel to the west.
- Western section of trail completely demolished.
- Eastern section of trail almost completely destroyed.

Case Study # 3 – Alluvial Fan 4 of 6

During Flood – Water Raging

Typical Condition Immediately Post-Flood

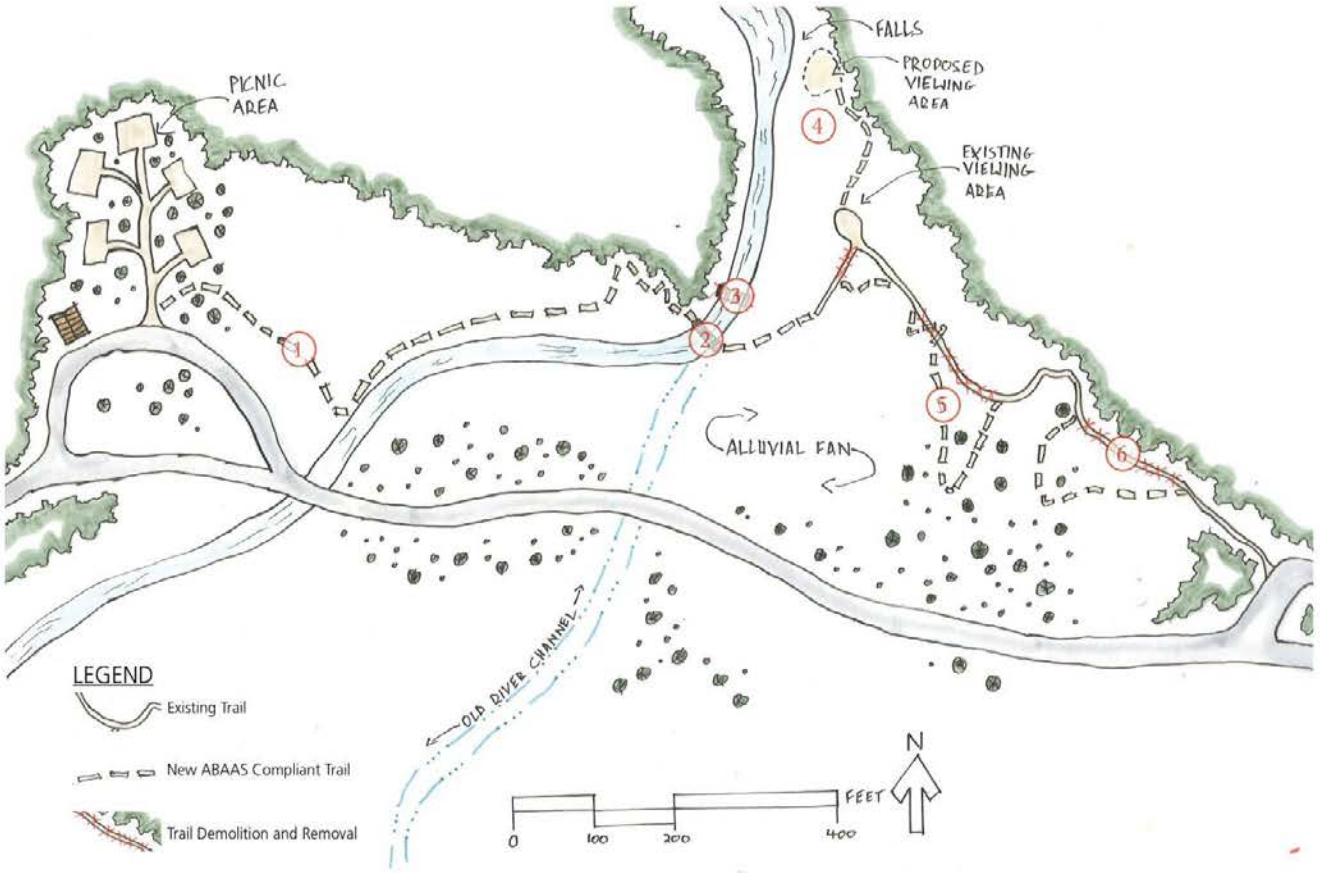
Case Study # 3 – Alluvial Fan 5 of 6

Alluvial Fan Accessible Trail Proposal

DRAFT August, 2014

National Park Service
U.S. Department of the Interior

1. ABAAS compliant trail with average grade of 7.5% and width of 60". Trail would be lined on both sides with native rock.
2. Construct new "breakaway" bridge approximately 60' to the south of old location to accommodate ABAAS compliant grades.
3. Demolish and remove and old bridge and abutments.
4. Move viewing area north (closer to falls) and construct approximately 50' of ABAAS compliant trail.
5. Modify and reroute portions of East Alluvial Fan Trail to comply with ABAAS maximum grade requirements.
6. Demolish and remove old asphalt trail.



Summary graphic is intended for potential fundraising purposes.

Case Study # 4 – Ouzel Falls 1 of 4

The Problem

- Flooding in Ouzel Creek destroyed a multiple use bridge cutting off access to a popular loop hike.

- Social Trail leading to “unofficial” overlook receives much more use due to destruction of lower (original) viewing area.

Case Study # 4 – Ouzel Falls 2 of 4

Before the Great Flood of 2013

After the Flood of 2013

Case Study # 4 – Ouzel Falls 3 of 4

Option 1
- Utilizes existing abutment locations.
- Two spans required: 40' and 38'
- Pier anchored to existing boulder.

Pros
- Bridge acts as "viewing platform" for Ouzel Falls.
- Pier construction would be minimal.
- Traditional Multi-Use bridge style could be constructed.

Cons
- Necessary to drill into native rock.
- Bridge is located near water line (approx 3-5').
- Three large coniferous trees would need to be removed.
- North shore abutment would need to be raised.

Option 2
- Original bridge location.
- Two spans required: 40' and 24'
- Pier location moved to a more protected area.

Pros
- Bridge acts as "viewing platform" for Ouzel Falls.
- Abutment reconstruction would be minimal.
- Traditional Multi-Use bridge style could be constructed.
- No trees or vegetation would need to be removed.

Cons
- Constructed pier more susceptible to failure during major flood event.
- Bridge deck located near water line (approx 3-5').

Option 3
- Located approximately 10' east of original bridge location.
- Two spans required: 40' and 34'
- Pier anchored to existing boulder.

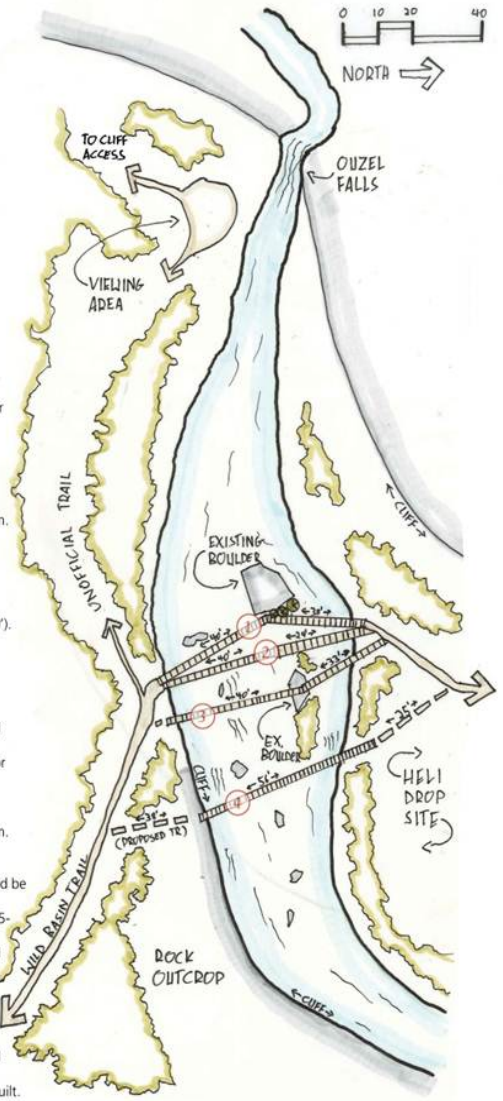
Pros
- Bridge acts as "viewing platform" for Ouzel Falls.
- Traditional Multi-Use bridge style could be constructed.
- Bridge deck located further from water line (approx 5-10').
- Minimal abutment construction due to favorable site conditions.

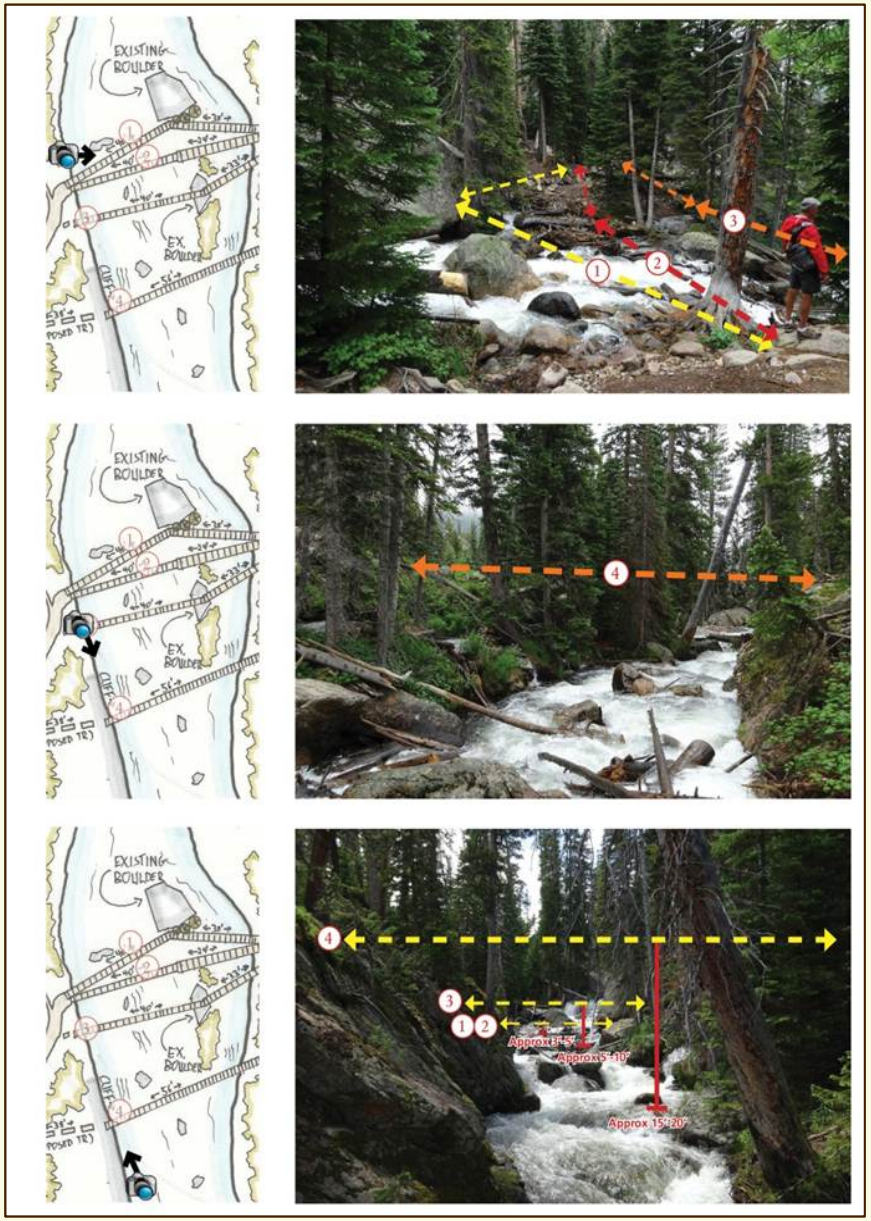
Cons
- Necessary to drill into native rock.
- Some trees and vegetation would need to be removed.
- Original abutment location would likely remain impacted since it offers good views of falls.
- May need to remove habitat tree (snag) that could harbor cavity nesting birds.

Option 4
- Located approximately 60' east of original bridge location.
- One 56' span required.

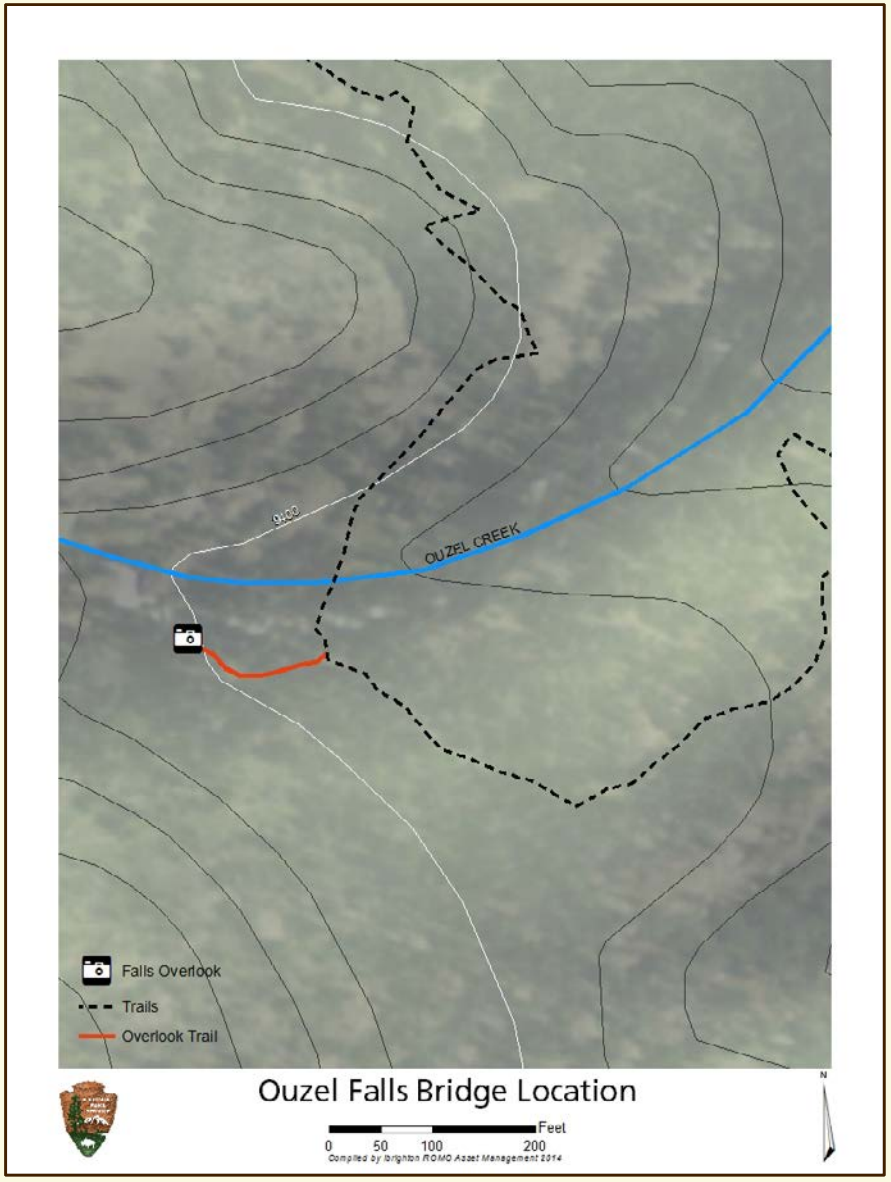
Pros
- Only one span would be needed and overall length would be the shortest.
- Bridge deck located well away from water line (approx 15-20') and would survive any future flood event.
- South abutment anchored to existing cliffside and would need minimal construction.

Cons
- May be necessary to drill into native rock.
- Some trees and vegetation would need to be removed.
- Bridge would not offer view of the falls.
- Original abutment location would likely remain impacted since it offers good views of falls.
- Approximately 63' of additional trail would need to be built.
- May need to remove habitat tree (snag) that could harbor cavity nesting birds.





Case Study # 4 – Ouzel Falls 4 of 4



Lessons Learned … RMNP *Sketchbook* Process to Date

- **Keep it Short & Simple (KISS).** Distill information down to the most critical components to make informed decisions.

- **Illustrate design parameters early in the process.** Remove as much of the "subjective" component as possible, i.e.: utilize the *Sketchbook* or other trail design material as your guide and reference when questions come up.

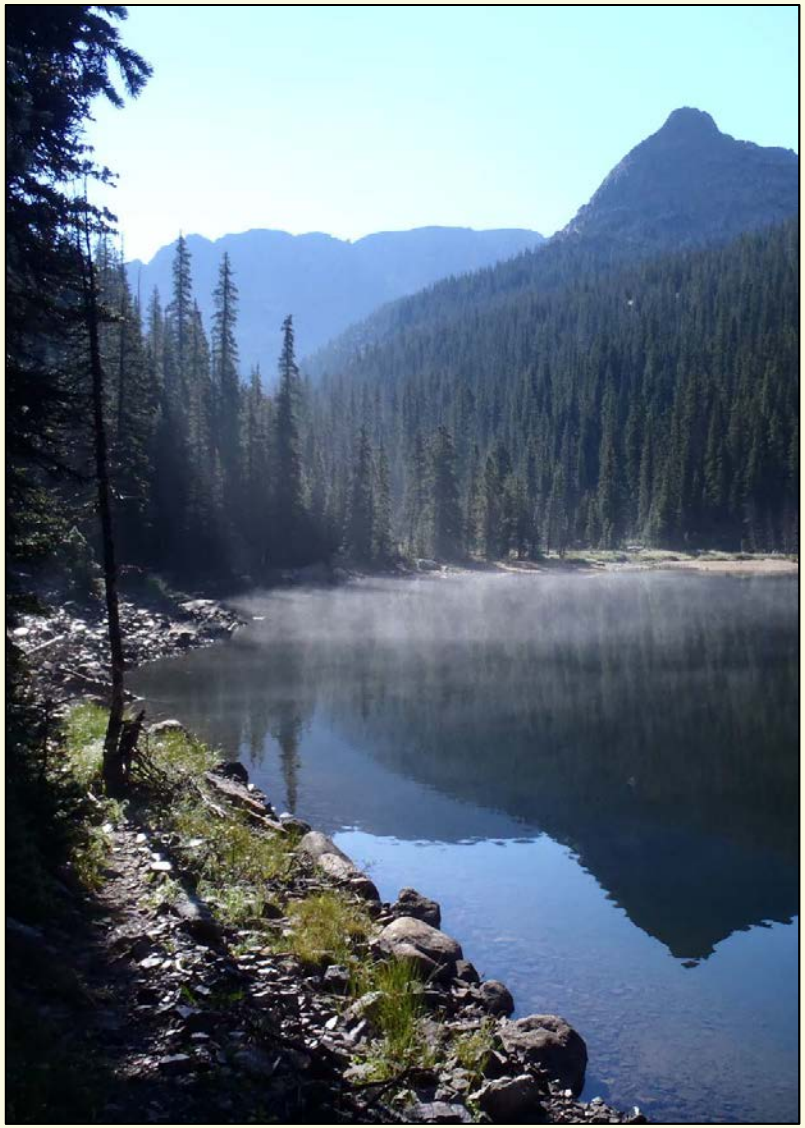
- **Be straightforward about strengths and weaknesses** of a trail design. Sometimes the "no action" is the best course to take.

- **Inform planning staff early on in the process of potential road blocks** such as the presence of T&E, or cultural resources.

- **Identify clear goals** for each meeting / field trip of the Interdisciplinary Working Group and at each step of the process.
  - Team members need to know the issues to keeping the process moving forward.

- **Expect the scope to change** once field work begins.
  - Some areas will require much more work than anticipated, other areas may see slight improvements!
  - Conditions are continuing to change rapidly in the field post storm!

And Success Stories! … RMNP *Sketchbook* Process



Incorporate cultural and ecological resource staff into the Interdisciplinary Design Team that goes into the field.

- Staff members who participated in the design process ended up learning a great deal about trails, and created an atmosphere of trust and openness.

Use visual aids as much as possible.

- Park Planners have a limited amount of time (especially after a disaster!). Photos and graphics can be invaluable in getting information conveyed quickly and effectively.
- A good reference: *Envisioning Information* by Edward Tufte.

Lessons Learned

Before the Flood of 2013

After the Flood of 2013
Hey – This Might Actually Be Better!

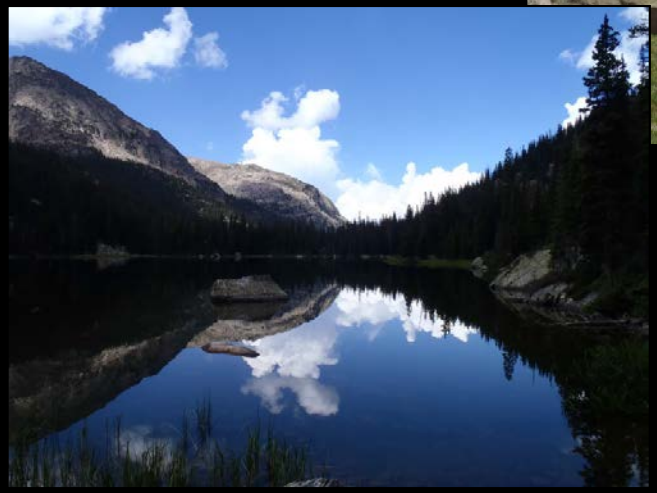
With a natural disaster, you never know what to expect!

Images from Rocky Mountain National Park

Hayden Lake

Balance Rock

Keyboard of the Winds



Lake Verna

RMNP – Stewardship Partnerships & Training Opportunities

Partnerships

Local Businesses
Outfitters / Liveries
Youth Agency Opportunities, i.e.: Boy Scouts, etc.

Expertise

Publicity
Funding
Labor / Material Donations
Educational Materials

Training

Volunteers for Outdoor Colorado
Outdoor Stewardship Initiative
Rocky Mountain Conservancy

Many Potential Dividends / Benefits to NPS & Our Partners

What can the trails community expect to see / hear from Rocky staff in the near / distant future?

Environmental Assessments

Compliance Process Products / Public Review
2015 – Complete Compliance Process
2016 – Shovel Ready – Implementation of Projects

Training Opportunities

Volunteers for Outdoor Colorado (VOC)
VOC / Outdoor Stewardship Initiative

Next Steps

Implementation of Select Project – 2016 < Hoped For!

Reminder: Towards a Mountain Trail Sustainability Ethic …

1. *Inspiration …*
2. *Optimum Investment*
3. *Stewardship of a Woodlot*
4. *Intrinsic Values of Land*
5. *Fundamentals of Outdoor Recreation*
6. *Landscape Architectural Tools & Techniques*
7. *Nonprofit Agency Partnerships*
8. *Training*
9. *Art & Science*
10. *It takes … hard work.*

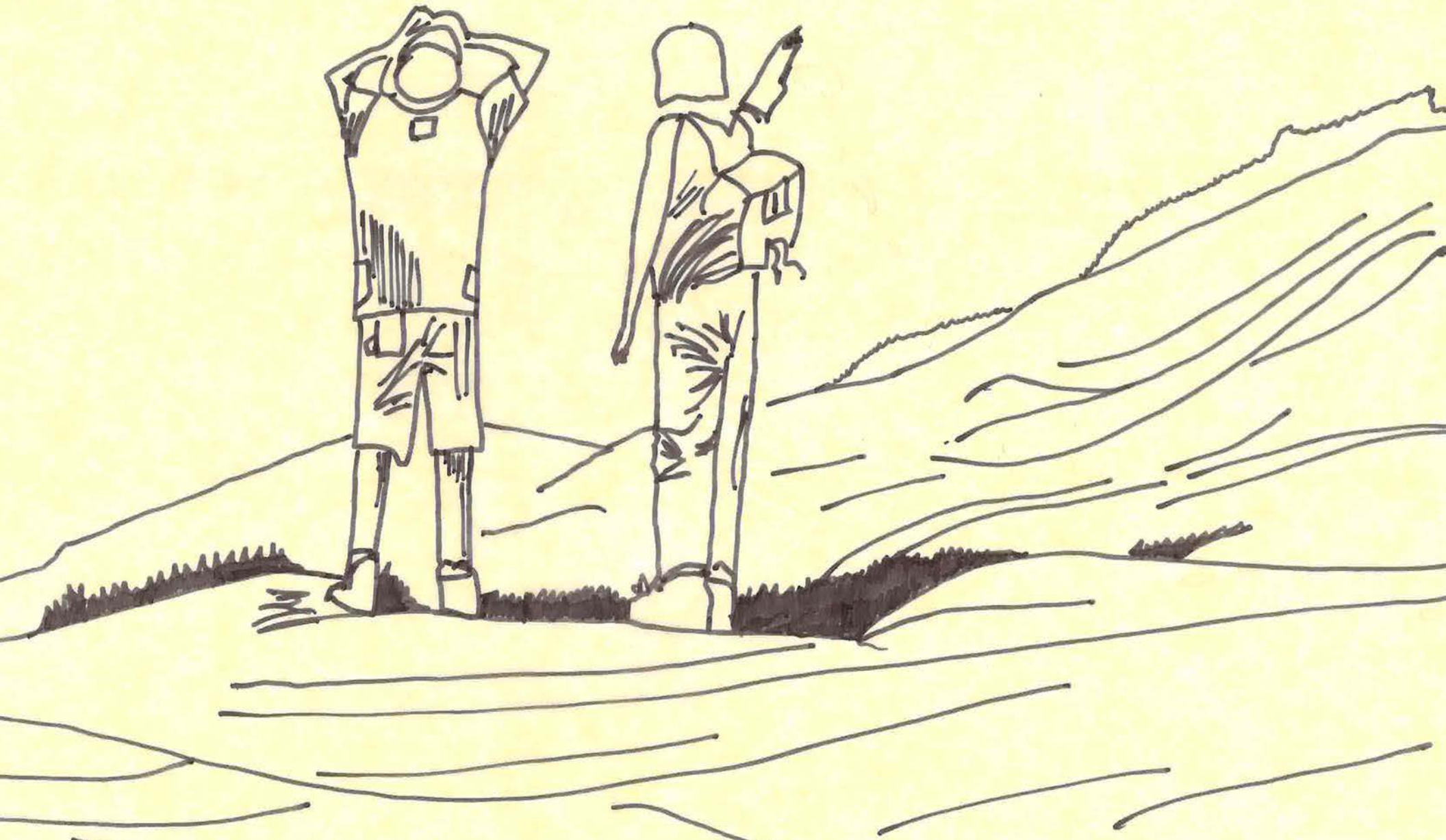
"Not only are land managers, nonprofit agency partners and future generations depending upon you, but our nation's precious public lands – their natural and cultural resources with their associated intrinsic resource values – are also depending upon you.

What role will you play in helping shape the mountain trail sustainability ethic in the 21st century?"

– *Sketchbook, 2007 edition*, page 156.

December 2014: Webinar 3 *Towards a Sustainability Ethic …*

1. Students will learn the importance of ***understanding*** and ***giving full consideration to*** all the cogs of the Trail Project Cycle including Lessons Learned & Pitfalls to Avoid.
2. Students will learn New Tools & Techniques and how these apply to Sustainable Mountain Trail project formulation.
3. Students will learn the Sustainable Mountain Trails *Sketchbook* / Workbook Training process and how this might apply to their Trail Networks.
4. Students will see an overview of Case Studies & Examples which demonstrate adherence to Mountain Trail Sustainability Guidelines.
5. "What Role Will You Play?" Students will be challenged to consider … New Partnerships, New Training Opportunities, and New Tools & Techniques to enhance the larger Sustainable Mountain Trails community.




Joe
Dawn

Question & Answer Time


End!