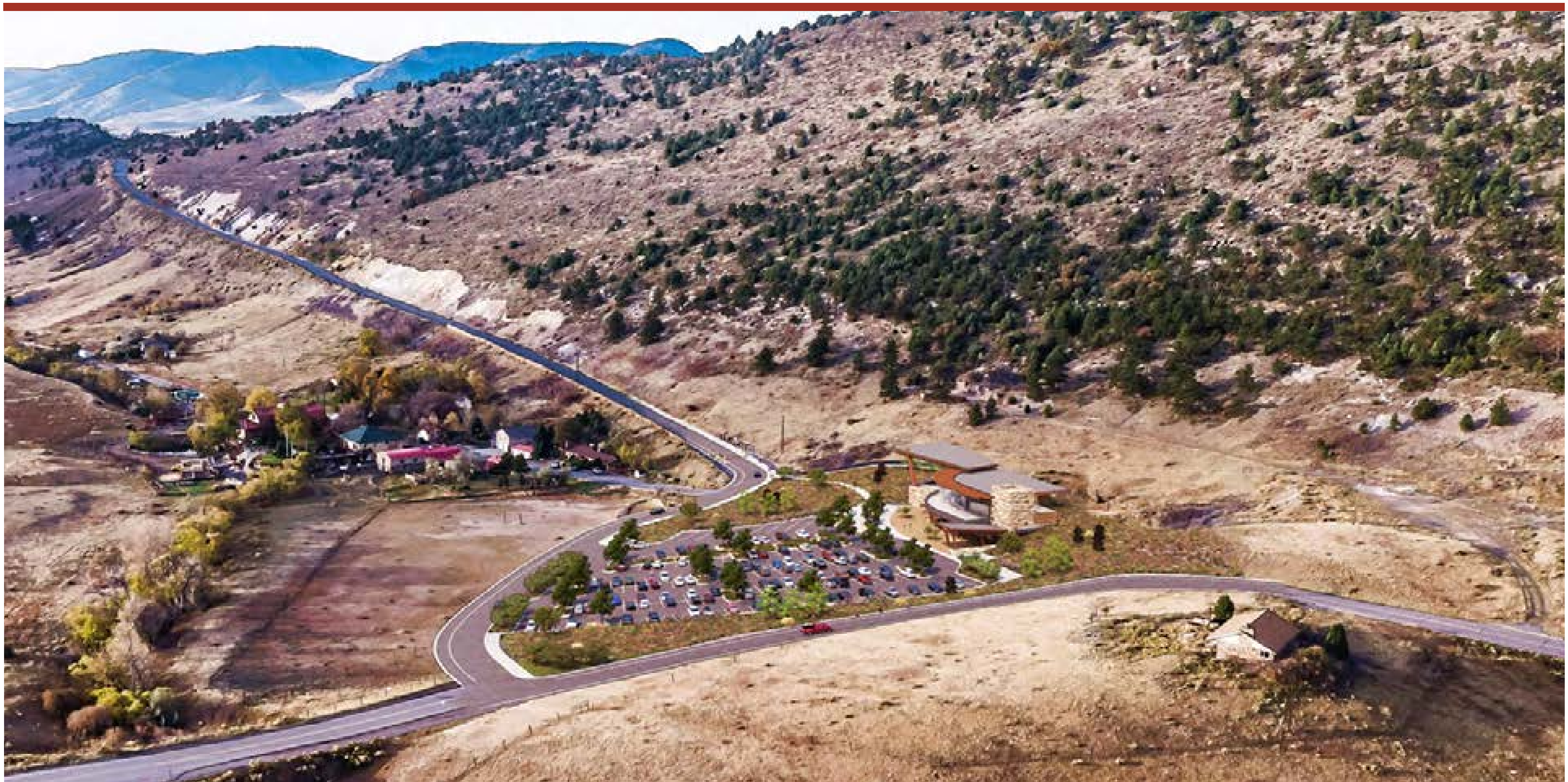
DINOSAUR RIDGE MASTER PLAN
JEFFERSON COUNTY, COLORADO



WESTRACKS
A JEFFCO RECREATION AREA

JEFFERSON COUNTY COLORADO Open Space

FRIENDS OF DINOSAUR RIDGE

NORRIS DESIGN

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INTRODUCTION & PURPOSE

INTRODUCTION

This report is intended to provide a consolidation of recommendations to improve visitor experience, resource preservation, recreation management, programming, facility and amenity functions at what is commonly known as Dinosaur Ridge. The area has an extensive history which can be explored through many publications and actual visitation to the existing Dinosaur Ridge Visitor Center.

The recommendations in the report should serve as a starting point for more detailed designs, engineering, and final construction documents. Some recommendations may be performed by Friends of Dinosaur Ridge and Jefferson County in-house personnel. Other recommendations may require formal development applications, bidding, and contracting. Friends of Dinosaur Ridge and Jefferson County Open Space will analyze these recommendations and determine the best methods for implementation.

All improvements are driven by one or more of the following three factors:

Visitor Safety (VS)

Visitor Experience (VE)

Resource Protection (RP)

DINOSAUR RIDGE OVERVIEW - AREAS OF FOCUS

Jefferson County Open Space - Matthews / Winters Park

1. Existing Dinosaur Ridge Visitor Center
2. Ute Council Tree
3. Alameda Parkway - Shoulder
4. Cretacious Gate (East Access)
5. Rooney Ranch
6. Crocodile Creek
7. Main Track Site
8. Ripple Marks
9. Trail Crossing
10. Ridge Plaza
11. Rock Cut
12. Raptor Site
13. Dakota Ridge
14. Brontosaurus Bulges
15. Bone Quarry
16. Bus Turnaround
17. Jurassic Gate (West Access)
18. Jurassic Gate Parking
19. Existing Dinosaur Ridge Discovery Center

GOALS & OBJECTIVES

GOALS & OBJECTIVES

Dinosaur Ridge and the Visitor Center is within Jefferson County Open Space (JCOS) Matthews / Winters Park and part of the greater Westracks Recreation Area. The Friends of Dinosaur Ridge (FODR) operate under a License Agreement from JCOS to provide education and preservation services at the Ridge. Most of the interpretive fossil sites on the ridge reside within the right of way (ROW) of Alameda Parkway, a county owned road that is closed to public traffic.

Infrastructure and exhibits on the ridge and at the visitor center have developed over the last 30 years without a cohesive plan or vision to guide the visitor experience and has resulted in a space that has the feeling of many individual projects. Visibility and visitation of the area has increased dramatically in recent years and has led to a need for better coordination of goals and objective between FODR and JCOS.

This Master plan identifies six joint goals and objectives. These include physical improvements as well as a better public understanding and utilization of Dinosaur Ridge.

1) Improve Visitor Safety

- Safer access from the Visitor Center to the Ridge Trail along Alameda Parkway and across the Rooney Road Intersection.
- Circulation and detangling of pedestrians, tour bus, and bicycle traffic on the Ridge Trail.
- Mitigation of rockfall concerns along the Ridge Trail and at individual sites.
- Limiting of visitor access during dangerous conditions.

2) Improve Resource Protection

- Rockfall mitigation.
- Drainage mitigation.
- Barriers and public education of human impacts.

3) Improve Visitor Experience

- Clearly define the pedestrian trail for safety, identification, wayfinding and overall "trail" experience.
- Unify the signage system into three distinct categories for easy recognition each with a constant look and aesthetic.
    - i. Regulatory
    - ii. Informational/Interpretive
    - iii. Wayfinding.
- Develop standards, guidelines, and details when making physical improvements that speak to the "Dinosaur Ridge" identity.
- Increase and improve the amount of shade along the Ridge Trail.

4) Determine the Future Visitor Center Location and Site Configuration

- A better and safer connection between the Visitor Center and the Ridge Trail.
- A facility to house a more ideal program of activities (to be further determined) – roughly 14,000 sf.
- Bathroom facilities accessible from the exterior of the building.
- A programmable outdoor educational plaza.
- At least 100 parking spaces and overflow parking opportunities.
- Bus parking and circulation accommodations.
- Better wayfinding and visitor orientation.

Potential Visitor Center Locations

5) Unify the Image and Brand of Dinosaur Ridge

- Rediscover the mission and purpose of Dinosaur Ridge.
- Identify Dinosaur Ridge in context with the Westracks Recreation Area and larger JCOS system.
- Examine the current branding collateral, styles, and executions of identification currently in use.
- Develop any modifications or refreshes to the Dinosaur Ridge brand.
- Identify how the Dinosaur Ridge brand can live within the overarching brand of the Westracks Recreation Area and the large identity of JCOS.
- Develop implementation methods for the refreshed brand.

FRIENDS OF DINOSAUR RIDGE

WESTRACKS
A JEFFCO RECREATION AREA

6) Unify and Align the Missions of FODR & JCOS

- Continue to improve on coordination and communication between the two groups.
- Clearly identify the roles and responsibilities between FODR, JCOS, and the larger Jefferson County Departments & Services.
- Strategic funding opportunities for prioritized projects and operations.
- Utilize the Westracks Recreation Area Brand with the Dinosaur Ridge sub-brand in joint public outreach and public relations efforts.

Preserve open space and parkland

Protect park and natural resources

Provide healthy, nature-based experiences

Jefferson County Open Space Mission Statement

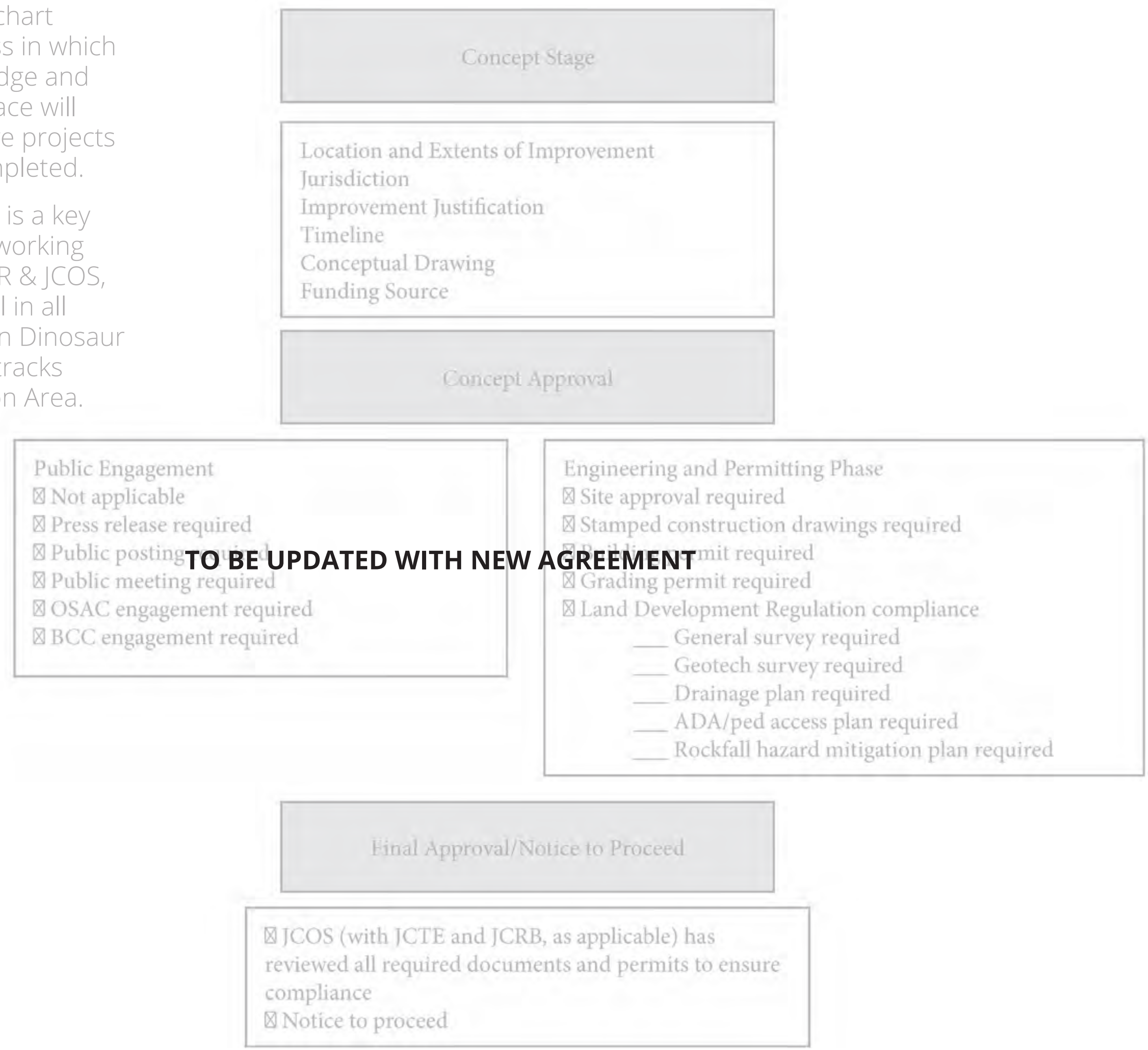
The mission of the Friends of Dinosaur Ridge is to educate the public about, and ensure the preservation of, the natural and historic resources of Dinosaur Ridge, Triceratops Trail, and the surrounding areas.

Friends of Dinosaur Ridge Mission Statement

DINOSAUR RIDGE PROJECT FLOW & PROCESS

The following project flow chart explains the formal process in which the Friends of Dinosaur Ridge and Jefferson County Open Space will use in collaboration to have projects within Dinosaur Ridge completed.

The project flow & process is a key element in the continued working relationship between FODR & JCOS, and will become a vital tool in all future project efforts within Dinosaur Ridge and the overall Westracks Jefferson County Recreation Area.



Preliminary Draft Dinosaur Ridge Project Flow chart provided by Jefferson County Open Space

MASTER PLAN KEY ITEMS & RECOMMENDATIONS

AREAS OF ACTION MATRIX

Key areas have been identified for various types of improvements to meet the goals and objectives. This matrix provides a quick reference outlining which goals are addressed, the priority of action, specific improvements, and broad cost estimates for each area.

Each 'Area of Action' is broken down into ***Short Term*** and ***Long Term*** goals, or improvements.
Short Term - Improvements that be addressed in the next few years, and can either be considered temporary or permanent solutions.
Long Term - Improvements that are intended to be addressed in the future or over a period of time, and when funds are available.

1. VS-Visitor Safety, RP-Resource Protection, VE-Visitor Experience
2. Improvement Priority: 1 (highest) - 3 (lowest)

Areas of Action	Goal Impacts	Priority	Specific Improvement	Estimated Cost
Proposed Visitor Center (See Pages 24-27)				
Short Term	VS/VE	1	Rooney Road & Alameda Boulevard Intersection Realignment	$289,000.00
Long Term	VS/VE	1	Visitor Center- Including: site work, building, and lanscaping	$4,850,000.00
			ESTIMATED TOTAL	**$5,139,000.00**
Circulation Improvements				
Existing Visitor Center to Ridge Trail (See Pages 28-29)				
Short Term	VS/VE	1	Regulatory & Wayfinding Signage, Striping, Enhanced Crosswalk Striping	$27,000.00
			ESTIMATED TOTAL	**$27,000.00**
Ridge Trail (See Pages 30-31)				
Short Term	VS	1	Repave Current Asphalt Road (Overlay), Striping, Regulatory Signage	$579,000.00
Long Term	VS	1	Concrete Pedestrian Trail, Integrated Drainage/Barrier Construction, Bus Drive Lane, Bike Travel Lane w/ Speed Control, Signage, Overlay Repaving	$1,963,000.00
			ESTIMATED TOTAL	**$2,542,000.00**
Dakota Ridge Trail (See Page 52)				
Short Term	VS	2	Regulatory Signage	$600.00
Long Term	VS	3	Barrier Fence, Wayfinding Signage	$22,350.00
			ESTIMATED TOTAL	**$22,950.00**

Areas of Action	Goal Impacts	Priority	Specific Improvement	Estimated Cost
Fossil Site Improvements				
Crocodile Creek (See Page 41)				
Short Term	RP	2	Regulatory Signage	$1300.00
Long Term	RP/VE	3	Rockfall Mitigation, Track Viewing Platform, Benches, Trash Receptacles, Barrier Fence	$140,000.00
			ESTIMATED TOTAL	**$141,300.00**
Main Track Site (See Page 42)				
Short Term	RP/VE	1	Regulatory Signage, Rockfall Mitigation, Minor Facility Improvements (paint), Replace Shade Cover on Structure	$77,000.00
Long Term	RP/VE	2…3	Track Cover, Barrier Fence, Trash Receptacle, Benches	$6,613,000.00
			ESTIMATED TOTAL	**$6,690,000.00**
Ripple Marks (See Page 43)				
Short Term	RP	2	Regulatory Signage, Rockfall Mitigation-Rockfall Fence	$230,000.00
Long Term	VE	3	Future Visitor Related Improvements, Rockfall Maintenance, Barrier Fence, Stone or Tilted Stone Seating	$54,000.00
			ESTIMATED TOTAL	**$284,000.00**
Raptor Site (See Page 44)				
Short Term	VS/RP	2	Regulatory Signage, Rockfall Mitigation, Replace Gate	$21,000.00
Long Term	VE	3	Wayfinding Signage, Barrier Fence, Reconfigure Exhibit	$19,000.00
			ESTIMATED TOTAL	**$40,000.00**
Rock Cut (*No Improvement Page Provided)				
Short Term	VS	1	Regulatory Signage "Keep Off", Rockfall Mitigation	$280,000.00
Long Term	RP/VE	3	Barrier Fence	$10,000.00
			ESTIMATED TOTAL	**$290,000.00**
Brontosaurus Bulges (See Page 45)				
Short Term	VS	1	Regulatory Signage, Rockfall Mitigation, Paint Railing	$117,000.00
Long Term	RP/VE	2	Barrier Fence, Stone/Tilted Stone Seating, Crusher Fines	$62,000.00
			ESTIMATED TOTAL	**$179,000.00**

AREAS OF ACTION MATRIX

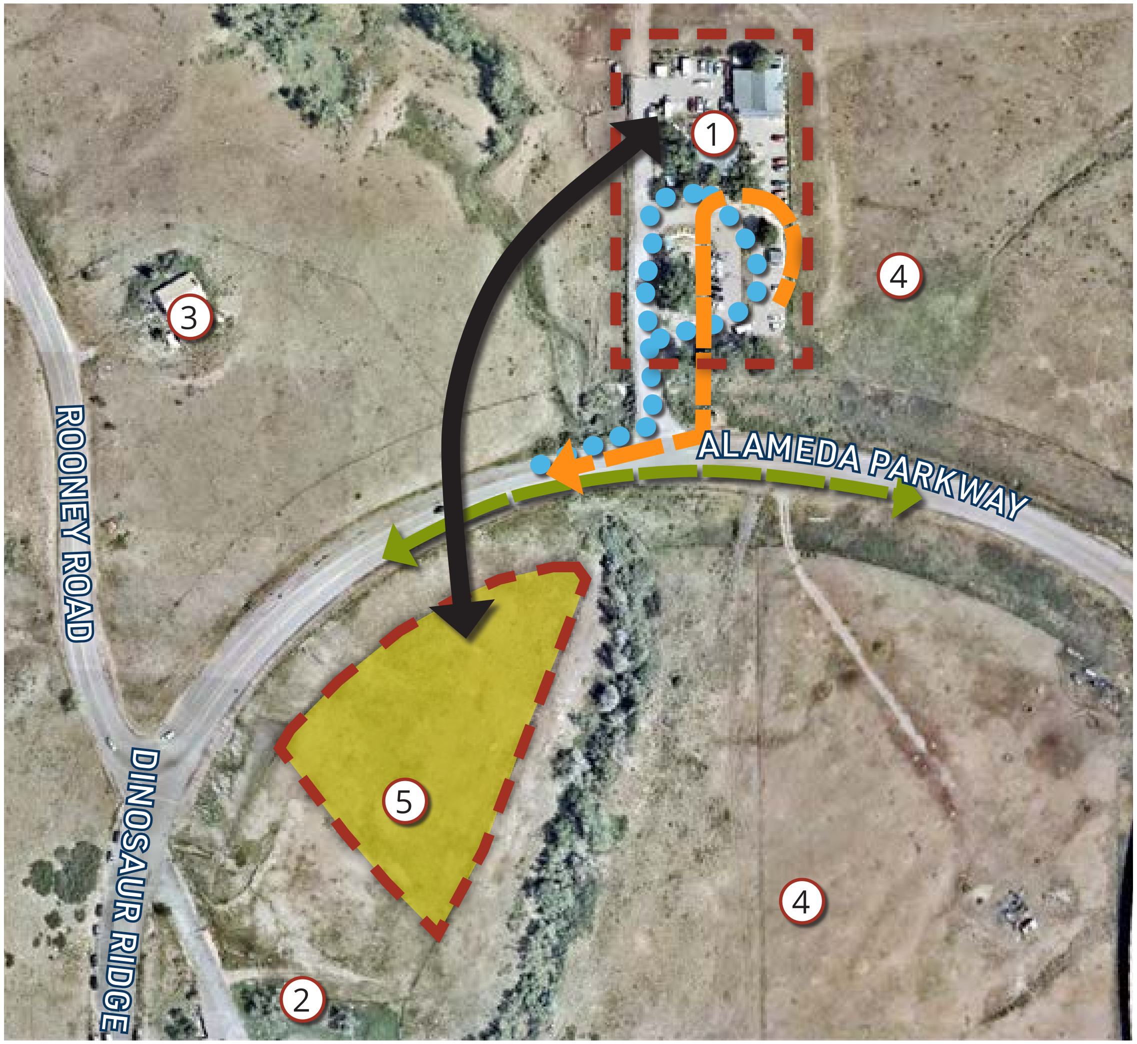
Areas of Action	Goal Impacts	Priority	Specific Improvement	Estimated Cost
Bone Quarry (See Page 46)				
Short Term	VS	1	Regulatory Signage, Rockfall Maintenance, Minor Facility Improvements (paint)	$22,000.00
Long Term	RP/VE	3	Stone/Tilted Seating, Barrier Fence, Trash Receptacle, Wayfinding Signage, Replace Roof, Chase Drains	$44,000.00
			ESTIMATED TOTAL	**$66,000.00**
Additional Site Improvements				
East Gate (Cretaceous) (See Pages 50-51)				
Short Term	VE	1	Regulatory Signage	$1,000.00
Long Term	VE	2	New Information Kiosk, Gate, Striping, Stone Columns, Barrier Fence, Wayfinding Signage	$82,000.00
			ESTIMATED TOTAL	**$83,000.00**
Ridge Plaza East & West (See Pages 54-57)				
Short Term	VS	1	Minor Structure Improvements-Paint, Regulatory Signage, Rockfall Mitigation-Spot Scaling and Rockfall Mesh	$109,000.00
Long Term	VE	3	Concrete Plaza, Vault Restroom, New Roof-Structures, Benches, Wayfinding Signage, Trash Receptacles, Barrier Fence, Bike Racks, Stone Columns	$1,742,000.00
			ESTIMATED TOTAL	**$1,851,000.00**
West Gate (Jurassic) (See Pages 58-59)				
Short Term	VE	1	Regulatory Signage	$1,000.00
Long Term	VE	2	New Information Kiosk, Gate, Striping, Stone Columns, Barrier Fence, Wayfinding Signage	$82,000.00
			ESTIMATED TOTAL	**$83,000.00**
Bus Turnaround (See Pages 60-61)				
Short Term	VS	1	Regulatory Signage, Traffic Control for Pedestrians-Striping, Determine Alternative Option (Use existing West Parking, Use Discovery Center, Etc)	$12,000.00
Long Term	VE	3	Update/Replace Buses, Add Port-o-Let at Location, Traffic Control for Pedestrians, Striping	$270,000.00
			ESTIMATED TOTAL	**$282,000.00**

Areas of Action	Goal Impacts	Priority	Specific Improvement	Estimated Cost
Port-o-Let (*No Improvement Page Provided)				
Short Term	VS	1	Relocation to Ridge Plaza	$500.00
			ESTIMATED TOTAL	**$500.00**
Informational Signage Program (See Pages 62-63)				
Short Term	VE	1	Information Signage program for all Fossil & Additional Site Improvements	$54,000.00
			ESTIMATED TOTAL	**$54,000.00**
Branding				
Short Term	VE	1	Update Main Signage with New FODR Logo	TBD
Long Term	VE	2	Incorporate Brand Book Standards with Any New Documents, Signage, Advertising, Physical Improvements, etc.	TBD
			ESTIMATED TOTAL	**TBD**
Management & Maintenance				
Short Term	VS, RP, VE	1	Revisit FODR, JCOS, JeffCo Road & Bridge Roles, Develop Review Schedules and Standards.	TBD
Short Term	VS, RP, VE	1	Develop Review Schedules and Standards, Spot Inspections After Storm & Freeze/Thaw Events,	TBD
			ESTIMATED TOTAL	**TBD**
			ESTIMATED GRAND TOTAL	**$17,774,000.00**
** Grand Total is an estimation based on the Short & Long Term Improvements listed above, and are subject to change.*				

NOTES:

1. All Estimated Costs have been rounded to the nearest 1,000.
2. A 10% contingency has been applied to all Site Improvements listed above, unless otherwise noted in the cost estimate breakdown.
3. A cost estimate breakdown is provided within the Supporting Documents portion of this Master Plan Document. Please reference pages 87-93 for additional information.
4. All road, curb and gutter, raised concrete curb, stained concrete walk, and striping improvements are identified in the Ridge Trail Improvements found under Circulation Improvements, and NOT in the individual Site Improvements.

VISITOR CENTER - CURRENT STATUS



ADJACENT PROPERTY USES

1. Existing Visitor Center (To Be Exchanged)
2. Rooney Ranch
3. Grandma Rooney's House
4. Future Foothills Parkway Business Park
5. Future Open Space Property For Dinosaur Ridge

CIRCULATION KEY

- Bike Circulation
- Bus Circulation
- Pedestrian Circulation
- Land Swap

ARCHITECTURAL CHARACTER

A sweeping roof-line, site trellis and overall site circulation should create a strong connection as visitors approach the welcome plaza.

Visitor amenities are available at the plaza such as stroller parking, seating areas in the shade, and picnic areas.

Situated among native water-wise plantings, the site plazas and pathways should provide visitors with options for exploring the indoor and outdoor facilities as well as the environment and natural setting.

Large glass curtain walls should face the south and east toward the valley and mountain views beyond.

Interior spaces include the liberal use of glazed walls, providing focused views from the central building atrium, exhibits, and offices.

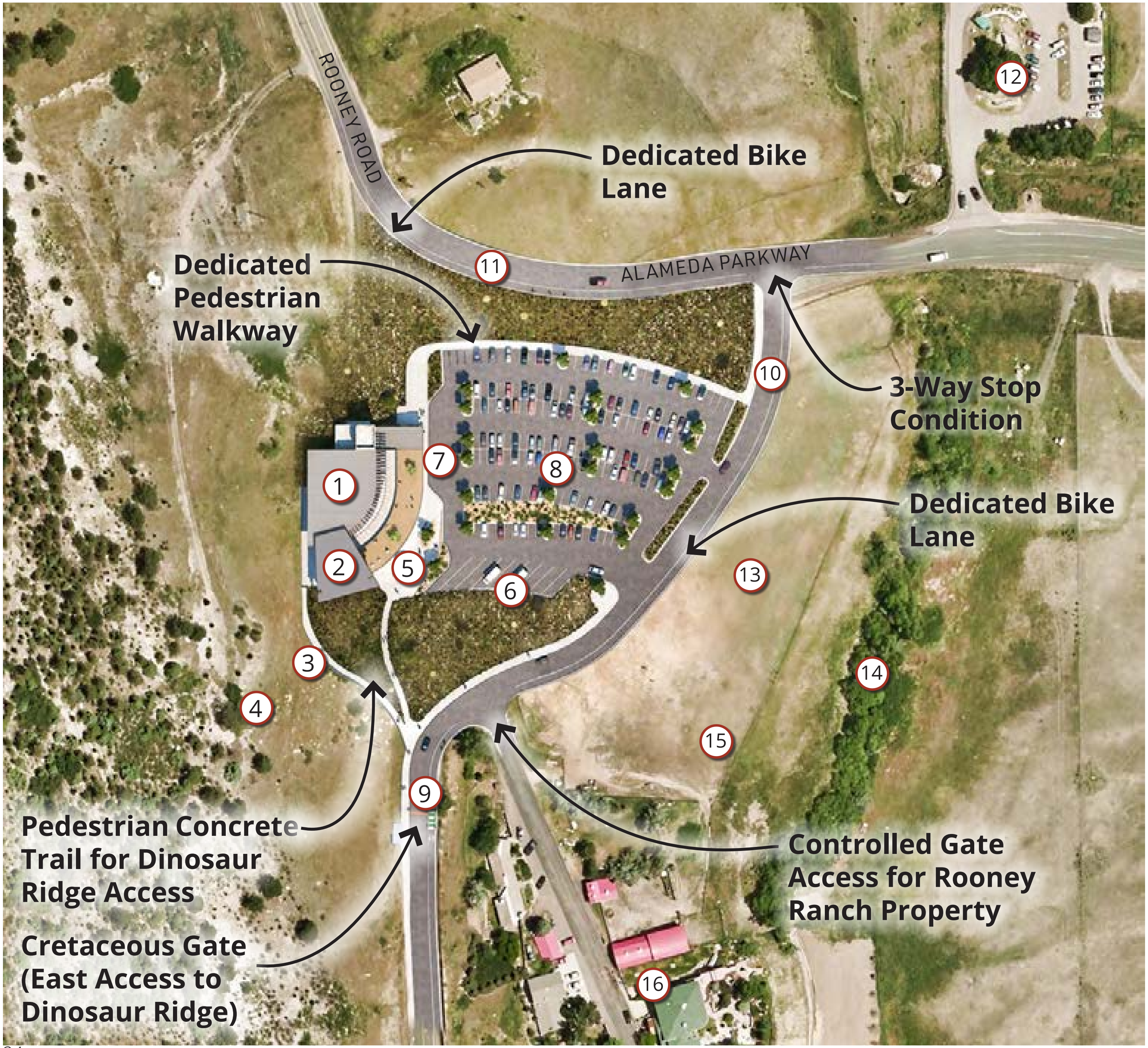
Site walls are constructed from local stone and provide delineation of outdoor areas that create small micro-climates protecting select planting areas.

A shade structure provides respite from the elements with built-in seating and a walkway that connects the main entrance to the proposed outdoor demonstration area.

An interpretive walkway traces the side of the building, connecting the surrounding landscape to a plaza that offers views. Descriptions of this distinctive landscape and destination are provided through interpretive signage located along the pathway.

The plaza looks out over the valley, and includes a demonstration area which is used for educational events at the Visitor Center.

VISITOR CENTER SITE PLAN & CONSIDERATIONS



1. Visitor Center
2. Visitor Center Overlook Deck and Education Gathering Space
3. Ute Council Tree Interpretive Sign Location
4. Ute Council Tree
5. Ground Level Plaza
6. Bus Parking
7. Visitor Drop-off & Bus Hub
8. Parking Lot
9. East Gate (Cretaceous)
10. Access Drive
11. Realign Rooney Road and Alameda for Through Traffic
12. Existing Visitor Center - To Be Relocated
13. Potential Overflow Parking Area
14. Existing Rooney Gulch
15. Detention Pond
16. Existing Rooney Ranch

KEY SITE PLAN & BUILDING CONSIDERATIONS

1. Located adjacent to the Ridge Trail access.
2. Realigns the Alameda Road and Rooney Road to improve multimodal circulation..
3. Locates all facilities south of Alameda to avoided pedestrian vehicular conflicts.
4. Allows for safer and more traditional intersection movements.
5. Clearly define pedestrian, bicycle and vehicular routes and lanes.
6. Aligns focus of building to the Ridge Trail.
7. Provides prominent entry visible from the Alameda access and good parking lot relationship.
8. Provides substantial parking with overflow parking opportunities.
9. Provide bus parking and staging.
10. Provides direct vehicular access to the Ridge Trail road lanes. Maintains a dedicated access point and gated entry to the
11. Rooney Ranch facilities.
12. Provides large shaded patio area for group gatherings, presentations, and event hosting.
13. Provides exterior bathroom access.
14. Provides multi-floor access to the Ridge Trail.
15. Provides good visibility and interpretive opportunities to the Ute Council Tree while not providing direct access.
16. Conforms to the spirit of Front Range Mountain Backdrop Report.
17. Building may require above average Geotechnical and Drainage remedies.

VISITOR CENTER - NORTHEAST VIEW

1. Visitor Center
2. Visitor Center Overlook Deck and Education Gathering Space
3. Ute Council Tree Interpretive Sign Location
4. Ute Council Tree
5. Ground Level Plaza
6. Bus Parking
7. Visitor Drop-off & Bus Hub
8. Parking Lot
9. East Gate (Cretaceous)
10. Access Drive
11. Realign Rooney Road and Alameda for Through Traffic
12. Existing Visitor Center - To Be Relocated
13. Potential Overflow Parking Area
14. Existing Rooney Gulch
15. Detention Pond
16. Existing Rooney Ranch

VISITOR CENTER - SOUTHWEST VIEW

1. Visitor Center
2. Visitor Center Overlook Deck and Education Gathering Space
3. Ute Council Tree Interpretive Sign Location
4. Ute Council Tree
5. Ground Level Plaza
6. Bus Parking
7. Visitor Drop-off & Bus Hub
8. Parking Lot
9. East Gate (Cretaceous)
10. Access Drive
11. Realign Rooney Road and Alameda for Through Traffic
12. Existing Visitor Center - To Be Relocated
13. Potential Overflow Parking Area
14. Existing Rooney Gulch
15. Detention Pond
16. Existing Rooney Ranch

EXISTING CONFLICT

(1) Pedestrian Circulation

PROPOSED SOLUTION

(1) Pedestrian Crossing Warning Device

Prior to the relocation of the current visitor center, key improvements have been identified to improve visitor safety until such time the visitor center is moved. Due to concerns regarding the increasing year over year visitor numbers and the continued tangling of pedestrians and vehicular traffic along Rooney Road and Alameda Parkway.

Key improvement recommendations:

1. Install additional pedestrian crossing warning devices at the intersection of Rooney Road and Alameda Parkway.
2. Re-stripe the crosswalk with high visibility striping.
3. Delineate edge of pedestrian walk to prevent overhang by parked vehicles.

CIRCULATION IMPROVEMENTS - VISITOR CENTER TO RIDGE TRAIL

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Visitor Experience (VE)

SHORT TERM SOLUTIONS

1. Delineate edge of pedestrian walk with striping to discourage overhang by parked vehicles.
2. Stripe Intersection with High Visibility Striping

LONG TERM SOLUTIONS

3. Install Pedestrian Crossing Warning Device
4. New Visitor Center Location and Circulation Improvements

VEHICULAR OVERHANG
Delineate edge of pedestrian walk with striping to discourage overhang by parked vehicles impeding pedestrian circulation flow.

Example of a Pedestrian Crossing Warning Device

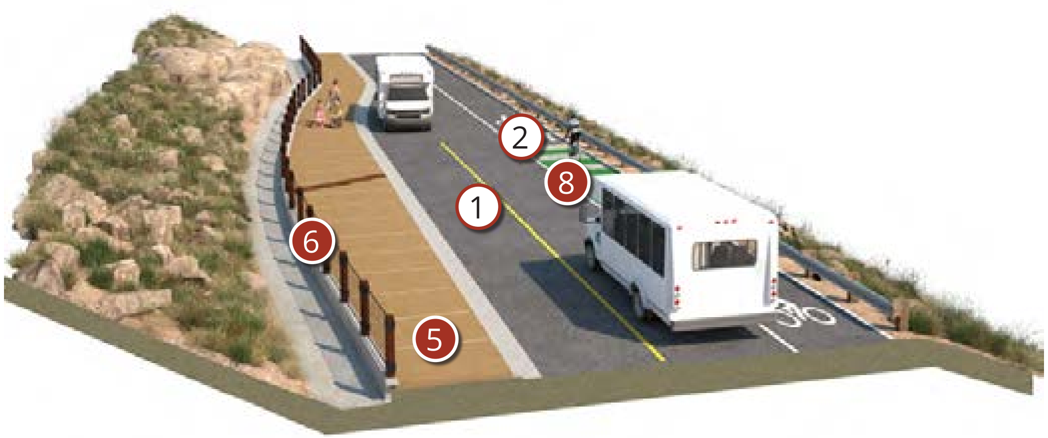
CIRCULATION IMPROVEMENTS - RIDGE TRAIL

The current ridge trail experience is shared by pedestrian visitors, tour buses, cyclists passing through the old Alameda Parkway/ Dakota Ridge road cut, and travelers of the Dakota Ridge Trail that crosses the Ridge Trail at the Road Cut. All of these visitors are sharing the old Alameda Parkway road section. The available cross section along the old roadway is limited to needed drainage improvements on the upslope side and a guard rail and steep drop-off on the down side of the ridge. The available width varies widely along the trail from 28'-0" to 52'-0". This master plan identifies the division of travel lanes between pedestrians, buses and cyclists. While pedestrians have priority, buses must yield to cyclists. Visitor Safety (VS) and Visitor Experience (VE) are key goal impacts in these recommendations.

The current pavement section is in desperate need for replacement. Depending on available funds, the application of the recommendations in this report may need to be phased. Jefferson County Transportation and Engineering has indicated they are able to implement the culvert replacements and provide a pavement overlay and striping immediately. Improvements to the pavement should be done in conjunction with the sidewalk and drainage improvements. If the walk and drainage improvements cannot be accommodated in the first phase, considerations should be made as to how they will be added in a later design and construction phase.

Available Road Widths

CIRCULATION IMPROVEMENTS - RIDGE TRAIL



One Way Traffic Road Section, Typical
Refer to Page 32 for additional information

MAXIMUM RIDGE TRAIL WIDTHS

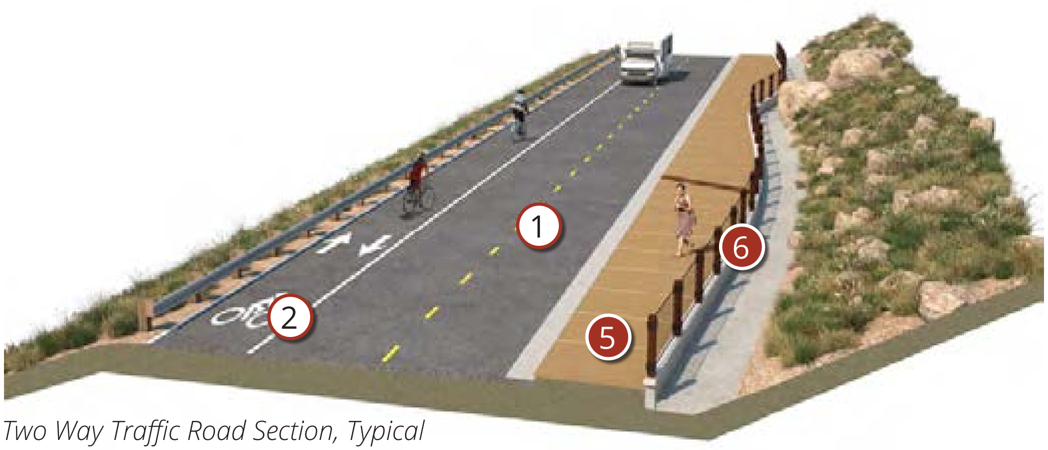
XX' Various Road Widths

SHORT TERM SOLUTIONS

1. Repave Current Asphalt Road
2. Pedestrian, Bus, Bike Travel Lane Striping
3. Bike Travel Lane Speed Control
4. Wayfinding Signage

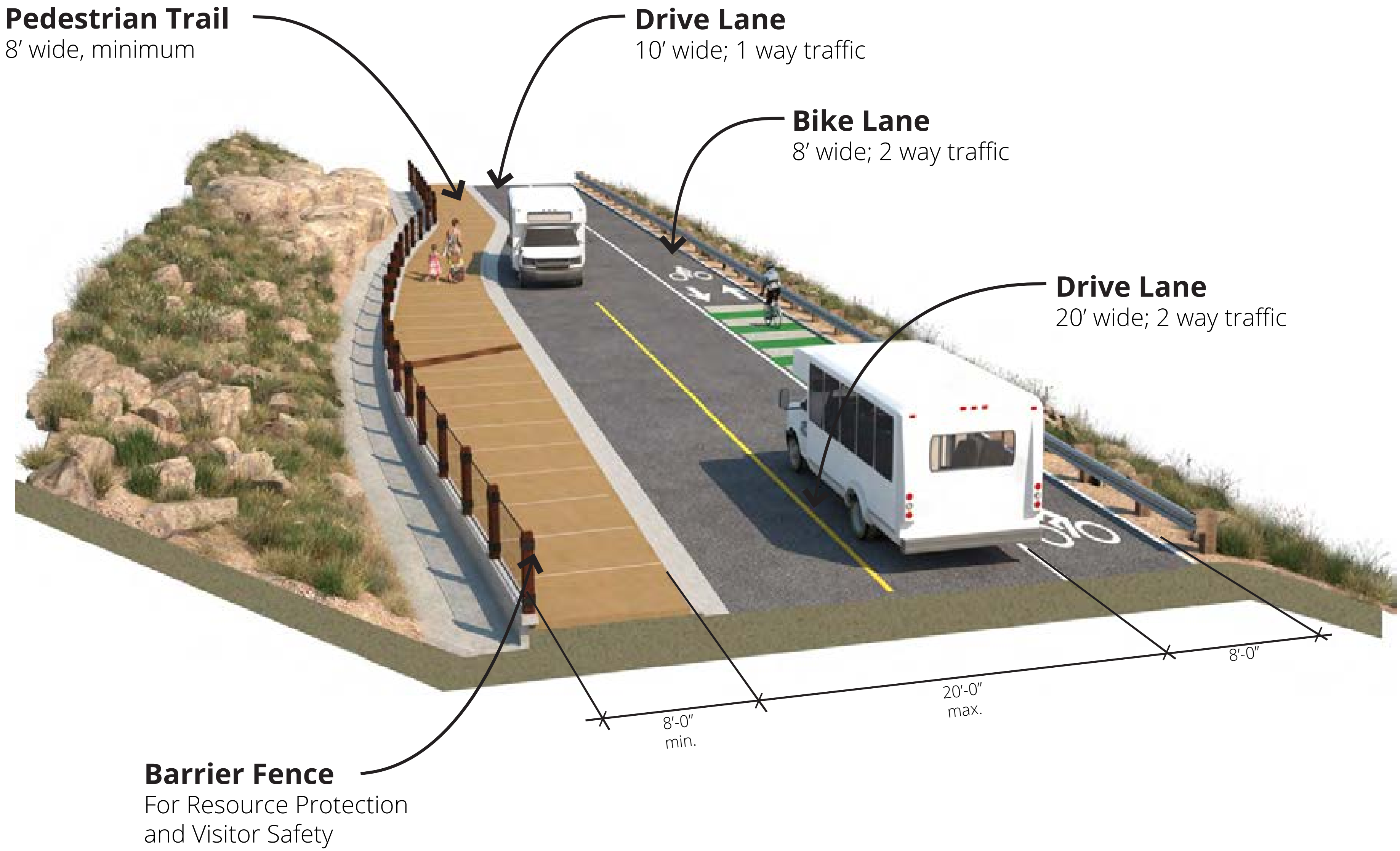
LONG TERM SOLUTIONS

5. Concrete Pedestrian Trail
6. Integrated Drainage/Barrier Construction
7. Additional Signage
8. Bike Lane Designation Paint

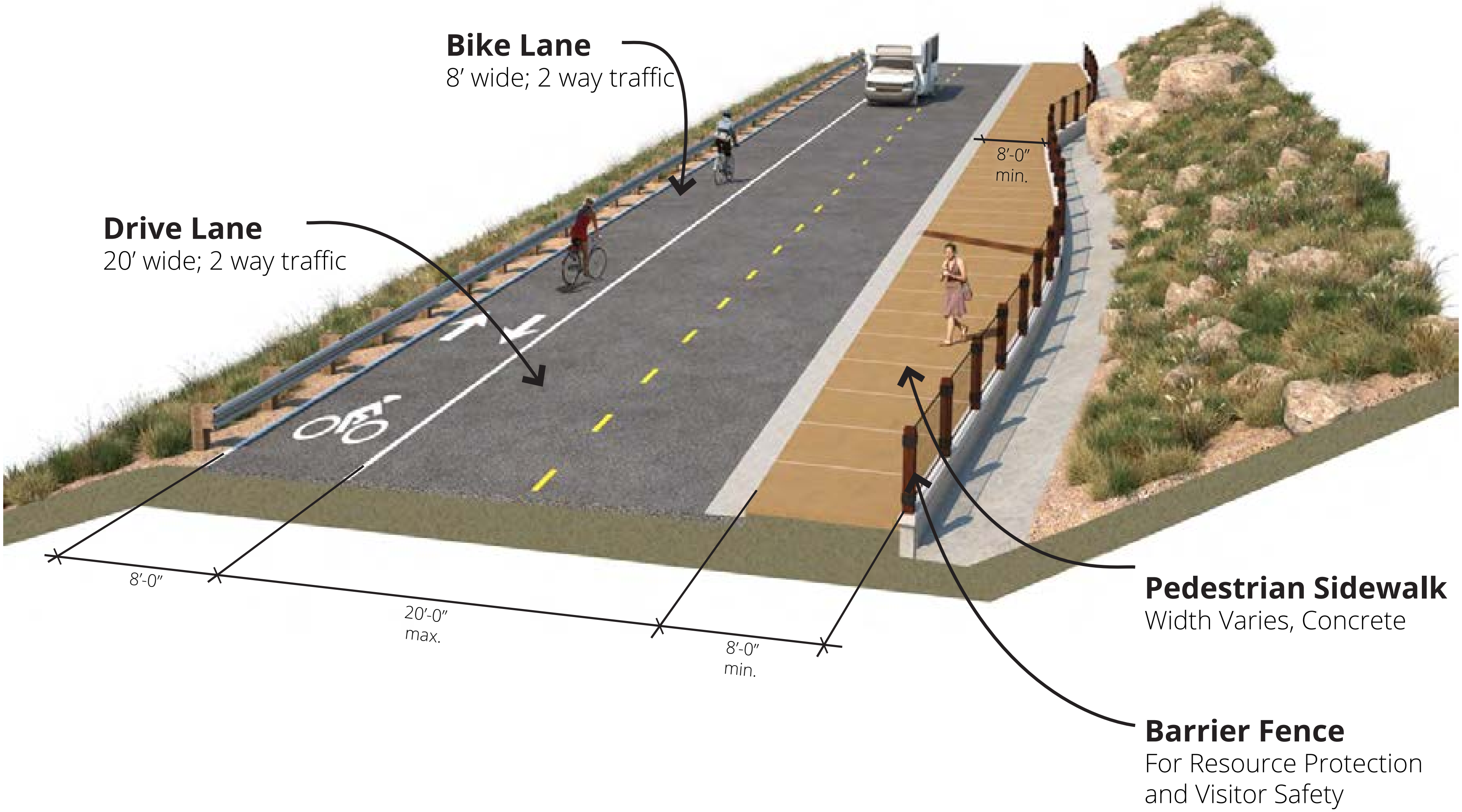


Two Way Traffic Road Section, Typical
Refer to Page 33 for additional information

CIRCULATION - VARIED SIDEWALK SEGMENT - ONE WAY TRAFFIC



CIRCULATION - VARIED SIDEWALK SEGMENT - TWO WAY TRAFFIC



ROCKFALL IMPROVEMENTS

Jefferson County Open Space (JCOS) has requested a site plan for the Dinosaur Ridge Recreation Area to enhance visitor experience and improve resource preservation, recreation management, programming, park facilities, and site amenities. As part of the overall site plan and future site-specific preservation projects, JCOS has requested a geologic hazard study of ridge areas above Alameda Parkway within the recreation area. Conceptual level pavement rehabilitation options have also been requested for Alameda Avenue. Rockfall is the primary geologic hazard present at the sites identified on Dinosaur Ridge. The rockfall hazard rating and recommended conceptual level rockfall mitigation for eight sites in Dinosaur Ridge Recreation Area are summarized in the following table.

Please refer to **Appendix - A** for the full Geologic Hazard Study & Pavement Recommendations.

ROCKFALL IMPROVEMENTS

	Site	Rockfall Hazard Rating	Recommended Rockfall Mitigation
1	Crocodile Creek	Moderate	• Spot scaling • Rock Dowels
2	North of Main Track Site	High	• Spot scaling • Clean catchment • Maintain pedestrian barrier • Drainage improvements
3	South of Main Track Site	Moderate	• Spot scaling • Buttress • Pedestrian barrier
4	North side of cut at upper curve	High	• Spot scaling • Extend rockfall mesh
5	South side of cut at upper curve	Moderate	• Spot scaling • Clean catchment • Pedestrian barrier
6	Brontosaurus Bulges	Moderate	• Spot scaling • Rockfall fence • Drainage improvements
7	Between Brontosaurus Bulges and Dinosaur Bone Site	Moderate	• Spot scaling • Pedestrian barrier • Catchment area
8	Dinosaur Bone Site	Moderate	• Spot scaling • Drainage improvements

DRAINAGE IMPROVEMENTS - CULVERTS

1 Culvert 1
2 Culvert 2
3 Culvert 3
S Side Culvert
4 Culvert 4
5 Culvert 5

DRAINAGE IMPROVEMENTS - CULVERTS

	Culvert	Existing Q10/CFS	Existing Size/In	Existing Undersized	Proposed Q10/CFS	Proposed Size/In
1	Culvert 1	11.4	18	Yes	34.7	42
2	Culvert 2	17	24	No	7.5	24
3	Culvert 3	7.1	18	No	7.1	24
4	Culvert 4	1.7	18	No	1.7	18
5	Culvert 5	9.4	18	No	3.9	18
S	Side Culvert	7.1	18	No	7.1	24

DRAINAGE IMPROVEMENTS - DITCHES

1 Ditch 1

2 Ditch 2

t1 Tracks Ditch 1

t2 Tracks Ditch 2

3 Ditch 3

4 Ditch 4

b1 Bulges Ditch

b2 Bones Ditch

5 Ditch 5

DRAINAGE DITCH KEY

- Roadside Ditch Typical Section 1
- Roadside Ditch Typical Section 2
- Upper Ditch Typical Section
- Natural Swale/Ditch Section

Please refer to **Appendix - B** for the full Final Conceptual Drainage Report created by Muller Engineering Company.

DRAINAGE IMPROVEMENTS - DITCHES

	Ditch Name	Proposed Q10/CFS	Typical Section 1		Typical Section 2	
			Depth/FT	Velocity/FPS	Depth/FT	Velocity/FPS
1	Ditch 1	34.7	1.3	13.7	1.5	14.6
2	Ditch 2	7.5	0.9	9.8	0.9	10.5
t1	Tracks Ditch 1	0.8	0.6	5.1	N/A	N/A
t2	Tracks Ditch 2	9.8	0.9	12.6	0.9	13.4
3	Ditch 3	7.1	0.9	9.6	0.9	10.3
4	Ditch 4	1.7	0.7	5.1	0.7	5.4
b1	Bulges Ditch	2.2	0.7	6.2	0.8	6.6
b2	Bones Ditch	2.2	0.7	6.1	N/A	N/A
5	Ditch 5	3.9	0.8	6.1	0.8	7.6

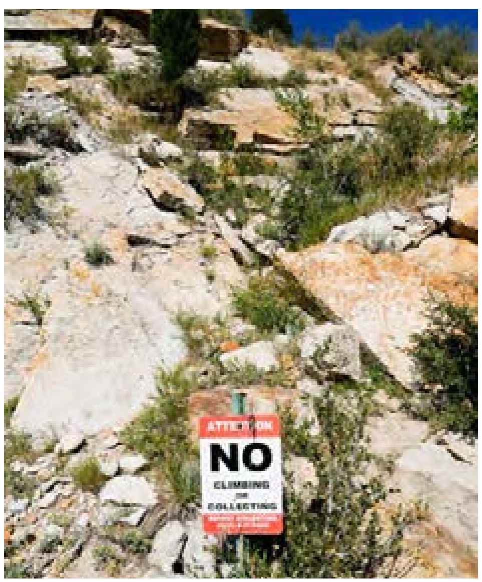
FOSSIL SITE IMPROVEMENTS

1. Crocodile Creek
2. Tracks Site
3. Ripple Marks
4. Raptor Site
5. Brontosaurus Bulges
6. Bone Quarry

This master plan identifies a number of improvements for each fossil site. These represent a consolidation of recommendations from stakeholder discussions, engineering recommendations, and on-site observations. These recommendations are intended to serve as preliminary designs. The recommendations have been broken into short term and long-term improvements to help with prioritization and phasing of the various recommendations.

CROCODILE CREEK

S Site Location - Crocodile Creek



Existing Site Photos - Crocodile Creek Site

Recommended Improvements

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Resource Protection (RP)
3. Visitor Experience (VE)

SHORT TERM SOLUTIONS

1 Regulatory Signage

2 Bike Lane Striping

LONG TERM SOLUTIONS

3 Track Viewing Platform

4 Informational Signage

5 Rockfall Mitigation

6 Rockfall Maintenance

7 Bike Lane Designation Paint

8 Stone or Tilted Stone Seating

9 Drainage Improvement- Roadside Ditch Typical Section 2

10 Drainage Improvement- Upper Ditch Typical Section

Proposed Crocodile Creek Exhibit Model

MAIN TRACK SITE

S *Site Location - Tracks Site*

Existing Site Photo - Tracks Site Exhibit

Recommended Improvements

Proposed Track Cover - Dan O'Brien, Architect

IMPROVEMENT NEEDS

1. Resource Protection (RP)
2. Visitor Experience (VE)

SHORT TERM SOLUTIONS

1. Rockfall Mitigation
2. Paint Structure
3. Regulatory Signage
4. Bike Lane Striping
5. Replace Shade Cover

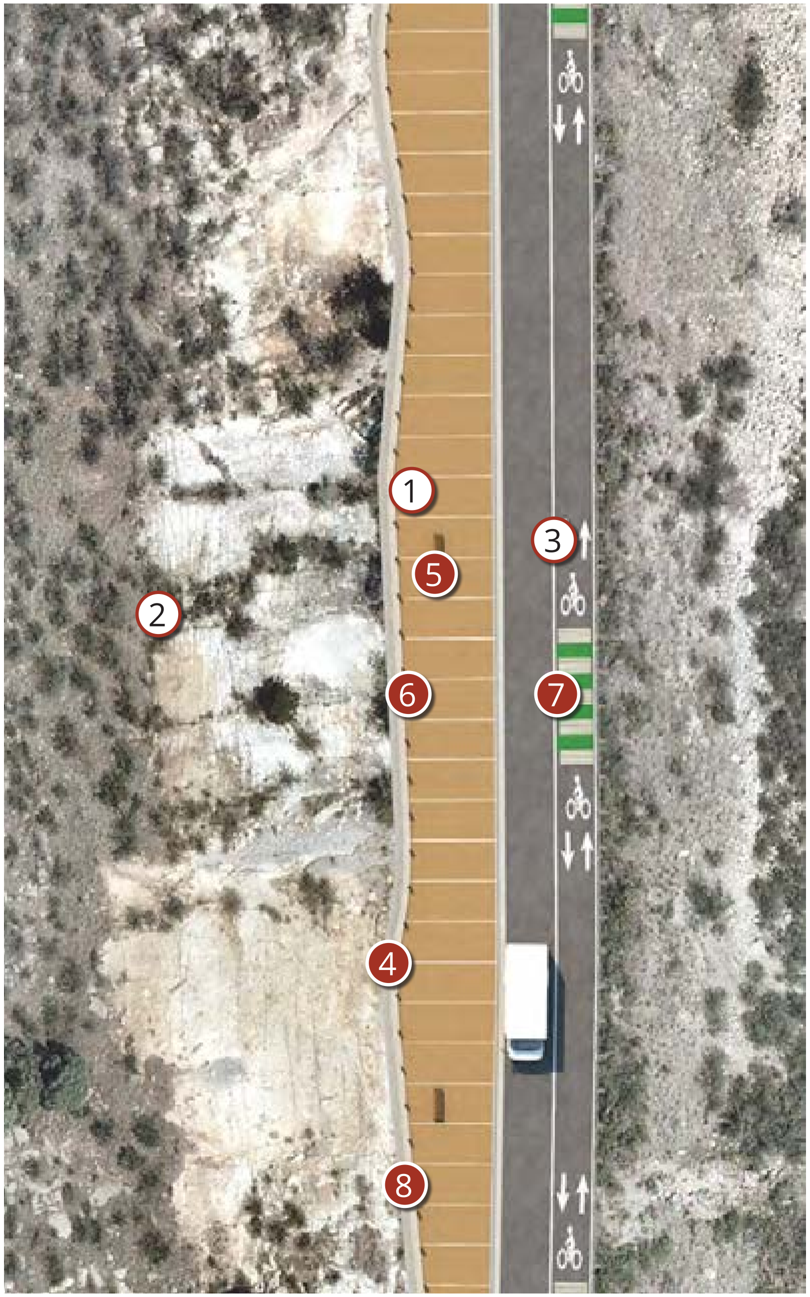
LONG TERM SOLUTIONS

5. Track Cover
6. New Information Signage
7. Barrier Fence
8. Bike Lane Designation Paint
9. Trash Receptacle
10. Drainage Improvement- Roadside Ditch Typical Section 2
11. Drainage Improvement- Upper Ditch Typical Section

RIPPLE MARKS

Ⓢ *Site Location - Ripple Marks*

Existing Site Photos - Ripple Marks Site



Recommended Improvements

IMPROVEMENT NEEDS

1. Resource Protection (RP)
2. Visitor Experience (VE)

SHORT TERM SOLUTIONS

① Regulatory Signage

② Rockfall Mitigation

③ Bike Lane Striping

LONG TERM SOLUTIONS

④ Barrier Fence

⑤ Stone or Tilted Stone Seating

⑥ Informational Signage

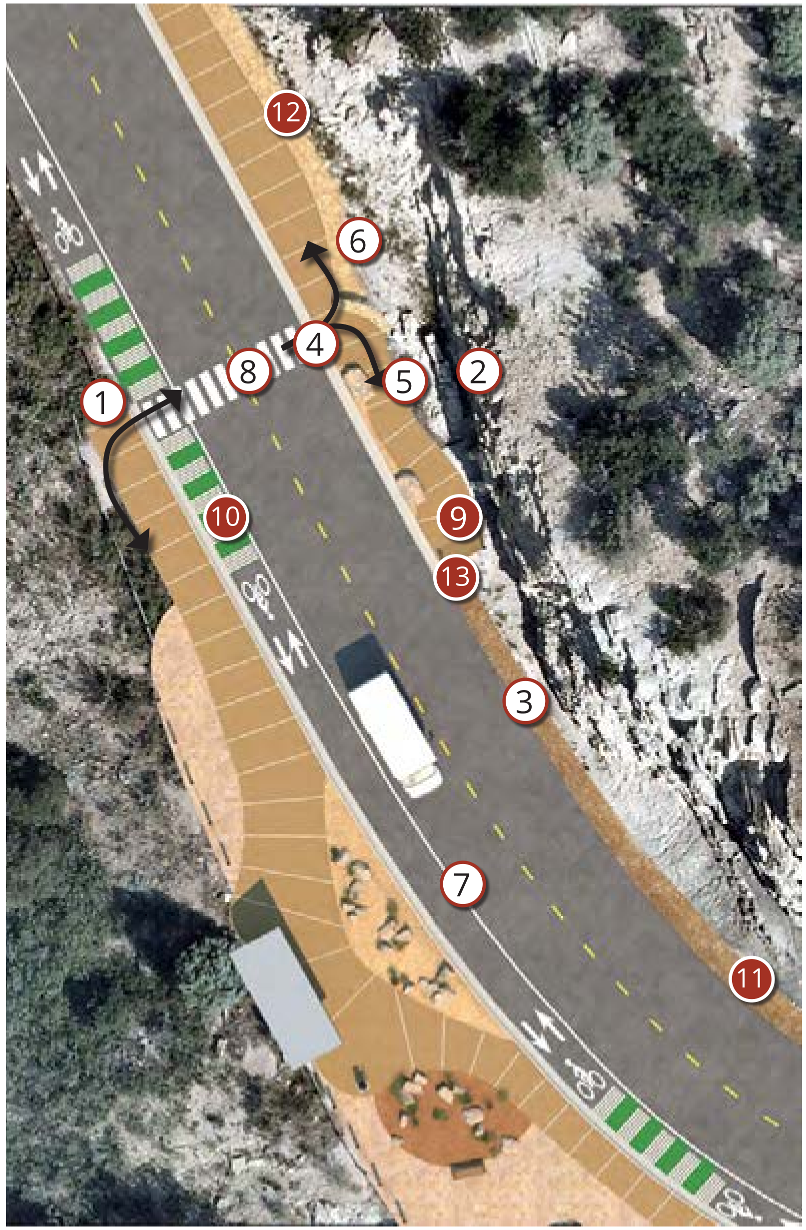
⑦ Bike Lane Designation Paint

⑧ Drainage Improvement- Roadside Ditch Typical Section 2

RAPTOR SITE

S *Site Location - Raptor Site*

Existing Site Photo - Raptor Site Exhibit



Recommended Improvements

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Resource Protection (RP)
3. Visitor Experience (VE)

SHORT TERM SOLUTIONS

1 Wayfinding Signage

2 Rockfall Mitigation

3 Remove Jersey Barrier after Rockfall Mitigation

4 Improve ADA Access-Expand Concrete Plaza

5 Replace Gate

6 Informational/ Interpretive Signage

7 Bike Lane Striping

8 Marked Pedestrian Crossing

LONG TERM SOLUTIONS

9 Reconfigure Exhibit

10 Bike Lane Designation Paint

11 Drainage Improvement-Natural Swale/Ditch Section

12 Drainage Improvement-Roadside Ditch Typical Section 2

13 Barrier Fence

BRONTOSAURUS BULGES

S *Site Location - Brontosaurus Bulges*

Existing Site Photo - Brontosaurus Bulges Exhibit

Recommended Improvements

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Resource Protection (RP)
3. Visitor Experience (VE)

SHORT TERM SOLUTIONS

1. Regulatory Signage
2. Rockfall/Drainage Mitigation
3. Paint Railing
4. Bike Lane Striping

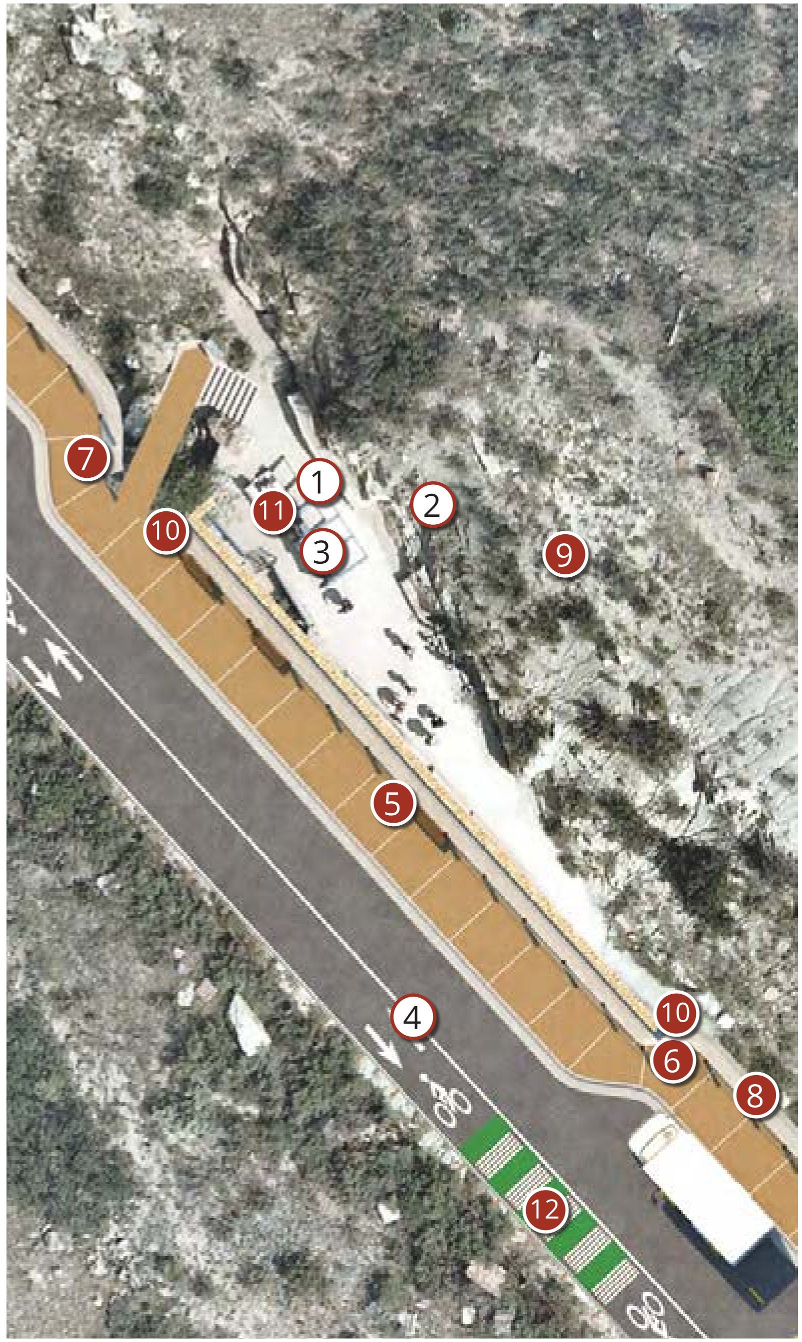
LONG TERM SOLUTIONS

5. Informational/ Interpretive Signage
6. Bike Lane Designation Paint
7. Drainage Improvement- Roadside Ditch Typical Section 2

BONE QUARRY

S *Site Location - Bone Quarry*

Existing Site Photo - Bone Quarry



Recommended Improvements

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Resource Protection (RP)
3. Visitor Experience (VE)

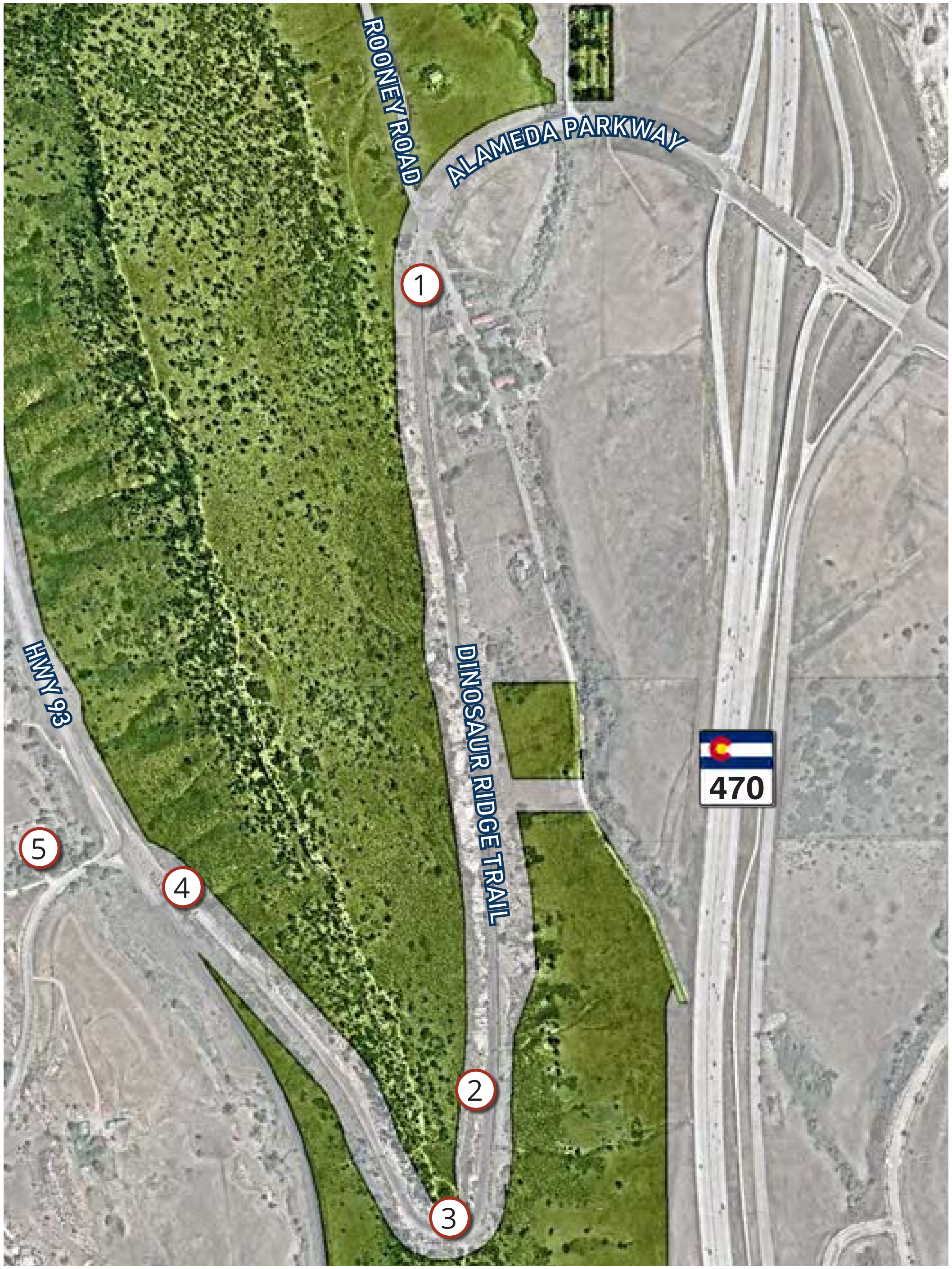
SHORT TERM SOLUTIONS

1. Regulatory Signage
2. Rockfall Mitigation
3. Paint Structure
4. Bike Line Striping

LONG TERM SOLUTIONS

5. Stone or Tilted Stone Seating
6. Barrier Fence
7. Wayfinding Signage
8. Drainage Improvement- Roadside Ditch Typical Section 1
9. Drainage Improvement- Upper Ditch Typical Section
10. Install Chase Drains
11. Replace Roof
12. Bike Lane Designation Paint

ADDITIONAL SITE IMPROVEMENTS



1. Cretaceous Gate (East Access)
2. Dakota Ridge Trail North Access/Crossing
3. Ridge Plaza
   - a. Valley History
   - b. East Overlook Shelter
   - c. Dakota Ridge Trail South Access
   - d. West Overlook Shelter
4. Jurassic Gate (West Access)
5. Bus Turnaround at Discovery Center

This master plan identifies a number of non-fossil site improvements. These represent a consolidation of recommendations from stakeholder discussions, engineering recommendations, and on-site observations. These recommendations are intended to serve as preliminary designs. The recommendations have been broken into short term and long-term improvements to help with prioritization and phasing of the various recommendations.

CRETACEOUS GATE (EAST ACCESS)

Ⓢ *Site Location - Cretaceous Gate*

Existing Site Photos - Cretaceous Gate (East Access)

IMPROVEMENT NEEDS

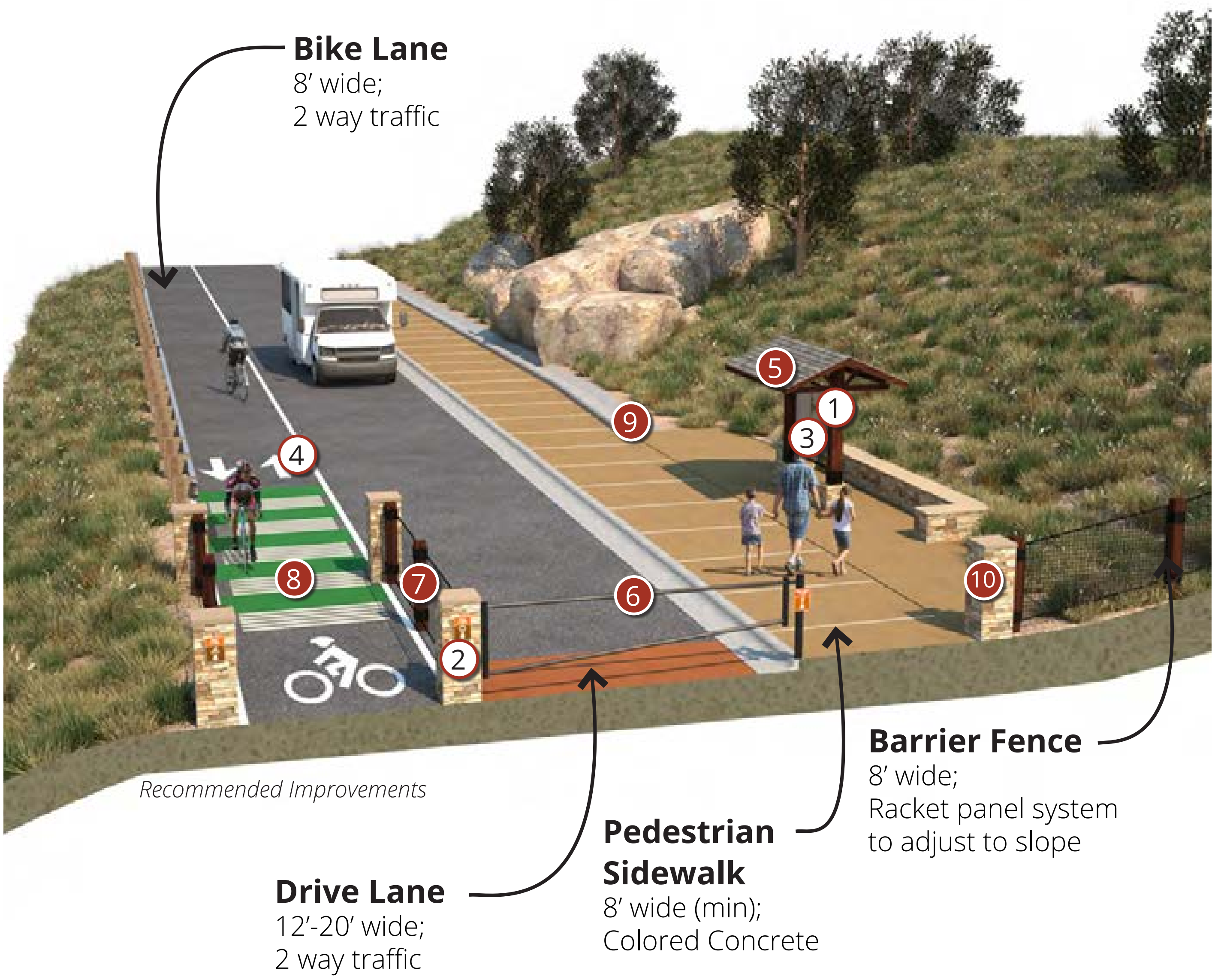
1. Visitor Safety (VS)
2. Visitor Experience (VE)

SHORT TERM SOLUTIONS

1. Regulatory Signage
2. Wayfinding Signage
3. Informational Signage
4. Bike Lane Striping

LONG TERM SOLUTIONS

5. New Informational Kiosk
6. New Gate with Branded Design
7. Entry Portal for Bikes
8. Bike Lane Designation Paint
9. Drainage Improvement- Roadside Ditch Typical Section 1
10. Stone Columns



Recommended Improvements

SHORT TERM SOLUTIONS

1. Regulatory Signage
2. Wayfinding Signage
3. Informational Signage
4. Bike Lane Striping

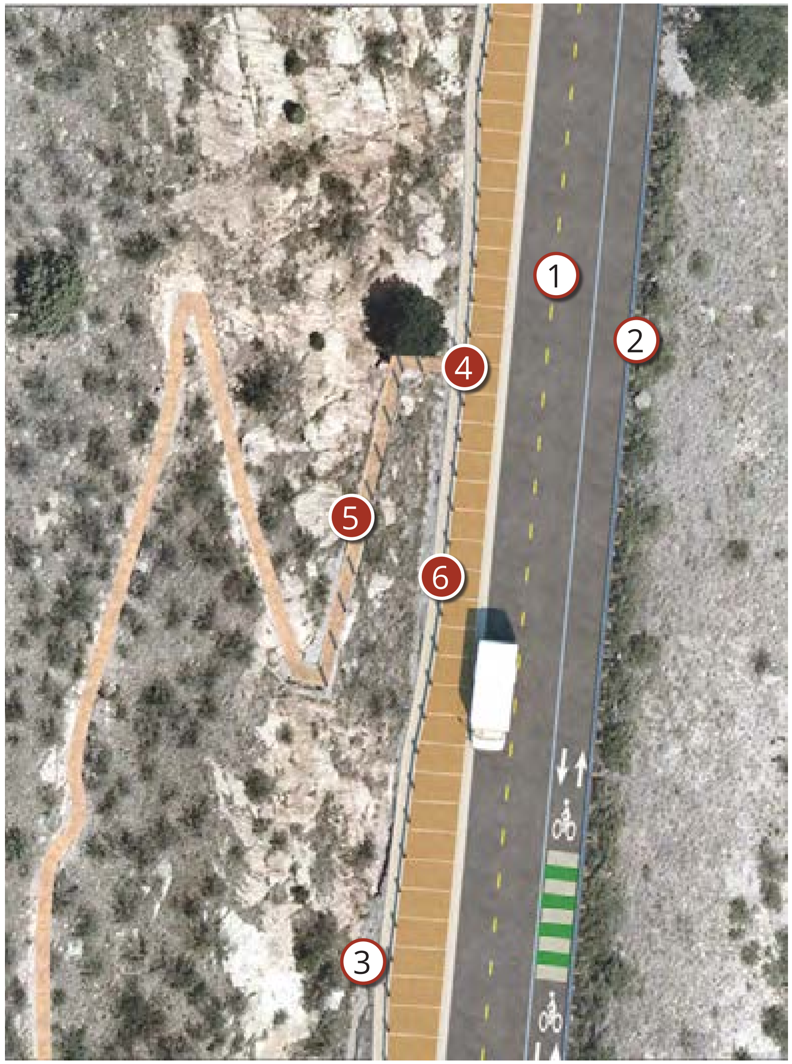
LONG TERM SOLUTIONS

5. New Informational Kiosk
6. New Gate with Branded Design
7. Entry Portal for Bikes
8. Bike Lane Designation Paint
9. Drainage Improvement- Roadside Ditch Typical Section 1
10. Stone Columns

DAKOTA RIDGE TRAIL NORTH ACCESS/CROSSING

Ⓢ *Site Location - Dakota Ridge Trail North Acces/Crossing*

Existing Site Photos - Trail Access



Recommended Improvements

IMPROVEMENT NEEDS

1. Visitor Safety (VS)

SHORT TERM SOLUTIONS

① Remove Existing Pedestrian Crosswalk and Redirect Pedestrian Flow to West Side of Trail

② Remove Historic Coal Mine Interpretive Sign

③ Relocate Port O Let to Ridge Plaza

LONG TERM SOLUTIONS

④ Realign Dakota Ridge Trail to Ridge Walk

⑤ Replace Existing Rail with New Barrier Fence

⑥ Drainage Improvement-Roadside Ditch Typical Section 1

RIDGE PLAZA

S Site Location - Ridge Plaza

Existing Site Photos - Ridge Area East

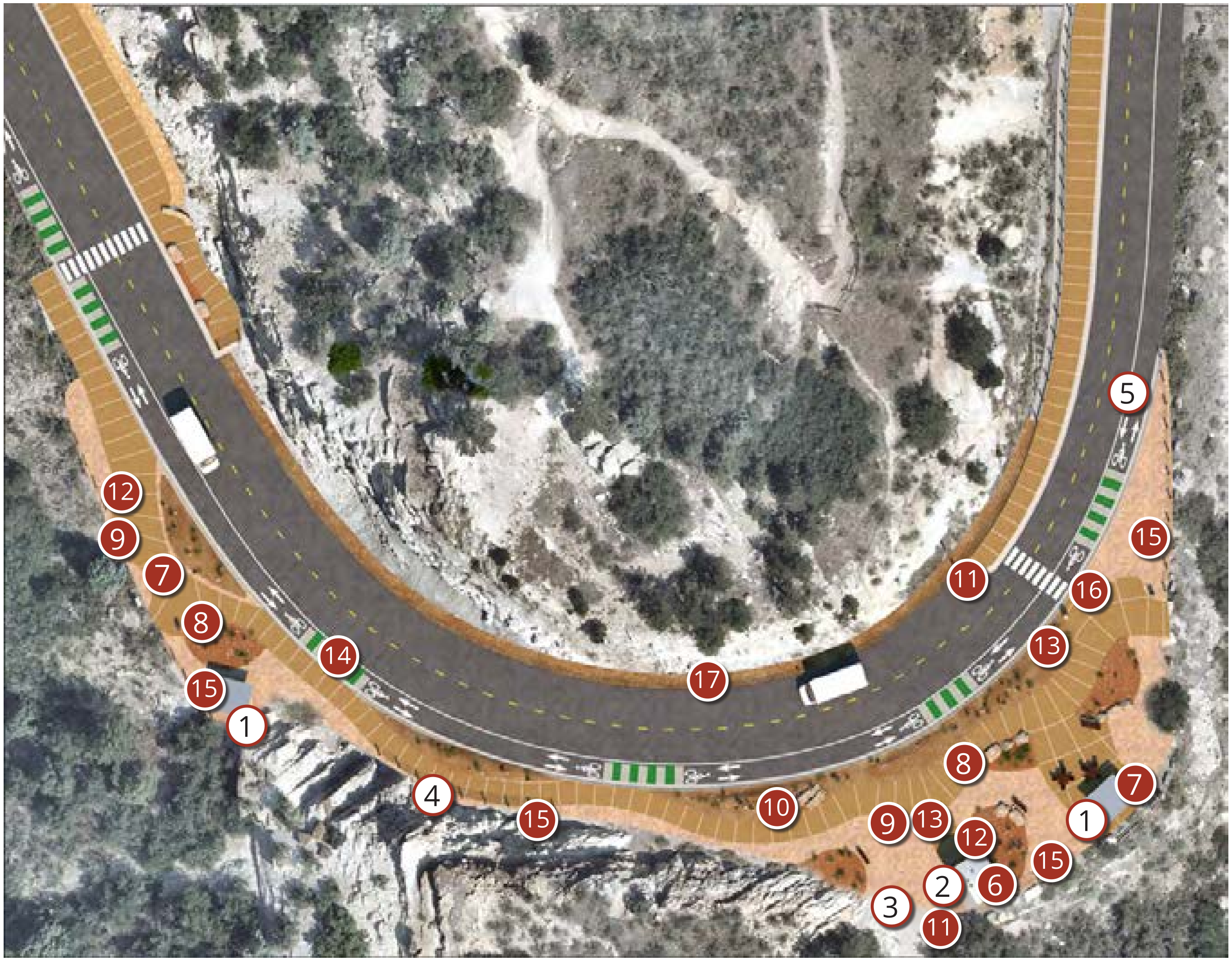
Existing Site Photos - Rock Cut

Repaint and Replace Roof on Existing Structures with Larger Footprint to Maximize Shade Coverage

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Visitor Experience (VE)
3. Resource Protection (RP)

RIDGE PLAZA



Recommended Improvements

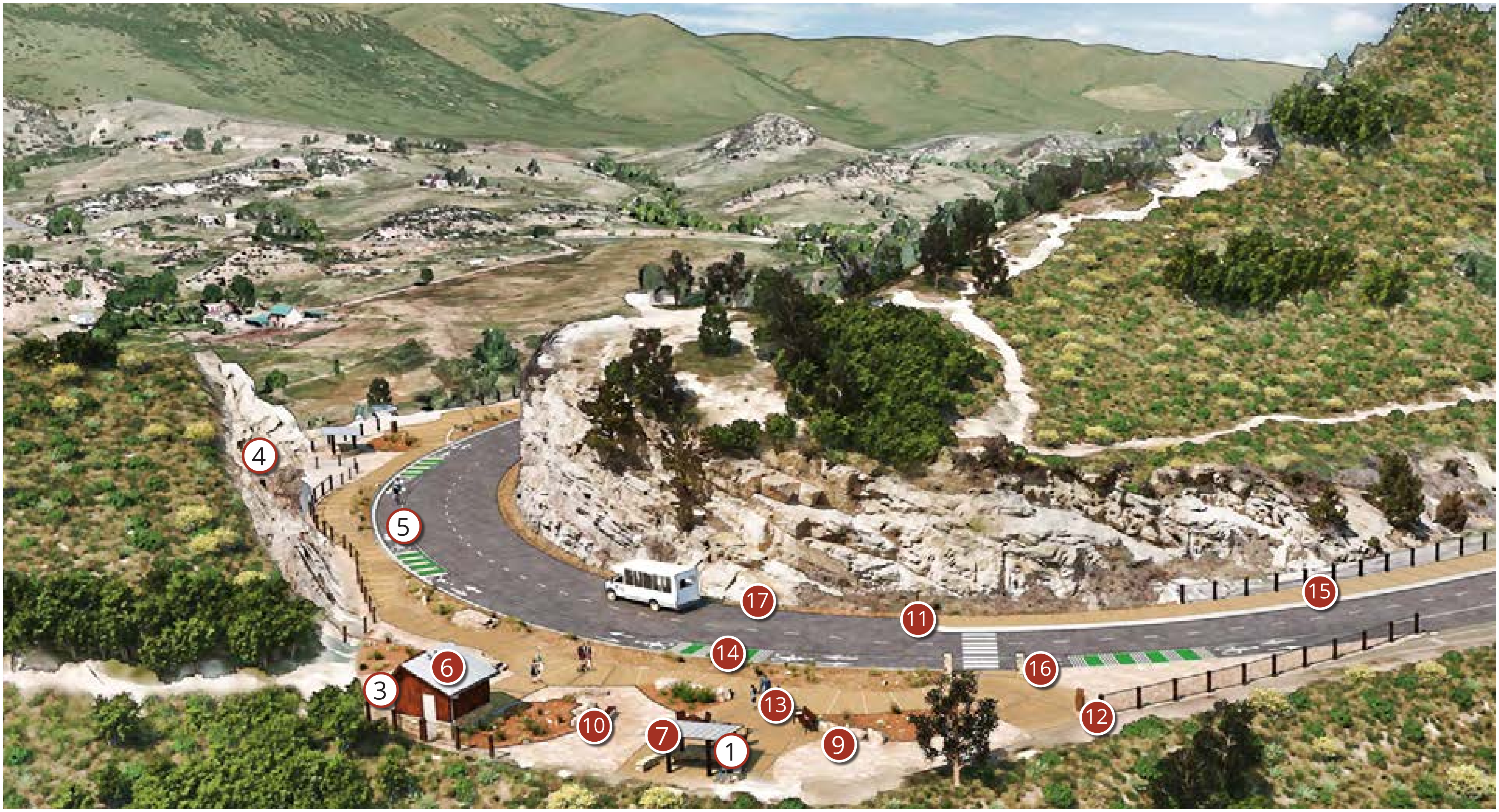
SHORT TERM SOLUTIONS

1. Minor Structure Improvements-Paint
2. Temporary Port O Let
3. Regulatory Signage
4. Rockfall Mitigation
5. Bike Lane Striping

LONG TERM SOLUTIONS

6. Vault Restroom
7. Replace Shelter Roof
8. Plaza Paving and Resurface
9. Benches
10. Landscape Boulders
11. Wayfinding Signage
12. Trash Receptacles
13. Improve ADA Access
14. Bike Lane Designation Paint
15. Barrier Fence
16. Stone Columns
17. Drainage Improvement-Natural Swale/Ditch Section

RIDGE PLAZA - WEST VIEW



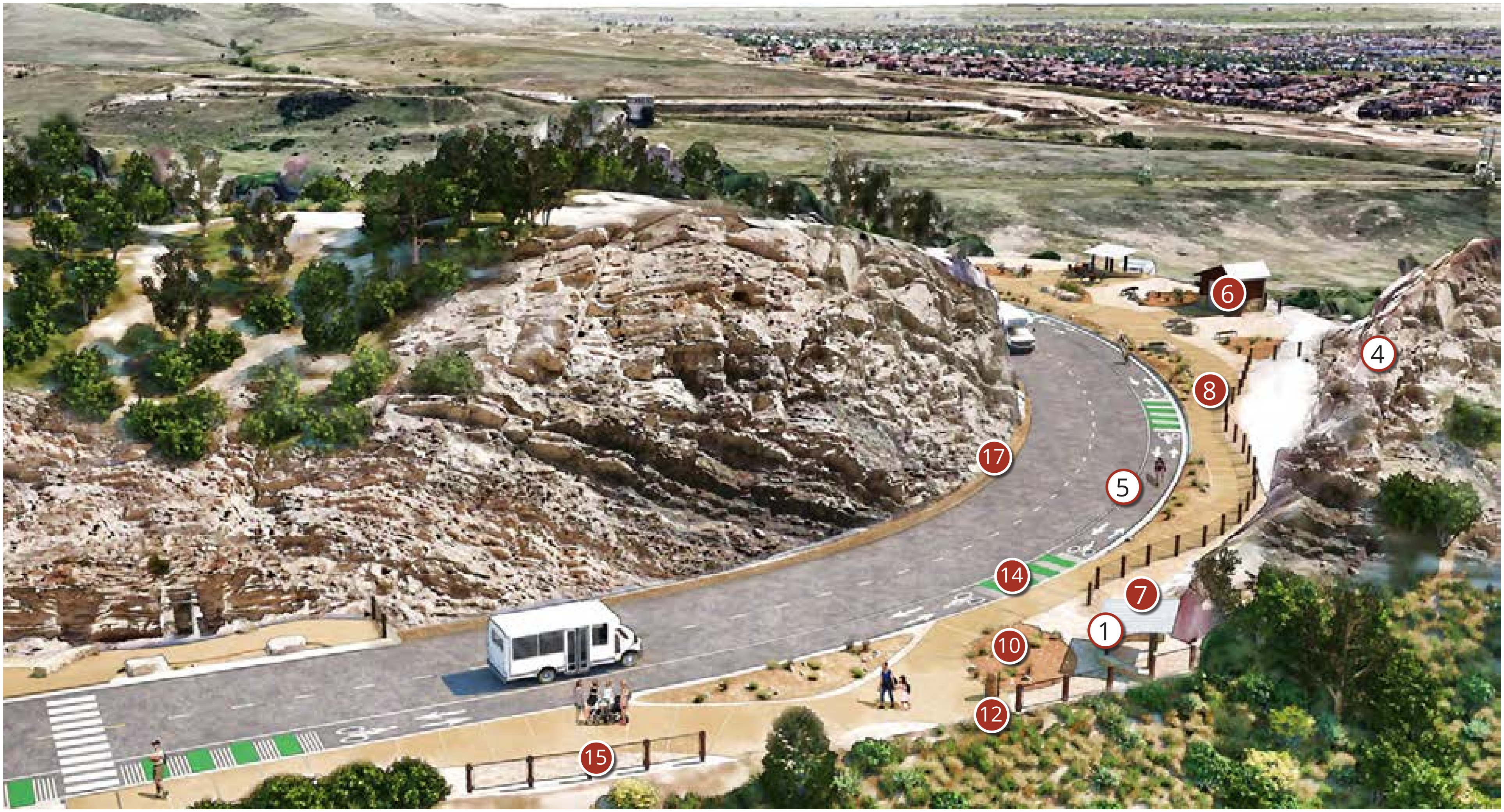
SHORT TERM SOLUTIONS

1. Minor Structure Improvements-Paint
2. Temporary Port O Let
3. Regulatory Signage
4. Rockfall Mitigation
5. Bike Lane Striping

LONG TERM SOLUTIONS

6. Vault Restroom
7. Replace Shelter Roof
8. Plaza Paving and Resurface
9. Benches
10. Landscape Boulders
11. Wayfinding Signage
12. Trash Receptacles
13. Improve ADA Access
14. Bike Lane Designation Paint
15. Barrier Fence
16. Stone Columns
17. Drainage Improvement-Natural Swale/Ditch Section

RIDGE PLAZA - EAST VIEW



SHORT TERM SOLUTIONS

1. Minor Structure Improvements-Paint
2. Temporary Port O Let
3. Regulatory Signage
4. Rockfall Mitigation
5. Bike Lane Striping

LONG TERM SOLUTIONS

6. Vault Restroom
7. Replace Shelter Roof
8. Plaza Paving and Resurface
9. Benches
10. Landscape Boulders
11. Wayfinding Signage
12. Trash Receptacles
13. Improve ADA Access
14. Bike Lane Designation Paint
15. Barrier Fence
16. Stone Columns
17. Drainage Improvement-Natural Swale/Ditch Section

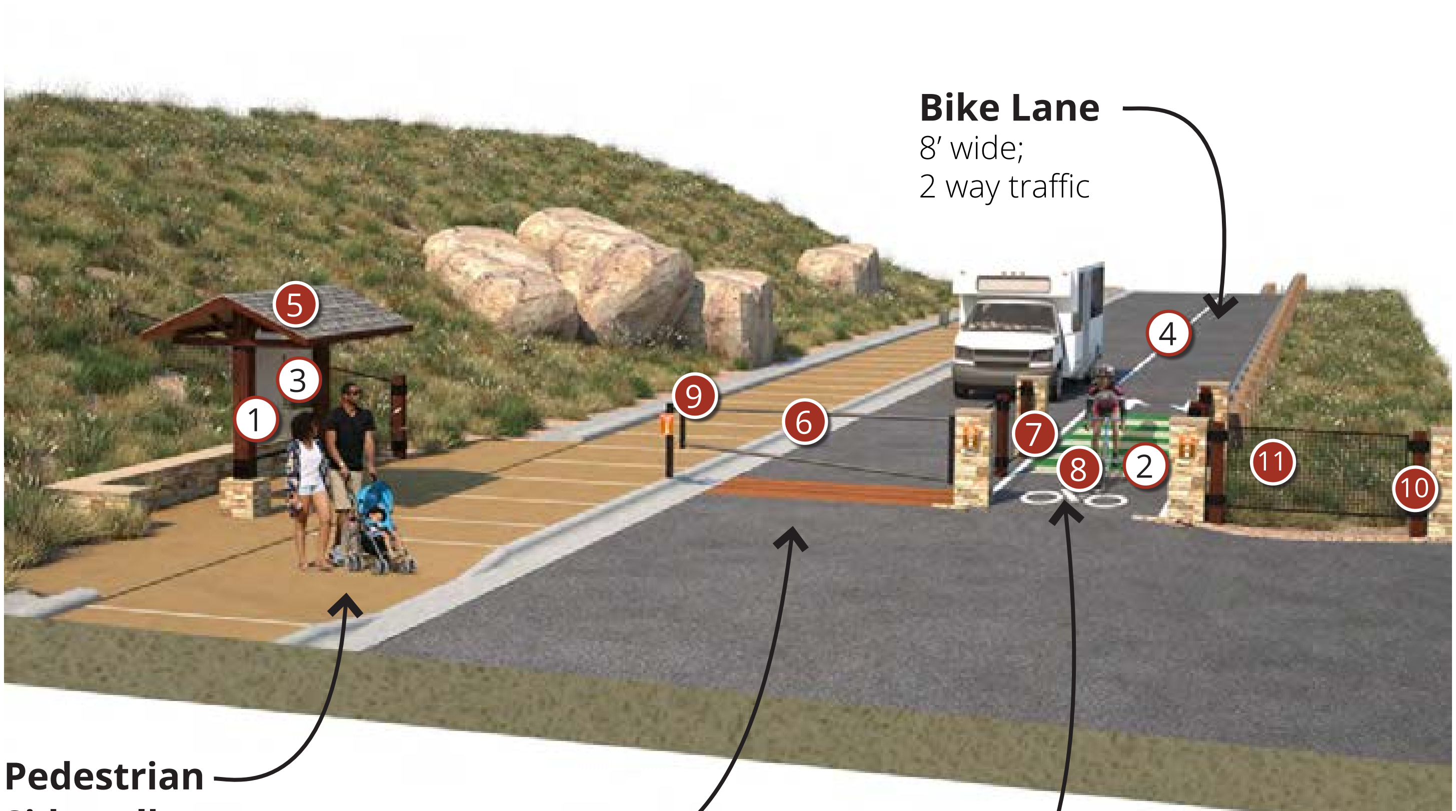
JURASSIC GATE (WEST ACCESS)

S *Site Location - Jurassic Gate*

Existing Site Photos - Jurassic Gate (West Access)

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Visitor Experience (VE)
3. Resource Protection (RP)



Recommended Improvements

SHORT TERM SOLUTIONS

1. Regulatory Signage
2. Wayfinding Signage
3. Informational Signage
4. Bike Line Striping

LONG TERM SOLUTIONS

5. New Informational Kiosk
6. New Gate with Branded Design
7. Entry Portal for Bikes
8. Bike Lane Designation Paint
9. Drainage Improvement- Roadside Ditch Typical Section 1
10. Stone Columns
11. Barrier Fence

BUS TURNAROUND

S Site Location - Bus Turnaround

Existing Site Photos - Current Bus Turnaround

Existing Site Photos - Discovery Center Use for Bus Turnaround

IMPROVEMENT NEEDS

1. Visitor Safety (VS)
2. Visitor Experience (VE)

SHORT TERM SOLUTIONS

1. Use Discovery Center for Bus Turnaround
2. Regulatory Signage
3. Bike Lane Striping
4. Traffic Control for Pedestrians

LONG TERM SOLUTIONS

5. New Gate
6. New Informational Kiosk
7. New Informational Signage
8. Wayfinding Signage
9. Bike Lane Designation Paint
10. Trash Receptacle
11. Benches

Recommended Improvements

SHORT TERM SOLUTIONS

1. Use Discovery Center for Bus Turnaround
2. Regulatory Signage
3. Bike Lane Striping
4. Traffic Control for Pedestrians

LONG TERM SOLUTIONS

5. New Gate
6. New Informational Kiosk
7. New Informational Signage
8. Wayfinding Signage
9. Bike Lane Designation Paint
10. Trash Receptacle

Example of a Pedestrian Crossing Warning Device

SIGNAGE - EXISTING LOCATIONS

The existing signage at Dinosaur Ridge is a wide conglomeration of sign types and standards that has become very cluttered and visually confusing. To address this, the Master Plan reorganizes the signage system into 3 types of signs each having a recognizable standard for easy identification of each.

These include:

1. Regulatory Signs-
   Rules and Regulations, Prohibitive Access, Warning Signs, etc.

2. Information Signs-
   Educational/
   Interpretive Information.

3. Wayfinding Signs-
   Maps, Directional Arrows, Pedestrian/Bus/Cyclist Routes, etc.

This master plan does not provide a comprehensive sign plan. An inventory of existing signage has been provided and broken into the three categories with approximate quantities of each for an idea of the amount of signage present.

It is recommended that the existing Informational Signs are converted to the new standards provided as a single project process.

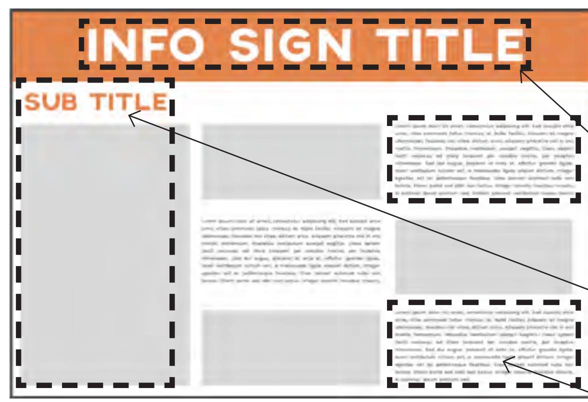
REGULATORY SIGNS
+/- 29 SIGNS

INFORMATIONAL SIGNS
+/- 66 SIGNS

PROPOSED SIGNAGE STANDARDS

INFORMATIONAL SIGN

- Signage to maintain Jefferson County design standards, utilizing Jeffco brand defined fonts, colors, and icons.
- To be metal sign face mounted within metal frame.
- Frame to be repurposed from existing frames, painted with automotive grade exterior paint to match mounting details of primary wayfinding signage.
- Height to follow ADA standards



INFORMATION HIERARCHY
In order to ensure easy readability, following the below information hierarchy will help provide guidance to signage layout formatting.

Primary Signage Title
3 second read

Subhead Title & Graphics
10 second read

Body Copy
30 second read

REGULATORY SIGN

- Signage to maintain Jefferson County design standards, utilizing Jeffco brand defined fonts, colors, and icons. Title of regulatory sign to be brand red in order to signify important nature of regulation messaging.
- To be metal sign face mounted to 4"x4" wood post.
- Height to follow ADA standards.

SIGNAGE - EXISTING LOCATIONS

WAYFINDING SIGNS
+/- 4 SIGNS

- Signage to maintain Jefferson County design standards, utilizing Jeffco brand defined fonts, colors, and icons. Dinosaur Ridge specific accent color, PMS 1595 to be used on content titles and subtitles in order to create location-specific brand recognition.
- To be metal sign face with digital print mounted to metal mesh backing and secured to wood post with metal bracketing components.
- Stacked stone base to coordinate with architectural details.
- Coffered detailing on top of posts.

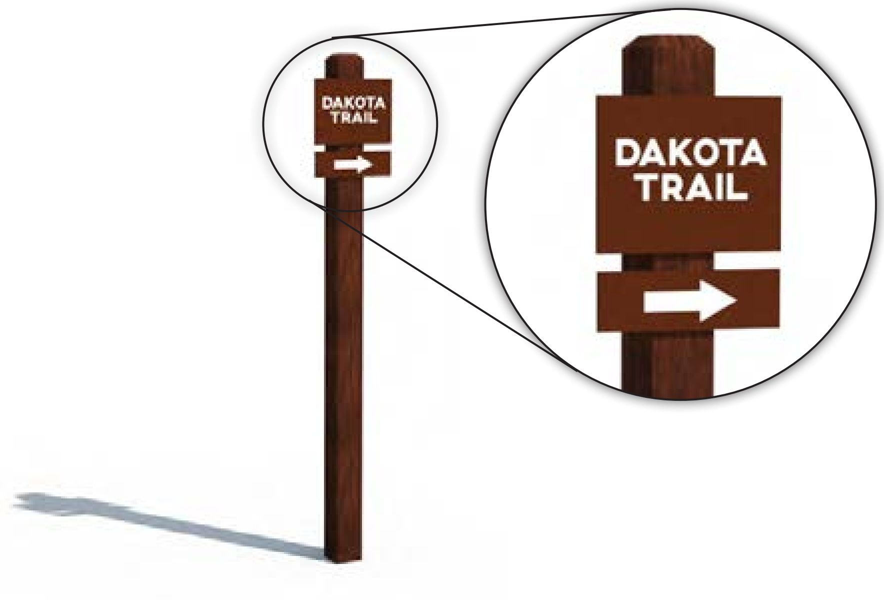
INFORMATION HIERARCHY
In order to ensure easy readability, following the below information hierarchy will help provide guidance to signage layout formatting.

Primary Signage Title
3 second read

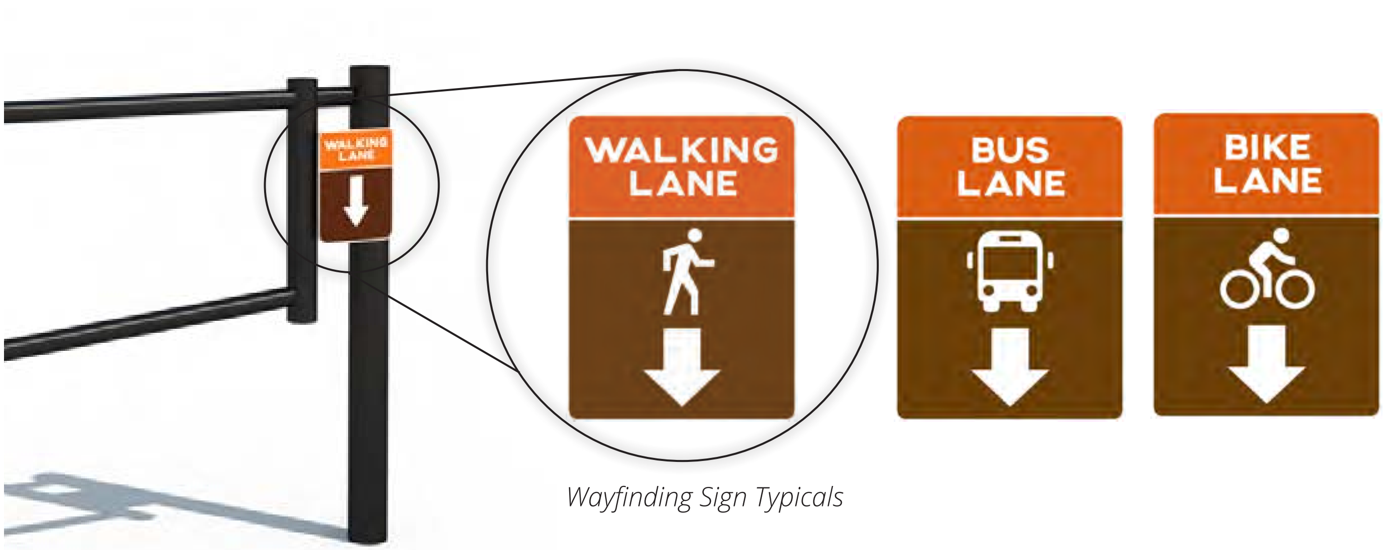
Subhead Title
10 second read

Body Copy
30 second read

PROPOSED SIGNAGE STANDARDS



- Signage to maintain Jefferson County design standards, utilizing Jeffco brand defined fonts, colors, and icons.
- Recognizable arrow system to support ease of readability and understanding.
- To be new composit material per JCOS standard detail, mounted to 4"x4" wood post.
- Height to follow ADA standards.



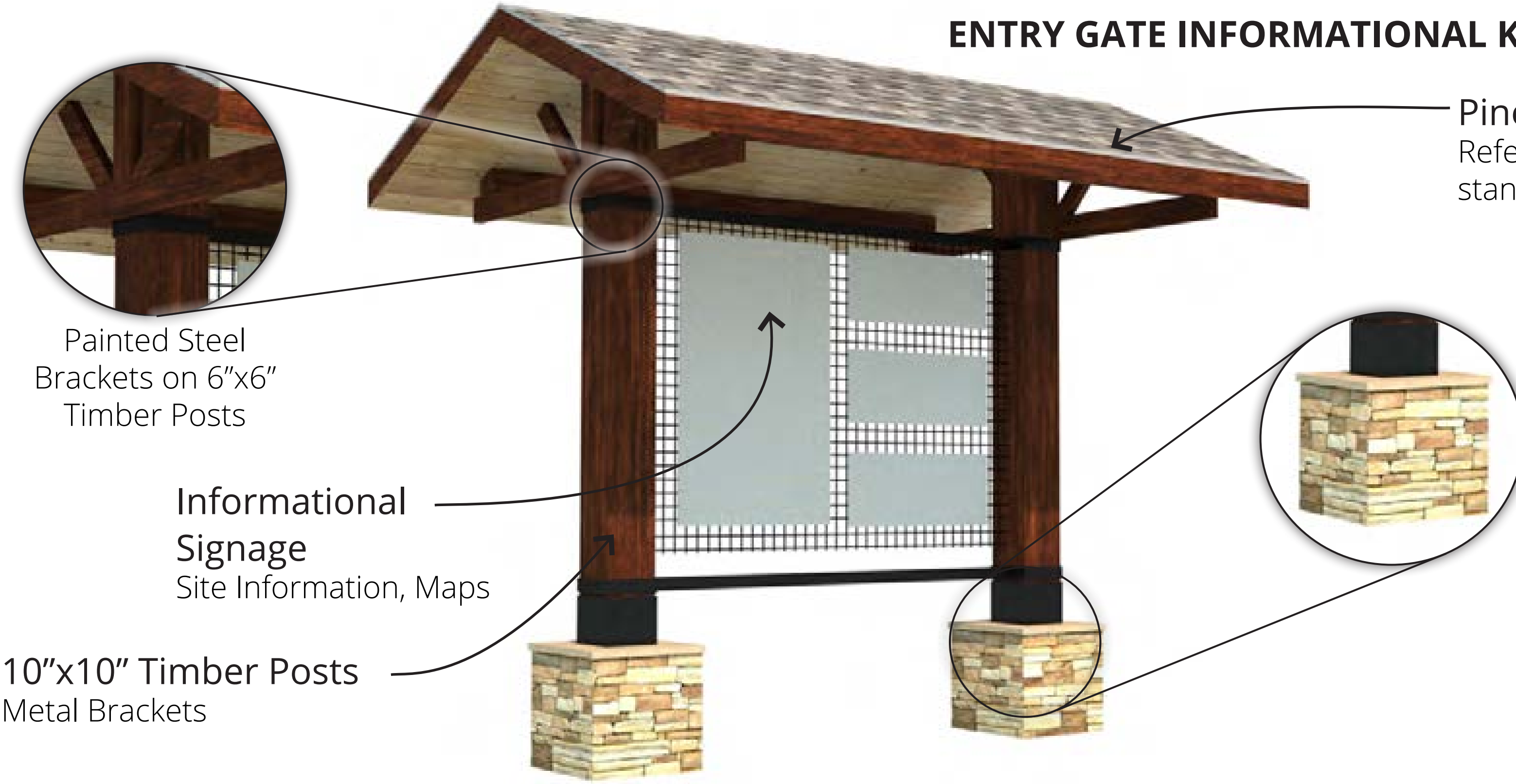
Wayfinding Sign Typicals

- Signage to maintain Jefferson County design standards, utilizing Jeffco brand defined fonts, colors, and icons. Dinosaur Ridge specific accent color, PMS 1595 to be used on content titles and subtitles in order to create location-specific brand recognition.
- Recognizable icon system to support ease of readability and understanding.
- To be metal sign face with digital print mounted to metal gate post or sandstone column.
- Height to follow ADA standards.

W WAYFINDING SIGN

FUTURE SITE AMENITIES & DETAILS

ENTRY GATE INFORMATIONAL KIOSK



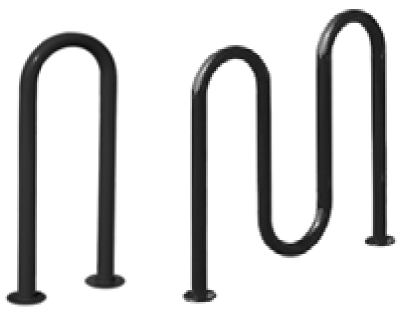
FENCE BARRIER

Note:
All wood timber posts to be ACQ treated and stained with Cabot exterior stain per Jeffco Open Space standards and color specifications.

FUTURE SITE AMENITIES & DETAILS

Madison 6' Thermory Flat
Bench

Stone Steating -
Sandstone Slab - 1.5' W x 1.5' Ht. x 6' L



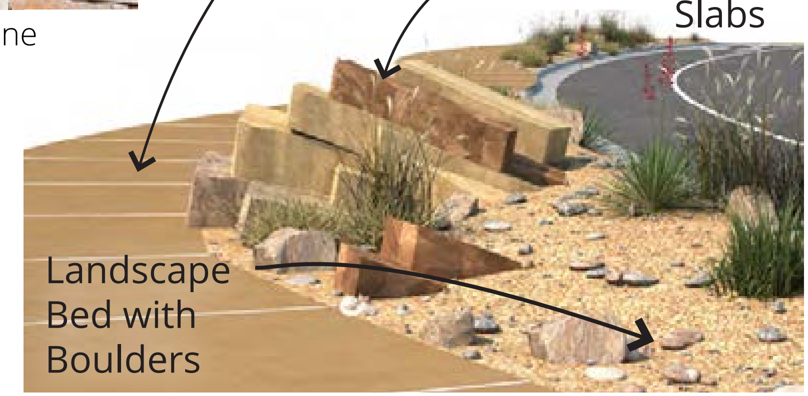
Bike Racks

Beacon Hill Thermory Tables
(including ADA option)

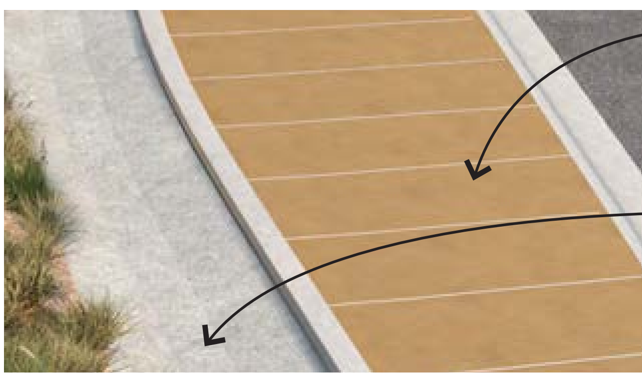
Bear Resistant
Trash Receptacle

FUTURE SITE AMENITIES & DETAILS

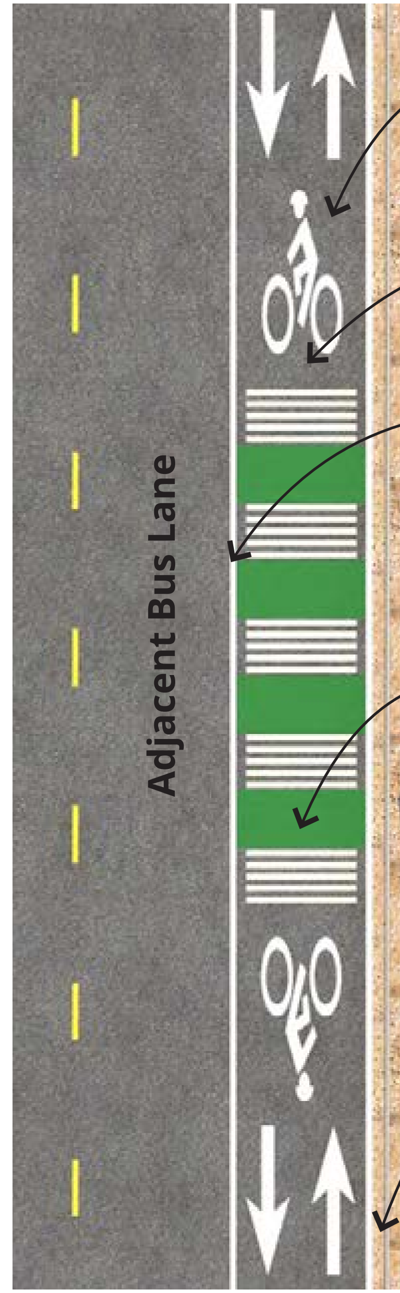
Stacked Sandstone Construction



Tilted Stone Seating - Sandstone Slabs (Orientate Angle & Direction with Hogback)

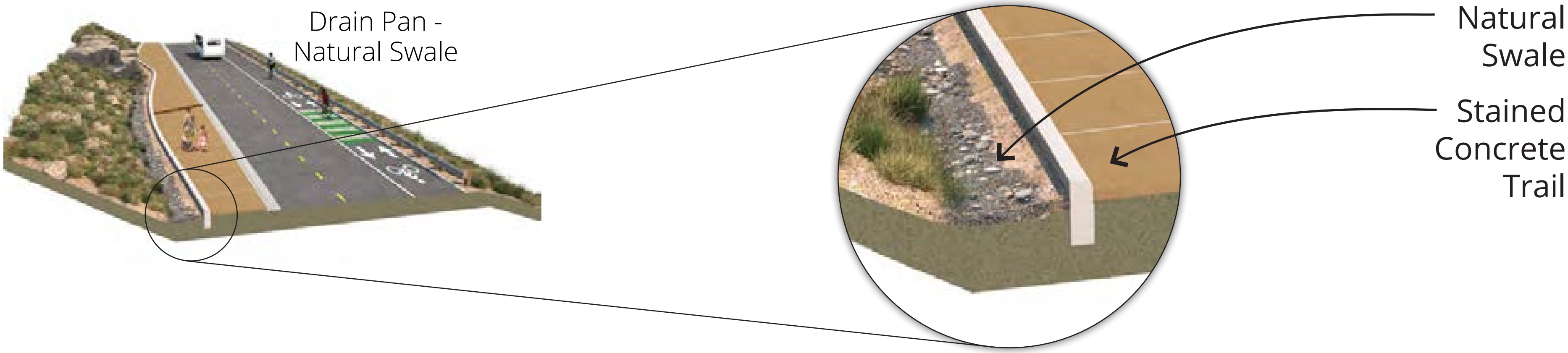


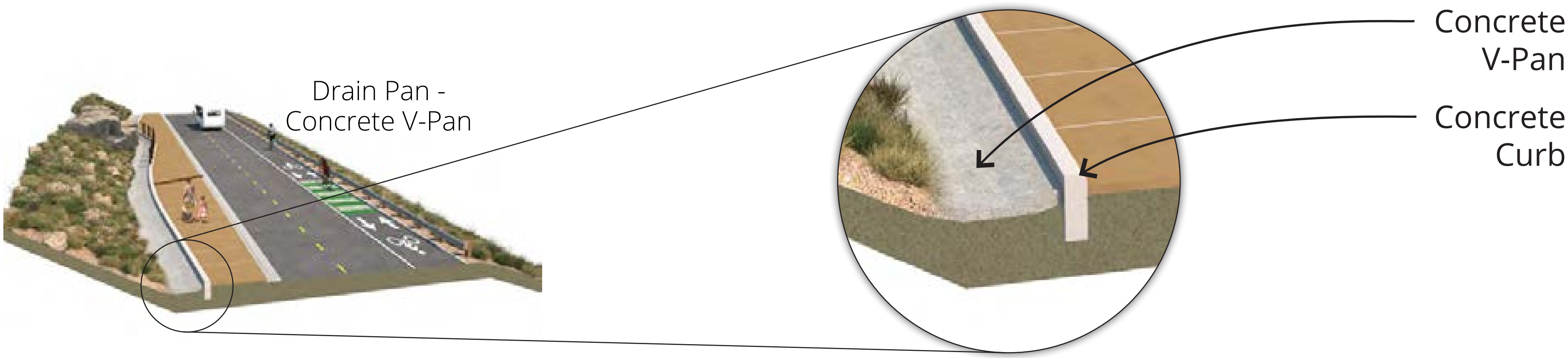
Stained Concrete Trail

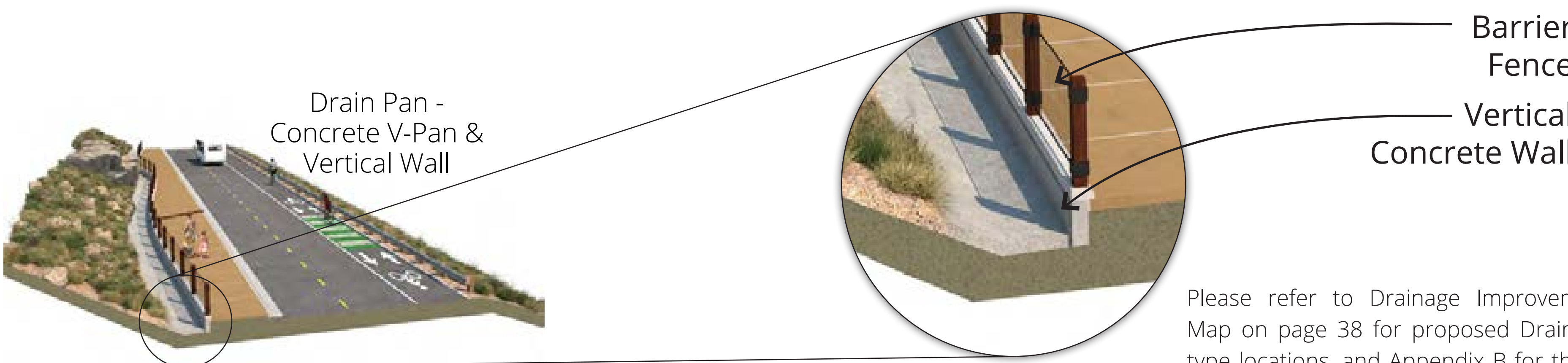


Bike Lane Striping and Designation Paint Scheme

FUTURE SITE AMENITIES & DETAILS







Please refer to Drainage Improvements Map on page 38 for proposed Drain Pan type locations, and Appendix B for the full Final Conceptual Drainage Report created by Muller Engineering Company.

VAULT RESTROOM FACILITY

Corrugated Metal Roof

Weather-treated wood siding

Restrooms
ADA accessible restroom to be provided

Stacked Sandstone Base
Material to match existing used on site

RIDGE PLAZA SHADE STRUCTURES

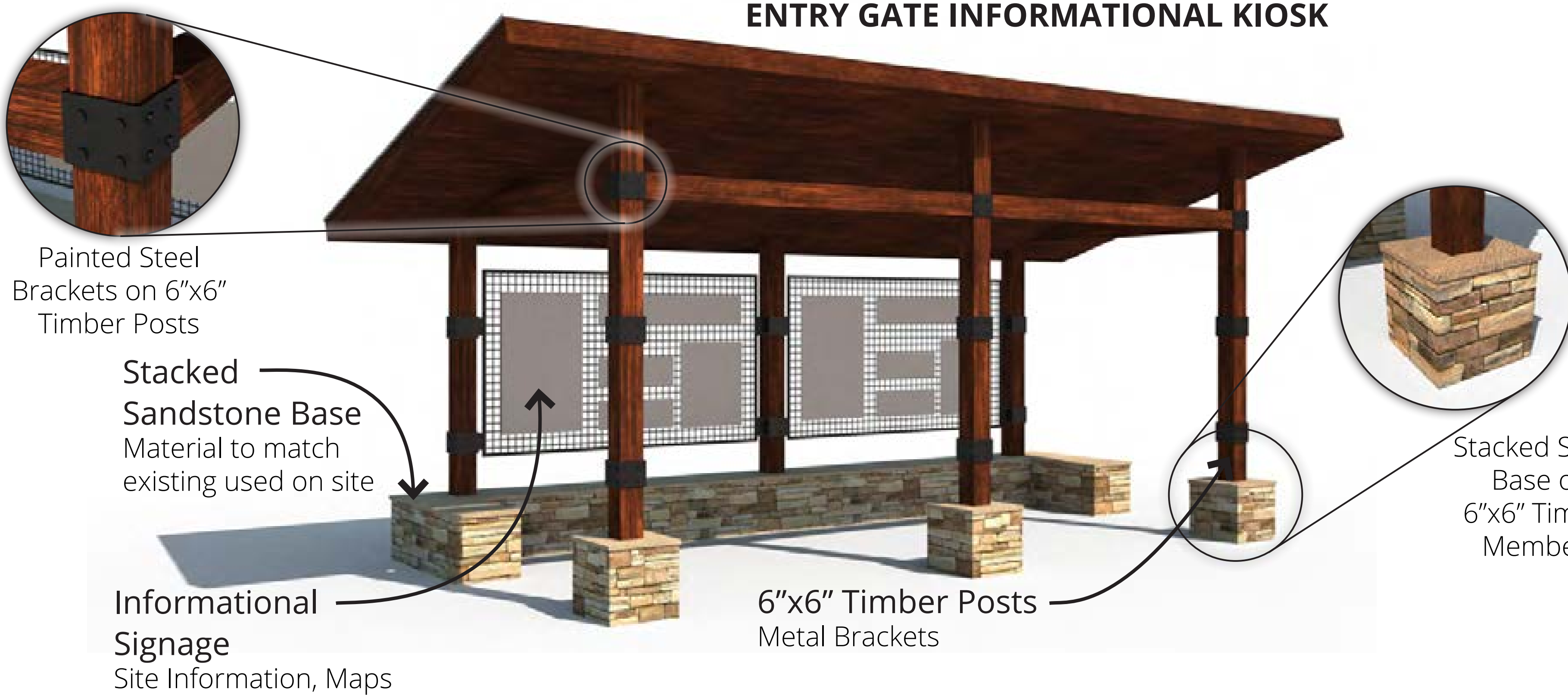
Replace Existing Roof
New roof to be galvanized-corrugated metal roof material

Stacked Sandstone Base
Keep existing stacked stone base intact

Repaint Steel Members
All existing shade structures at Ridge Plaza to have existing paint stripped, primed, and repainted with faux - corten textured exterior rated paint

Note:
Same application is to be applied at additional sites with existing structural members (blue paint). These include:
- Main Track Site
- Brontosaurus Bulges
- Bone Quarry

ENTRY GATE INFORMATIONAL KIOSK



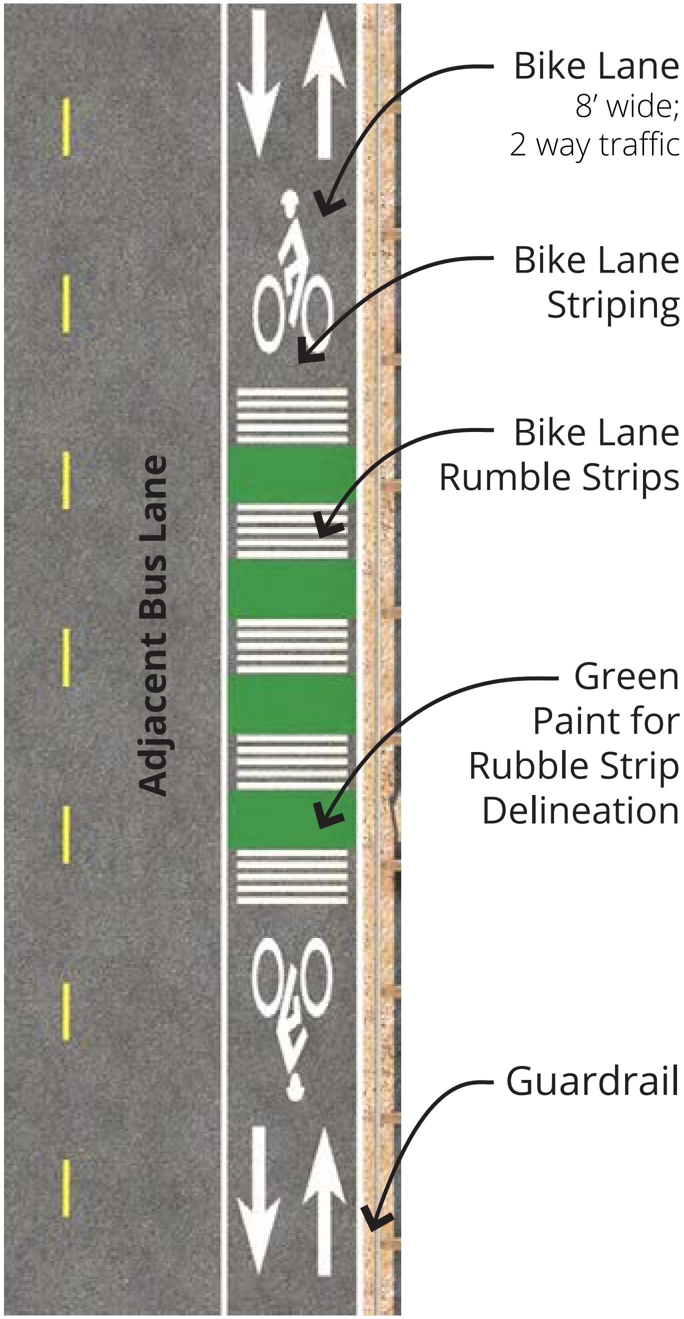
CIRCULATION IMPROVEMENT - VISITOR CENTER TO RIDGE TRAIL

SHORT TERM SOLUTIONS

1. Install Curb Stops along Pedestrian Walk

VEHICULAR OVERHANG
Install curb stops along pedestrian walkway to prevent overhang andimpeding pedestrian circulation flow.

BIKE LANE RUMBLE STRIP & STRIPING



BIKE LANE RUMBLE STRIP EXAMPLE

BUS TURNAROUND - ROUND-A-BOUT AT HWY 93 INTERSECTION

Round-a-bout Images Provided as an Example Only

BRANDING

A brand is more than just a name, tagline, or logo. A brand is your promise to your audience. Key components that define your brand creating visual continuity and recognition which in turn create value:

- Brand Purpose and Positionging
- Name
- Tagline
- Logo
- Brand Fonts
- Brand Color Palette

These elements should be integrated in all aspects of brand expression including but not limited to:

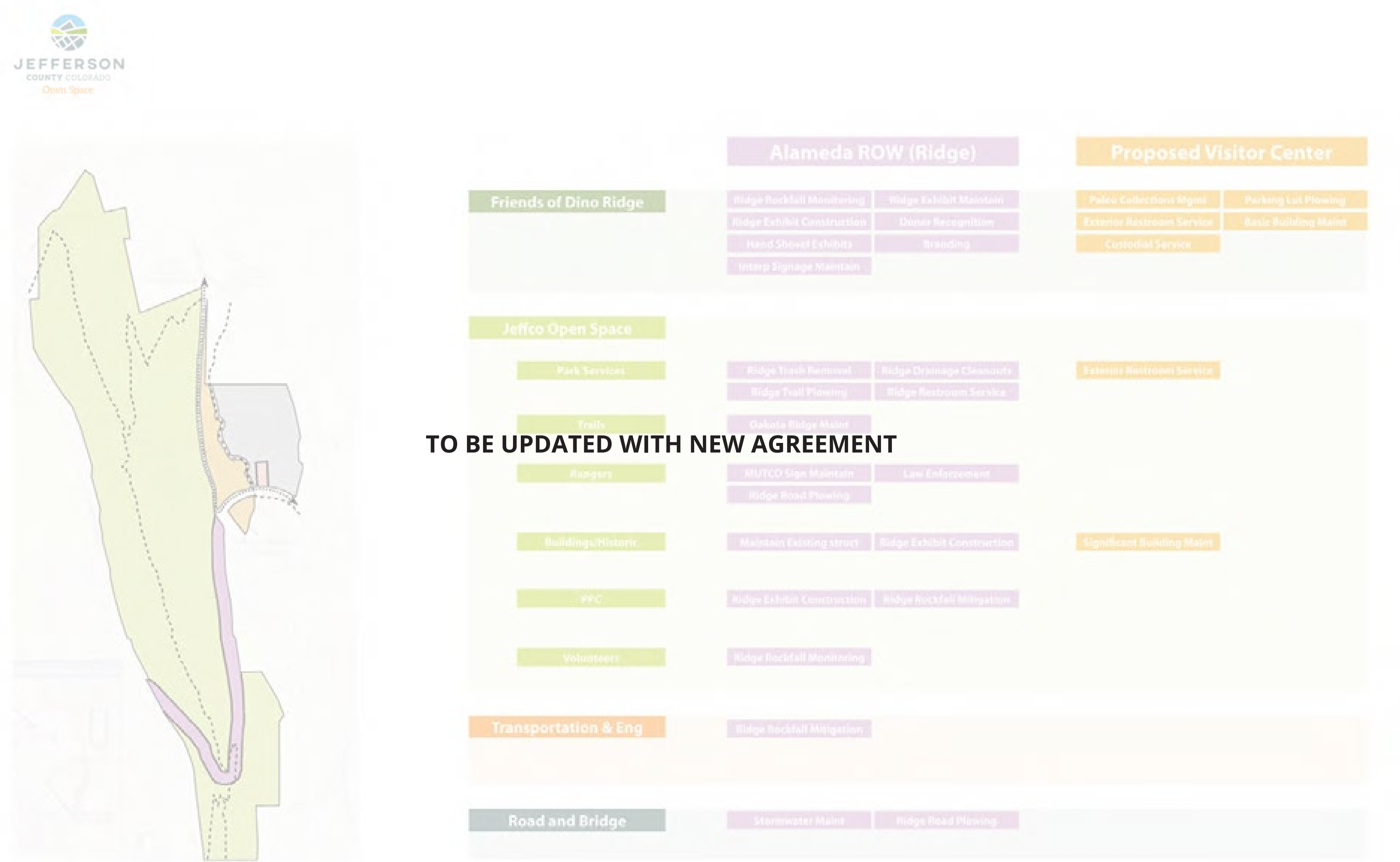
- Signage Design
- Website Design
- Print Collateral Design

BRAND RECOMMENDATION

- There is consensus the name should change from "Friends of Dinosaur Ridge" to "Dinosaur Ridge"
- The logo should be revisited and updated in order to better reflect the meaningful and valuable brand purpose and positioning statement
- The signage should be updated to enhance the visitor experience and create a cohesive and unified brand design approach
- Dinosaur Ridge should associate with the Westracks masterbrand in order to leverage the equity of the larger entity and create connection

FRIENDS OF DINOSAUR RIDGE

FRIENDS OF DINOSAUR RIDGE
AT WESTRACKS



TO BE UPDATED WITH NEW AGREEMENT

Preliminary Draft Maintenance/Management Matrix provided by Jefferson County Open Space

SUPPORTING CONTENT

ACKNOWLEDGEMENTS

This Dinosaur Ridge Master Plan could not have been made possible without continuous involvement by a dedicated group of organizations and individuals. Their efforts to extend knowledge and access to the paleontological, geologic and outdoor discovery in Jefferson County, Colorado has been tremendous. They have come together in the formation of this Master Plan to plant a vision and direct a path forward to further educate and serve the local, regional and international public. For this, they are being acknowledged and extended the highest amount of gratitude from all those who visit and experience Dinosaur Ridge.

ACKNOWLEDGEMENTS

Friends of Dinosaur Ridge Board Members

Friends of Dinosaur Ridge Participating Staff Members

History Colorado

National Park Service

Dan O'Brien, Architect

Jefferson County Board of County Commissioners

Jefferson County Open Space, and Participating Staff

Jefferson County Transportation and Engineering, and Participating Staff

Jefferson County Road and Bridge, and Participating Staff

Dinosaur Ridge and the surrounding area was formally designated the "Morrison Fossil Area" in 1973 by the National Park Service as a National Natural Landmark. It is located within the Westracks Recreation Area and is part of the Jefferson County Open Space Matthews/Winters Park. It is found about a mile south of where Interstate 70 pierces the Dakota Ridge Hogback before ascending the Front Range slopes of the Colorado Rocky Mountains.
Prior to the route and construction of I-70, other roadways worked their way west from central Denver and carved their way over and through the hogback. This brought thousands of people to the mountain playgrounds that have been enjoyed for over a century. One early road was Alameda Parkway. The parkway served as an access road to what is now the famous Red Rocks Park. Construction of the road cut through the Dakota Ridge Hogback, revealed a number of paleontological treasures deposited millions of years earlier when a great inland sea and shoreline covered the area. Early discovery, exploitation and pilfering of these treasures spread the bones and artifacts all over the world during a time period known as the Dinosaur Wars. Luckily, many deposits still exist today and are now the centerpiece of Dinosaur Ridge. These are now on display for the interested public to see, experience and learn about in their original outdoor resting place.

VISITOR CENTER - CONCEPT 1

COST ESTIMATE:

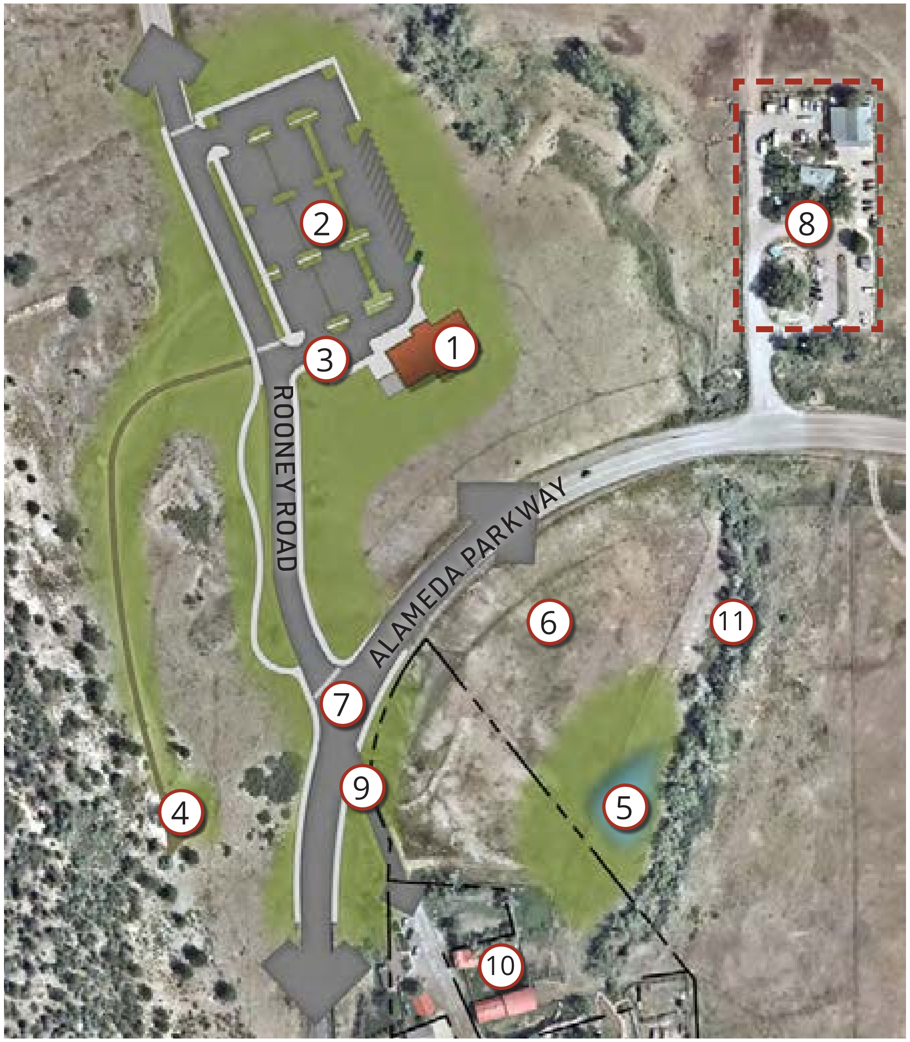
GRAND TOTAL: $4,539,737.26

ANALYSIS

1. Maintains existing roadway alignments and parcel boundaries.
2. Visitor Center is located at the northeast corner of Alameda and Rooney Road.

1. Visitor Center
2. Lower Parking Lot
3. Upper Parking Lot
4. Visitor Drop-off & Bus Tour
5. Colorow Council Tree
6. Detention Pond
7. Keep Existing Intersection - Add Pedestrian Crossing Signal
8. Existing Visitor Center - To Be Relocated
9. Private Drive and Ridge Access
10. Existing Rooney Ranch
11. Existing Rooney Gulch

VISITOR CENTER - CONCEPT 2



COST ESTIMATE:

GRAND TOTAL: $4,287,628.98

ANALYSIS

1. Maintains existing roadway alignments and parcel boundaries.
2. Visitor Center is located at the northeast corner of Alameda and Rooney Road.
3. All proposed parking is located north of Visitor Center.

(1) Visitor Center

(2) Parking Lot

(3) Visitor Drop-off & Bus Tour

(4) Colorow Council Tree

(5) Detention Pond

(6) Potential Overflow Parking Lot

(7) Keep Existing Intersection - Add Pedestrian Crossing Signal

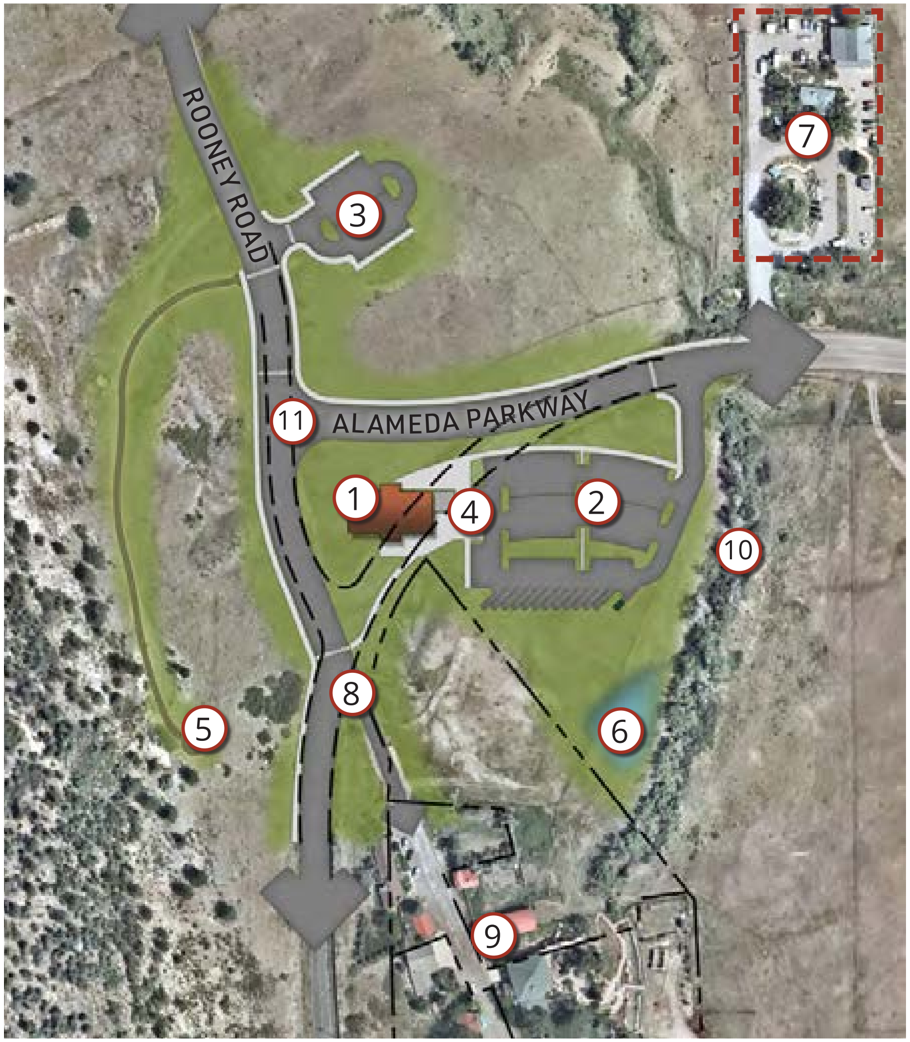
(8) Existing Visitor Center - To Be Relocated

(9) Private Drive and Ridge Access

(10) Existing Rooney Ranch

(11) Existing Rooney Gulch

VISITOR CENTER - CONCEPT 3



COST ESTIMATE:

GRAND TOTAL: $4,405,923.26

ANALYSIS

1. Creates new intersection at Rooney Road and Alameda.
2. Visitor Center is located at the southeast corner of Alameda and Rooney.
3. Proposed visitor parking is located south of Visitor Center.

(1) Visitor Center

(2) Parking Lot

(3) Upper Parking Lot

(4) Visitor Drop-off & Bus Tour

(5) Colorow Council Tree

(6) Detention Pond

(7) Existing Visitor Center - To Be Relocated

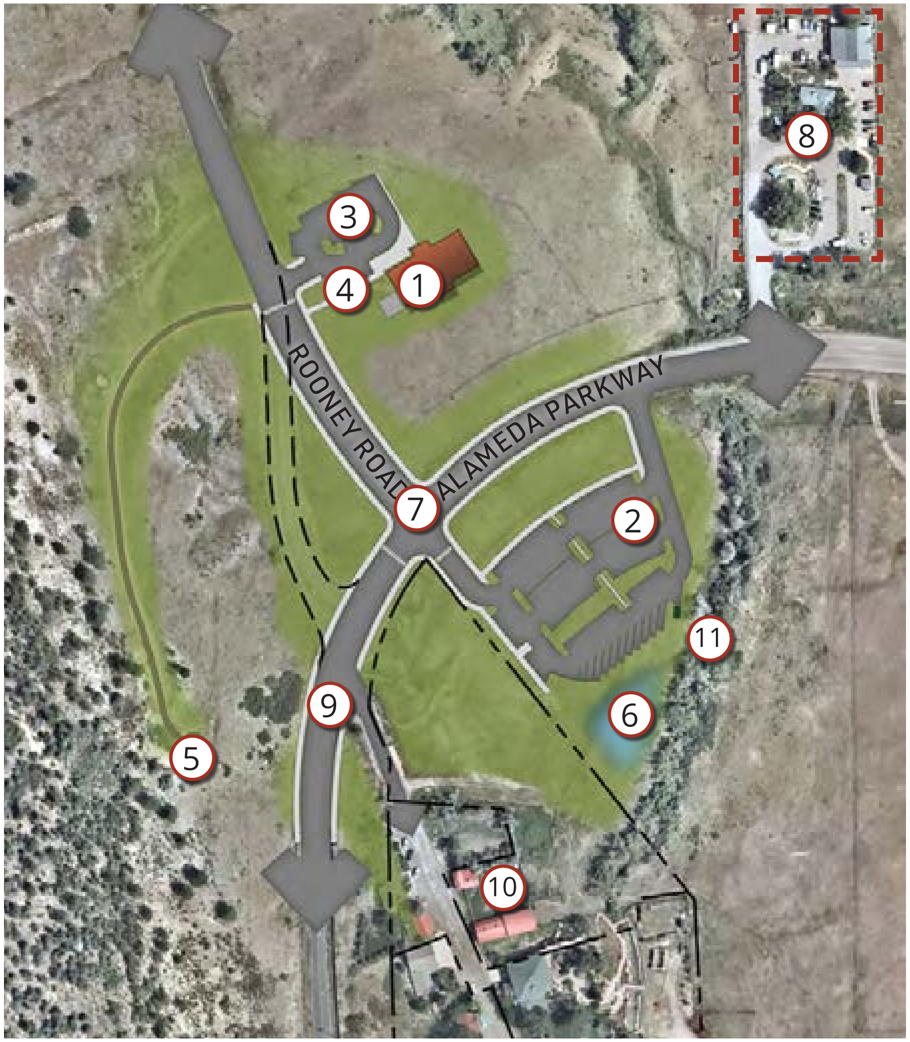
(8) Private Drive and Ridge Access

(9) Existing Rooney Ranch

(10) Existing Rooney Gulch

(11) Relocate Intersection for 90° Turn

VISITOR CENTER - CONCEPT 4



COST ESTIMATE:

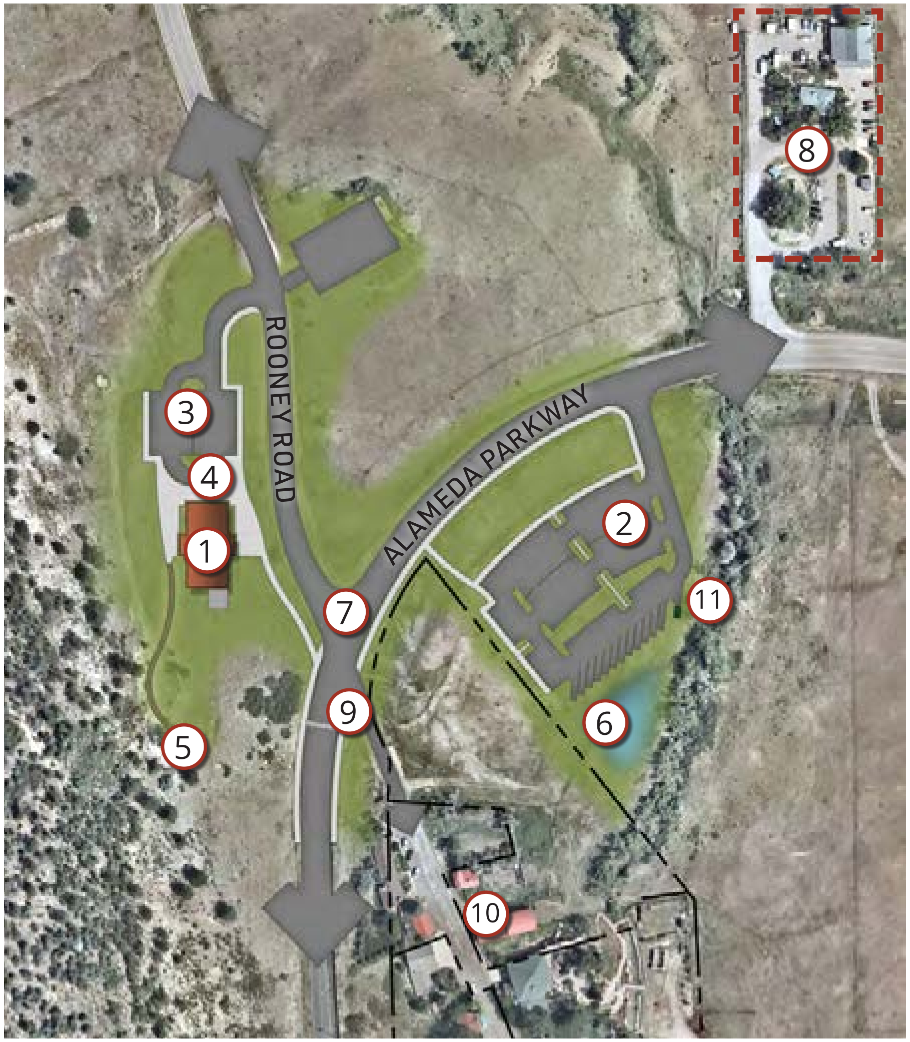
GRAND TOTAL: $4,394,463.26

ANALYSIS

1. Creates new intersection at Rooney Road and Alameda.
2. Visitor Center is located at the northeast corner of Alameda and Rooney Road.

1. Visitor Center
2. Lower Parking Lot
3. Upper Parking Lot
4. Visitor Drop-off & Bus Tour
5. Colorow Council Tree
6. Detention Pond
7. Realign Rooney Road - Add Pedestrian Crossing Signal
8. Existing Visitor Center - To Be Relocated
9. Private Drive and Ridge Access
10. Existing Rooney Ranch
11. Existing Rooney Gulch

VISITOR CENTER - CONCEPT 5



COST ESTIMATE:

GRAND TOTAL: $4,519,612.10

ANALYSIS

1. Keeps current road alignment at Rooney Road and Alameda.
2. Visitor Center and parking is located on the west side of Rooney Road.
3. Additional parking is located at the southeast corner of Rooney Road, Alameda and Dinosaur Ridge.

1. Visitor Center
2. Lower Parking Lot
3. Upper Parking Lot
4. Visitor Drop-off & Bus Tour
5. Colorow Council Tree
6. Detention Pond
7. Keep Existing Intersection - Add Pedestrian Crossing Signal
8. Existing Visitor Center - To Be Relocated
9. Private Drive and Ridge Access
10. Existing Rooney Ranch
11. Existing Rooney Gulch

VISITOR CENTER - CONCEPT 6

COST ESTIMATE:

GRAND TOTAL: $4,408,946.26

ANALYSIS

1. Keeps Visitor Center and parking south of Rooney Road and Alameda.
2. Visitor Center and parking is located in close proximity to Dinosaur Ridge access point.

(1) Visitor Center

(2) Lower Parking Lot

(3) Bus Parking/Overflow

(4) Visitor Drop-off & Bus Tour

(5) Colorow Council Tree

(6) Detention Pond

(7) Realign Rooney Road and Alameda for Through Traffic

(8) Existing Visitor Center - To Be Relocated

(9) Private Drive to Rooney Ranch

(10) Visitor Center and Ridge Access

(11) Existing Rooney Ranch

(12) Existing Rooney Gulch

VISITOR CENTER - CONCEPT 7

COST ESTIMATE:

GRAND TOTAL: $4,468,466.26

ANALYSIS

1. Creates new intersection at Rooney Road and Alameda.
2. Visitor Center is located at the southwest corner of Alameda and Rooney.
3. Proposed visitor parking is located directly east of Visitor Center.

(1) Visitor Center

(2) Parking Lot

(3) Bus Parking/Overflow

(4) Visitor Drop-off & Bus Tour

(5) Colorow Council Tree

(6) Detention Pond

(7) Realign Rooney Road and Alameda for Through Traffic

(8) Existing Visitor Center - To Be Relocated

(9) Visitor Center and Ridge Access

(10) Private Drive to Rooney Ranch

(11) Existing Rooney Ranch

(12) Existing Rooney Gulch

PRELIMINARY COST ESTIMATE BREAKDOWN

NOTE

These estimates are based on master plannin and should be considered preliminary. Actual costs should be based on final designs.

Proposed Visitor Center					
Proposed Visitor Center					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Rooney Road & Alameda Boulevard Intersection Realignment	1	Ea.	$289,000.00	$289,000.00
	10% Contingency provided in estimate by others				
	TOTAL COST				**$289,000.00**
	LT				
	Visitor Center - Including: Site work, building, and landscaping	1	Ea.	$4,409,000.00	$4,409,000.00
	10% Contingency				$440,900.00
	TOTAL COST				**$4,849,900.00**
	GRAND TOTAL				**$5,138,900.00**
Circulation Improvements					
Existing Visitor Center to Ridge Trail					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Striping for Parking Delineation	1	Ea.	$10,000.00	$10,000.00
	Enhanced Crosswalk Striping	1	Ea.	$10,000.00	$10,000.00
	Wayfinding Signage	3	Ea.	$900.00	$2,700.00
	Regulatory Signage	3	Ea.	$600.00	$1,800.00
	10% Contingency				$2,450.00
	TOTAL COST				**$26,950.00**
	GRAND TOTAL				**$26,950.00**
Ridge Trail					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Overlay Repaving	1	Ea.	$500,000.00	$500,000.00
	Regulatory Signage	10	Ea.	$600.00	$6,000.00
	Pedestrian, Bus, Bike Lane Striping	1	Ea.	$20,000.00	$20,000.00
	10% Contingency				$52,600.00
	TOTAL COST				**$578,600.00**

	LT				
	Stained Concrete Pedestrian Trail (10' Wide Average)	57,160	SF	$10.00	$571,600.00
	Roll Top Curb and Gutter	5,762	LF	$35.00	$201,670.00
	Drainage Culverts	1	Lump	$10,500.00	$10,500.00
	Drainage Improvements-Ditch Type 1 (Vpan)	4,400	SF	$6.00	$26,400.00
	Drainage Improvements-Ditch Type 2 (Pan w/ Wall)	3,600	LF	$75.00	$270,000.00
	Drainage Improvements-Ditch Type-Natural Swale	600	LF	$6.00	$3,600.00
	Overlay Repaving	1	Ea.	$500,000.00	$500,000.00
	Wayfinding Signage	10	Ea.	$900.00	$9,000.00
	Pedestrian, Bus, Bike Lane Striping	1	Ea.	$20,000.00	$20,000.00
	Raised Concrete Curb (6" Ht)	5,716	LF	$25.00	$142,900.00
	Barrier Fence Allowance	1	Lump	$30,000.00	$30,000.00
	10% Contingency				$177,667.00
	TOTAL COST				**$1,963,337.00**
	GRAND TOTAL				**$2,541,937.00**
Dakota Ridge Trail					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	1	Ea.	$600.00	$600.00
	TOTAL COST				**$600.00**
	LT				
	Barrier Fence	325	LF	$60.00	$19,500.00
	Wayfinding Signage	1	Ea.	$900.00	$900.00
	10% Contingency				$1,950.00
	TOTAL COST				**$22,350.00**
	GRAND TOTAL				**$22,950.00**
Fossil Site Improvements					
Crocodile Creek					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	2	Ea.	$600.00	$1,200.00
	10% Contingency				$120.00
	TOTAL COST				**$1,320.00**

	LT				
	Rockfall Mitigation-Spot Scaling	1	Ea.	$13,500.00	$13,500.00
	Rockfall Mitigation-Rock Dowels	1	Ea.	$7,500.00	$7,500.00
	Track Viewing Platform	1	Ea.	$82,000.00	$82,000.00
	Bench-Flat	3	Ea.	$1,300.00	$3,900.00
	Trash Receptacles	1	Ea.	$1,500.00	$1,500.00
	Barrier Fence	321	LF	$60.00	$19,260.00
	10% Contingency				$12,766.00
	TOTAL COST				**$140,426.00**
	GRAND TOTAL				**$141,746.00**
Main Track Site					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Rockfall Mitigation-Spot Scaling	1	Ea.	$13,500.00	$13,500.00
	Rockfall Mitigation-Buttress	110	LF	$425.00	$46,750.00
	Paint Structure	1	Ea.	$3,000.00	$3,000.00
	Replace Roof on Structure	1	Ea.	$5,000.00	$5,000.00
	Regulatory Signage	3	Ea.	$600.00	$1,800.00
	10% Contingency				$7,005.00
	TOTAL COST				**$77,055.00**
	LT				
	Track Cover	1	Ea.	$6,000,000.00	$6,000,000.00
	Bench-Flat	3	Ea.	$1,300.00	$3,900.00
	Trash Receptacle	2	Ea.	$1,500.00	$3,000.00
	Barrier Fence	86	LF	$60.00	$5,160.00
	10% Contingency				$601,206.00
	TOTAL COST				**$6,613,266.00**
	GRAND TOTAL				**$6,690,321.00**
Ripple Marks					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	2	Ea.	$600.00	$1,200.00
	Rockfall Mitigation-Rockfall Fence	208	LF	$1,000.00	$208,000.00
	10% Contingency				$20,920.00
	TOTAL COST				**$230,120.00**

	LT				
	Barrier Fence	312	LF	$60.00	$18,720.00
	Stone or Tilted Stone Seat (Grouping)	2	Ea.	$15,000.00	$30,000.00
	10% Contingency				$4,872.00
	TOTAL COST				**$53,592.00**
	GRAND TOTAL				**$283,712.00**
Raptor Site					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Rockfall Mitigation-Spot Scaling	1	Ea.	$13,500.00	$13,500.00
	Regulatory Signage	1	Ea.	$600.00	$600.00
	Replace Gate Allowance	1	Lump	$5,000.00	$5,000.00
	10% Contingency				$1,910.00
	TOTAL COST				**$21,010.00**
	LT				
	Reconfigure Exhibit Allowance	1	Lump	$15,000.00	$15,000.00
	Barrier Fence	8	LF	$60.00	$480.00
	Wayfinding Signage	2	Ea.	$900.00	$1,800.00
	10% Contingency				$1,548.00
	TOTAL COST				**$18,828.00**
	GRAND TOTAL				**$39,838.00**
Rock Cut					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Rockfall Mitigation-Clean Catchment Allowance	1	Lump	$25,000.00	$25,000.00
	Rockfall Mitigation-Spot Scaling	1	Ea.	$13,500.00	$13,500.00
	Rockfall Mitigation-Rockfall Fence	215	LF	$1,000.00	$215,000.00
	Regulatory Signage	2	Ea.	$600.00	$1,200.00
	10% Contingency				$25,470.00
	TOTAL COST				**$280,170.00**
	LT				
	Barrier Fence	155	LF	$60.00	$9,300.00
	10% Contingency				$930.00
	TOTAL COST				**$10,230.00**
	GRAND TOTAL				**$290,400.00**

Brontosaurus Bulges					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	2	Ea.	$600.00	$1,200.00
	Rockfall Mitigation-Spot Scaling	1	Ea.	$13,500.00	$13,500.00
	Rockfall Mitigation-Rockfall Fence	90	LF	$1,000.00	$90,000.00
	Paint Railing	1	Ea.	$1,500.00	$1,500.00
	10% Contingency				$10,620.00
	TOTAL COST				**$116,820.00**
	LT				
	Barrier Fence	244	LF	$60.00	$14,640.00
	Stone or Tilted Stone Seat (Grouping)	2	Ea.	$15,000.00	$30,000.00
	Crusher Fines	15,650	SF	$0.75	$11,737.50
	10% Contingency				$5,637.75
	TOTAL COST				**$62,015.25**
	GRAND TOTAL				**$178,835.25**
Bone Quarry					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	2	Ea.	$600.00	$1,200.00
	Rockfall Mitigation-Spot Scaling	1	Ea.	$13,500.00	$13,500.00
	Paint Structure	1	Ea.	$5,000.00	$5,000.00
	10% Contingency				$1,970.00
	TOTAL COST				**$21,670.00**
	LT				
	Stone or Tilted Stone Seat (Grouping)	1	Ea.	$15,000.00	$15,000.00
	Barrier Fence	209	LF	$60.00	$12,540.00
	Trash Receptacle	1	Ea.	$1,500.00	$1,500.00
	Wayfinding Signage	2	Ea.	$900.00	$1,800.00
	Replace Roof	1	Ea.	$5,000.00	$5,000.00
	Chase Drains	2	Ea.	$2,000.00	$4,000.00
	10% Contingency				$3,984.00
	TOTAL COST				**$43,824.00**
	GRAND TOTAL				**$65,494.00**

Additional Improvements					
East Gate					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	2	Ea.	$600.00	$1,200.00
	10% Contingency				$120.00
	TOTAL COST				**$1,320.00**
	LT				
	New Informational Kiosk	1	Ea.	$20,000.00	$20,000.00
	Wayfinding Signage	2	Ea.	$900.00	$1,800.00
	New Gate	1	Ea.	$35,000.00	$35,000.00
	Stone Columns	5	Ea.	$3,000.00	$15,000.00
	Bike Rack-3 Loop	1	Ea.	$375.00	$375.00
	Barrier Fence	40	LF	$60.00	$2,400.00
	10% Contingency				$7,457.50
	TOTAL COST				**$82,032.50**
	GRAND TOTAL				**$83,352.50**
Ridge Plaza-East & West					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Minor Structure Improvements-Paint	2	Ea.	$2,000.00	$4,000.00
	Regulatory Signage	3	Ea.	$600.00	$1,800.00
	Rockfall Mitigation-Spot Scaling	1	Ea.	$13,500.00	$13,500.00
	Rockfall Mitigation-Rockfall Mesh	265	LF	$300.00	$79,500.00
	10% Contingency				$9,880.00
	TOTAL COST				**$108,680.00**
	LT				
	Vault Restroom	1	Ea.	$109,000.00	$109,000.00
	Replace Shelter Roof	2	Ea.	$5,000.00	$10,000.00
	Stained Concrete Pedestrian Trail (10' Wide Average)	135,000	SF	$10.00	$1,350,000.00
	Crusher Fines for Plaza	77,000	SF	$0.75	$57,750.00
	Bench-Flat	3	Ea.	$1,300.00	$3,900.00
	Picnic Tables	2	Ea.	$4,715.00	$9,430.00
	Landscape Boulders	18	Ea.	$250.00	$4,500.00
	Wayfinding Signage	4	Ea.	$300.00	$1,200.00
	Trash Receptacles	3	Ea.	$1,500.00	$4,500.00
	Bike Rack-3 Loop	2	Ea.	$375.00	$750.00
	Barrier Fence	450	LF	$60.00	$27,000.00
	Stone Columns	2	Ea.	$3,000.00	$6,000.00
	10% Contingency				$158,403.00
	TOTAL COST				**$1,742,433.00**
	GRAND TOTAL				**$1,851,113.00**

West Gate					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	2	Ea.	$600.00	$1,200.00
	10% Contingency				$120.00
	TOTAL COST				**$1,320.00**
	LT				
	New Informational Kiosk	1	Ea.	$20,000.00	$20,000.00
	Wayfinding Signage	2	Ea.	$900.00	$1,800.00
	New Gate	1	Ea.	$35,000.00	$35,000.00
	Stone Columns	5	Ea.	$3,000.00	$15,000.00
	Bike Rack-3 Loop	1	Ea.	$375.00	$375.00
	Barrier Fence	40	LF	$60.00	$2,400.00
	10% Contingency				$7,457.50
	TOTAL COST				**$82,032.50**
	GRAND TOTAL				**$83,352.50**
Bus Turnaround					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Regulatory Signage	1	Ea.	$600.00	$600.00
	Traffic Control for Pedestrians-Striping	1	Ea.	$10,000.00	$10,000.00
	10% Contingency				$1,060.00
	TOTAL COST				**$11,660.00**
	LT				
	Tour Buses	4	Ea.	$50,000.00	$200,000.00
	Add Port-o-Let location	1	Ea.	$5,000.00	$5,000.00
	Traffic Control for Pedestrians-Enhanced/Lighted Crosswalk	1	Ea.	$40,000.00	$40,000.00
	10% Contingency				$24,500.00
	TOTAL COST				**$269,500.00**
	GRAND TOTAL				**$281,160.00**
Port-o-Let					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Relocation to Ridge Plaza	1	Ea.	$500.00	$500.00
	TOTAL COST				**$500.00**
Information Signage Program					
	Item	**Quantity:**	**Unit:**	**Cost/Ea:**	**Cost/Total:**
	ST				
	Informational Signage	12	Ea.	$4,500.00	$54,000.00
	TOTAL COST				**$54,000.00**

REFERENCE DOCUMENTS

MASTER PLAN DOCUMENT PROCESS

Development of the Master Plan Document has involved extensive participation from members of Friends of Dinosaur Ridge, various stakeholder groups, Jefferson County staff members from numerous departments, Jefferson County Open Space, consultants and contractors. An outline of the Master Plan Document progression is as follows:

Discovery Phase (Consultant team, JCOS, FODR) - July 2018

- Initial investigation of existing condition, past improvment efforts, past planning efforts.
- Initial programming meetings with JCOS & FODR to explore needs and desires.

Planning & Design Charrettes

- Charrette #1 - Jefferson County Open Space - Mesa Room, August 14, 2018.
    - ◊ FODR, JCOS, Consultant Team formal review of initial investigative data and programming needs - Formal feedback and expansion of conclusions.
- Charette #2 - Jefferson County Open Space - Ponderosa Room, August 30, 2018.
    - ◊ FODR, JCOS, Jefferson County Traffic & Engineering, Jefferson County Road & Bridge, National Park Service, Dan O'Brien, History Colorado - Presentation of investigation and programming conclusions to larger stakeholder groups. Feedback and recommendations from stakeholder groups. Discussion of design solutions
- FODR Board of Directors Meeting - Dinosaur Ridge - Discovery Center, November 14, 2018.
    - ◊ FODR, JCOS, Consultant Team - Presentation of Analysis, programming, Rockfall Study, Visitor Center Options.

Documentation Process and Timeline

- Draft Rockfall Mitigation & Drainage Study: November 2018.
- Final Rockfall Mitigation & Drainage Study: January 2019.
- Development and Application of Design Solutions:

  October 2018 - January 2019.
- Development and Review of 1st Document Draft:

  February 2019.
- Developement of Visitor Center Cost Estimates:

  February - March 2019.
- Selection of Visitory Center Concept Option: March 2019.
- Final Development of Visitor Center: March 2019.
- Development and Review of 2nd Document Draft: April 2019.
- Development of Final Master Plan Document: April 2019.

REFERENCE DOCUMENTS

Sign Survey

Geology of Exposure along the Rockies Front Range

US Department of Interior, National Park Service, Morrison Fossil Area National Natural Landmark (Dinosaur Ridge) Letter

Rockfall/Drainage Draft Report - Friends of Dinosaur Ridge Comments.

Rockfall/Drainage Draft Report - Jefferson County Open Space Comments.

Bartlett, S., 2018, *A Survey of Rock Fall Hazards on Dinosaur Ridge, Submitted to the Board of Directors, The Friends of Dinosaur Ridge,* August 13, 2018, and Addendum 1, August 14, 2018.

Yeh and Associates, 2019, *Final Geologic Hazard Study and Pavement Recommendations, Dinosaur Ridge Recreation Area, Jefferson County, Colorado*, January 2019. **(Appendix - A)**

Muller Engineering Company, 2019, *Dinosaur Ridge Recreation Area, Final Conceptual Drainage Report, Jefferson County Open Space, Colorado*, January 2019. **(Appendix - B)**

Friends of Dinosaur Ridge - Branding Comments.

Friends of Dinosaur Ridge - Visitor Center Concept Options Review Comments.

Daniel H. O'Brien, Architect, 2009, *Dinosaur Ridge Track Cover,* February 2009.

Jefferson County Open Space, Master Plan 2014-2019.

Jefferson County Transportation & Engineering Memorandum, Drainage Draft Report Comments, November 2018.

Front Range Mountain Backdrop Technical Report, A Cooperative Effort of Boulder, Douglas, El Paso, Jefferson, and Larimer Counties, December 1996.

Andrews & Anderson, P.C., DHM, Inc. *Dinosaur Ridge*, July 1999.

Andrews & Anderson, P.C., DHM, Inc. *Dinosaur Ridge Visitor Center Master Plan, Phase Two*, 2000.

Winston Associates, *Visitor Center Concepts*, April 2002.

Anderson Hallas Architects, *Visitor Center Concepts*, 2007.

APPENDICES

APPENDIX - A

Final

Geologic Hazard Study and Pavement Recommendations

Dinosaur Ridge Recreation Area

Jefferson County, Colorado

Yeh Project No.: 218-188

January 25, 2019

Prepared for:

Norris Design
Attn: Mr. Sean Malone
1101 Bannock Street
Denver, Colorado 80204

Prepared by:

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2000 Clay Street, Suite 200
Denver, Colorado 80211

Phone: 303-781-9590
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Yeh and Associates, Inc.
Consulting Engineers & Scientists

Final

Geologic Hazard Study and Pavement Recommendations

Dinosaur Ridge Recreation Area

Jefferson County, Colorado

Yeh Project No.: 218-188

January 25, 2019

Prepared by:

Brett Arpin, P.E.
Senior Project Engineer

Reviewed by:

Todd Schlittenhart, P.E.
Project Manager

Yeh and Associates, Inc.
Consulting Engineers & Scientists

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EXECUTIVE SUMMARY

Jefferson County Open Space (JCOS) has requested a site plan for the Dinosaur Ridge Recreation Area to enhance visitor experience and improve resource preservation, recreation management, programming, park facilities, and site amenities. As part of the overall site plan and future site-specific preservation projects, JCOS has requested a geologic hazard study of ridge areas above Alameda Avenue within the recreation area. Conceptual level pavement rehabilitation options have also been requested for Alameda Avenue.

Rockfall is the primary geologic hazard present at the sites identified on Dinosaur Ridge. The rockfall hazard rating and recommended conceptual level rockfall mitigation for eight sites in Dinosaur Ridge Recreation Area are summarized in the following table.

Site	Rockfall Hazard Rating	Recommended Rockfall Mitigation
Crocodile Creek	Moderate	• Spot scaling • Rock dowels
North of Dinosaur Tracksite	High	• Spot scaling • Clean catchment • Maintain pedestrian barrier • Drainage improvements
South of Dinosaur Tracksite	Moderate	• Spot scaling • Buttress • Pedestrian barrier
South side of cut at upper curve	Moderate	• Spot scaling • Clean catchment • Pedestrian barrier
North side of cut at upper curve	High	• Spot scaling • Extend rockfall mesh
Brontosaurus Bulges	Moderate	• Spot scaling • Rockfall fence • Drainage improvements
Between Brontosaurus Bulges and Dinosaur Bone Site	Moderate	• Spot scaling • Pedestrian barrier • Catchment area
Dinosaur Bone Site	Moderate	• Spot scaling • Drainage improvements

The recommended rockfall mitigation techniques are the primary mitigation options recommended for each site and listed in preferred order. At most sites, one or more mitigation options may be implemented to lower the rockfall hazard rating. Upon acceptance of the overall site plan, we recommend a detailed rockfall mitigation analysis and design at each site in conjunction with final design and implementation of the selected project to finalize the rockfall mitigation approach that will be most effective in preserving resources and improving public safety.

The Alameda Avenue pavement within Dinosaur Ridge Recreation Area is generally in poor condition and a major rehabilitation program is warranted. A detailed pavement investigation, including subsurface investigation and laboratory testing, is necessary to identify preferred pavement rehabilitation strategies which may include full depth reclamation (FDR) and overlay, thin concrete overlay, cold-in-place recycling and overlay, hot-in-place recycling and overlay, and thick asphalt overlay.

1. Purpose and Scope of Study

This report presents the results of our geologic hazards study and pavement recommendations for the Jefferson County Open Space (JCOS) Dinosaur Ridge Recreation Area along Alameda Avenue in Jefferson County, Colorado. The Dinosaur Ridge area is part of a National Natural Landmark called the Morrison Fossil Area, designated in 1973.

The study was performed in accordance with our proposal to Norris Design dated July 20, 2018.

1.1 Purpose of Work

JCOS has requested a site plan for the Dinosaur Ridge Recreation Area to enhance visitor experience and improve resource preservation, recreation management, programming, park facilities, and site amenities. As part of the overall site plan and future site-specific preservation projects, JCOS has requested a geologic hazard study of ridge areas above Alameda Avenue within the recreation area. Conceptual level pavement rehabilitation options have also been requested for Alameda Avenue.

1.2 Scope of Work

Our scope of work included the following:

- Attend a project kick-off meeting with Norris Design and JCOS to identify key areas of geologic hazards.
- Plan and coordinate right-of-entry with JCOS and Friends of Dinosaur Ridge.
- Conduct a site reconnaissance to observe and document sites having geologic hazards.
- Prepare up to five conceptual level mitigation options at each site to improve public safety, maintain the natural characteristics of the sites, and mitigate the geologic hazard.
- Conduct a visual pavement distress survey of the existing asphalt pavement surface to identify and rate observed distresses within the study area.
- Prepare conceptual level pavement rehabilitation options in accordance with the intended shared use of Alameda Avenue within the study area.
- Prepare scoping level estimates of the construction costs associated with the conceptual geologic hazard mitigation options and pavement rehabilitation options.

- Prepare a geologic hazard study and pavement recommendations report.
- Attend one project meeting with Norris Design and JCOS to discuss the geologic hazard study and pavement recommendations.

2. General Site Conditions

Dinosaur Ridge, commonly referred to as the Dakota Hogback, is formed by tilted sedimentary rocks. Bedrock comprising the west slope of the ridge is erodible shales, thin limestones, and interbedded sandstone and siltstone of the Morrison Formation. More resistant sandstone with interbedded shale of the Lytle and South Platte Formations, making up the Dakota Group, outcrop on the east slope of the ridge.

Alameda Avenue ascends the east side of the ridge traversing south before cutting through the Hogback and descending the west side of the ridge traveling north. Numerous rock cuts are present along the road.

3. Geologic Hazards

3.1 Previous Work

Sam Bartlett RG, CEG, Preservation Committee Chairman of the Friends of Dinosaur Ridge, prepared a detailed discussion of site conditions and rockfall hazards in “A Survey of Rock Fall Hazards on Dinosaur Ridge” (2018). In this survey, the ridge was divided into 10 zones based on rock and slope characteristics and the potential for rockfalls. A tier system was applied to each zone to identify the severity of rockfall hazard and urgency for remediation with tier 1 being the highest hazard and tier 3 being the lowest. Table 1 summarizes the criteria established by Bartlett (2018) for each tier. Maintenance and mitigation options were presented for each zone.

Table 1 – Summary of Rockfall Hazard and Urgency of Remediation Tiers (from Bartlett, 2018)

Tier	Description
1	Very serious stability issues needing urgent attention
2	Serious stability issues with a high priority for remediation but less serious than Tier 1 issues
3	Stability issues that can be treated as a lesser priority and can wait for remediation as the higher priorities get treated or as funding is allocated

Also included in the report by Bartlett (2018) is a report by the National Park Service (NPS) evaluating the erosion and potential actions for the Dinosaur Tracks at Dinosaur Ridge (Pranger and Greco). The report identifies 12 potential sources of or factors contributing to the erosion of the rock surface at the tracksite. Four potential actions to reduce the rate of erosion and loss of the tracks were presented. Potential actions consist of patching eroded areas with colored concrete to support perched upslope rock slabs, installing rock bolts to hold remaining sandstone blocks in place, constructing a climate-controlled shelter over the tracksite, and salvaging the rocks with tracks from the tracksite and reassembling the rocks in a protected location.

3.2 Geologic Hazard Ratings

Rockfall is the primary geologic hazard present at the sites identified on Dinosaur Ridge. Rockfall hazard ratings of low, moderate, and high were evaluated for each site based on the criteria outlined in Table 2.

Table 2 – Rockfall Hazard Rating Criteria

Rockfall Hazard Rating	Criteria
Low	• Few loose rocks on slope or in ditch • Rock outcrops are massive and have minimal fracturing/discontinuities • Short slope length from rockfall source zone to Alameda Avenue • Few launching features on slope • Slope is well vegetated
Moderate	• Some loose rocks on slope or in ditch • Rock outcrops are somewhat fractured and exhibit some differential weathering • Moderate slope length from rockfall source zone to Alameda Avenue • Some launching features on slope • Slope is somewhat vegetated
High	• Many loose rocks on slope and in ditch • Rock outcrops are highly fractured and exhibit high differential weathering • Long slope length from rockfall source zone to Alameda Avenue • Numerous launching features on slope • Limited vegetation on slope

3.3 Geologic Hazard Sites

A site reconnaissance was performed to review geologic hazard sites identified in previous work and sites identified by JCOS. Table 3 summarizes the identified sites with a general site description and conceptual level mitigation options. A map showing the locations of the sites is provided in Appendix A. Typically, one to two mitigation options are selected as the primary mitigation for each site; however, to complement the selected projects under the overall site plan, the final design of rockfall mitigation for each site will likely incorporate secondary options to address site conditions and other constraints. Descriptions of the mitigation options are provided in the sections following the table.

Table 3 – Summary of Rockfall Hazard Sites and Mitigation Options

Site	Rockfall Hazard Rating	Zone (from Bartlett, 2018)	Tier (from Bartlett, 2018)	Description	Mitigation Options
Crocodile Creek	Moderate	2	2	Sandstone blocks undermined by erosion of thin shale seams, existing rock dowels installed in sandstone blocks	• Spot scaling • Rock dowels • Buttress
North of Dinosaur Tracksite	High	3a	1	Rockfalls have filled the ditch behind the timber barrier, drainage pipe from above the tracksite is damaged and separated in many locations	• Spot scaling • Clean catchment • Maintain pedestrian barrier • Drainage improvements
South of Dinosaur Tracksite	Moderate	3	3	Sandstone blocks undermined by erosion of thin shale seams	• Spot scaling • Rock dowels • Buttress • Pedestrian barrier
South side of cut at upper curve	Moderate	4	1	Differential erosion of fractured sandstone and shale, interpretive sign in rockfall catchment area	• Spot scaling • Clean catchment • Pedestrian barrier
North side of cut at upper curve	High	5	1	Fractured rockmass west of existing rockfall mesh, concrete barrier placed on road along ditch	• Spot scaling • Extend rockfall mesh • Pedestrian/traffic barrier
Brontosaurus Bulges	Moderate	7/8	1	Rockfall hazard from rock overhangs and outcrops on ridge above road	• Spot scaling • Rockfall shed • Rockfall fence • Drainage Improvements
Between Brontosaurus Bulges and Dinosaur Bone Site	Moderate	8	1	Rockfall hazard from rock overhangs and outcrops on ridge above road	• Spot scaling • Rockfall mesh • Pedestrian barrier • Catchment area
Dinosaur Bone Site	Moderate	8	1	Rockfall hazard from rock overhangs, existing rockfall mesh above site	• Spot scaling • Drainage improvements

4. Conceptual Rockfall Mitigation Options

4.1 Spot Scaling

Spot scaling consists of removing select loose rocks and debris in a controlled manner. Scaling is selective to limit disturbance to the slopes, reduce destabilization of other rock and debris, and preserve rocks with tracks or fossils, where possible. Scaling can help to preserve tracksites by removing loose rocks that have the potential to damage tracksites. Scaling is typically performed in conjunction with other mitigation options and is likely effective for two to five years as ongoing weathering and erosion may create new rockfall potential in the future. We recommend that scaling performed at Dinosaur Ridge be observed by a qualified representative of JCOS to limit detrimental effects. Spot scaling is estimated to cost approximately $7,000 to $20,000 per site depending on the size of the site and the amount of scaling necessary.

4.2 Rock Dowels

Rock dowels consist of installing steel bars into a hole drilled through a potentially unstable rock block into stable rock below. The steel bar is then anchored in the drill hole with an epoxy resin. The shear strength of the rock dowel acts to stabilize the rock blocks from sliding. The exposed end of the rock dowels can be covered with colored grout to reduce aesthetic impacts (Figure 1). Rock dowels have previously been installed in various locations at Dinosaur Ridge. As discussed in the NPS report (Pranger and Greco), rock dowels, referred to as rock bolts in the report, have the potential to fracture thin rock blocks. The risk of fracturing rock can be reduced by using this technique on thicker rock blocks that are not already fractured. Rock dowels are estimated to cost $5,000 to $10,000 per site depending on the number of rock dowels required.

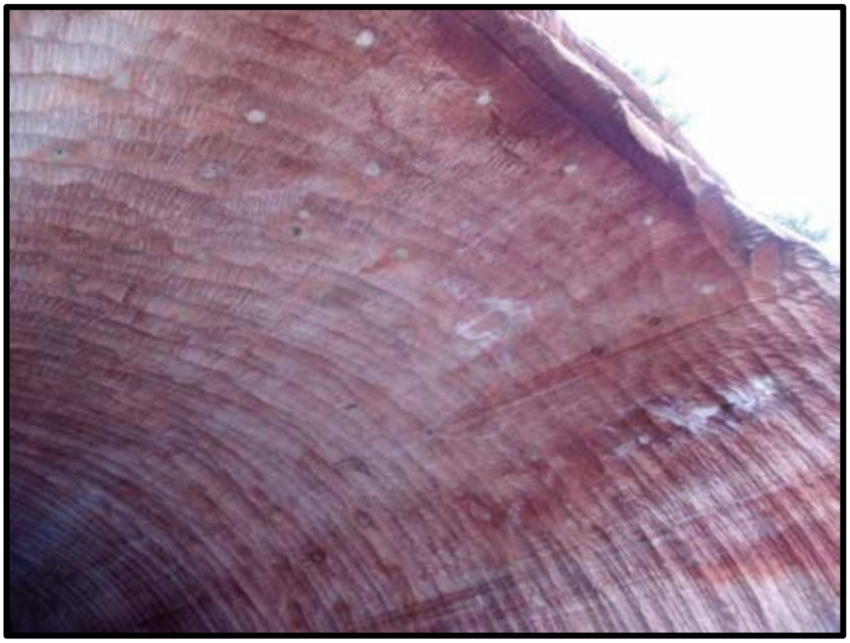

Figure 1 – Rock dowels supporting tunnel crest and covered with colored grout

4.3 Buttress

A buttress consists of rock dowels and sculpted shotcrete installed adjacent to a potentially unstable rock block. The buttress provides confinement to the rock block and prevents the rock from sliding. The rock dowels are installed into the stable rock on which the unstable rock would slide. Shotcrete is applied, sculpted, and colored to match the surrounding rock. This option would preserve tracksites and other features by stabilizing rock blocks in place. The NPS report (Pranger and Greco) suggest that this option may not be very effective when considering thin rock slabs and freeze-thaw cycles. While this option may not be effective in all situations, it can be effective when appropriately designed and constructed in the correct application. The design life of the buttress options is likely near 20 years as indicated in the NPS report (Pranger and Greco). An example of shotcrete sculpted and colored to match the surrounding rock is shown in Figure 2. The buttress option is estimated to cost $350 to $500 per linear foot.

Figure 2 – Example of shotcrete sculpted and colored to match surrounding rock

4.4 Rockfall Catchment Area

Rockfall catchment areas are presently used in areas such as north of the Dinosaur Tracksite. The catchment area generally consists of an area below the rockfall hazard that has been graded to retain rocks and prevent them from rolling into the roadway or other feature; the catchment area often has a barrier or other measures to prevent people from entering the area. Rockfall modeling and analysis are recommended to evaluate the required size of the rockfall catchment area. Rockfall catchment areas are effective but require periodic maintenance to remove accumulated rock and other debris. Catchment areas are generally already present at sites where they have been presented as a mitigation option. The cost to formalize the catchment area would include any necessary regrading, placing pedestrian barriers, and placing signs to keep visitors from entering the area.

4.5 Pedestrian Barrier

Pedestrian barrier, such as the timber barrier placed around the rockfall catchment area north of the Dinosaur Tracksite, can be used to prevent pedestrians and other users from entering rockfall hazard areas. Pedestrian barriers are typically used in conjunction with rockfall catchment areas. Rockfall modeling and analysis are recommended to evaluate the required size of the rockfall catchment area. The cost of pedestrian barriers is anticipated to be minimal compared to other rockfall mitigation options.

An alternative to the timber barriers already used on Dinosaur Ridge could include a stone faced concrete wall. Such a wall will be costlier to construct and maintain than a timber barrier. Impacts from rockfalls are likely to cause damage to the wall that would be costly to repair. Rockfall modeling and analysis would be required to design the wall to retain rockfall.

4.6 Drainage Improvements

Drainage improvements consist of collecting and conveying water around rockfall hazard areas to reduce impacts of erosion and freeze-thaw cycles. Muller Engineering Company has prepared a Conceptual Drainage Report for the Dinosaur Ridge Recreation Area (2019) as part of the overall site plan. The report describes drainage improvements for the tracksite, the Brontosaurus Bulges site, and the Dinosaur Bone site. The improvements generally consist of a ditch above each site to collect surface drainage and direct flows into rundowns. The drainage improvements will help to increase rockmass stability and preservation by diverting surface water. Where rockfall hazards are present above the drainage improvements, such as at the Brontosaurus Bulges site, additional rockfall mitigation measures may be needed. The cost of drainage improvements will be highly dependent on the site-specific design. The existing rockfall mesh at the Dinosaur Bone site may need to be removed and reset if the final drainage configuration conflicts with the mesh location.

It is our understanding that a wall has been designed to control and direct surface water drainage around the Crocodile Creek site where a stairway and viewing platform are proposed. Based on information provided to us, limited details of the design are available. The wall will likely improve rockmass stability and preservation by diverting surface water. Due to the adverse dip of the rock structure at the Crocodile Creek site, stabilization options, such as rock dowels and buttresses, in addition to the wall are likely the most efficient approach to preserving the site.

4.7 Rockfall Mesh

Rockfall mesh is a steel wire formed into somewhat flexible sheets similar to chain link. The rockfall mesh is anchored at the top of the slope by steel bars grouted into the ground. The mesh is draped over the slope to retain rockfall and direct it into a catchment area below the mesh. Rockfall mesh has previously been installed on the north side (south facing) cut at the upper curve of Alameda Avenue. Rockfall mesh is estimated to cost $250 to $350 per linear foot along the roadway and will depend on the height of the slope being mitigated.

4.8 Rockfall Shed

A rockfall shed consists of a structure covering interpretive signs and other highly visited areas to protect people and resources from rockfall. The shed is designed to withstand the impact of a rockfall without significant structural damage. Periodic maintenance would be required to remove accumulated rock and debris from the top of the rockfall shed. An example of a rock shed protecting a roadway is shown in Figure 3. A rockfall shed is estimated to cost $10,000 per linear foot.

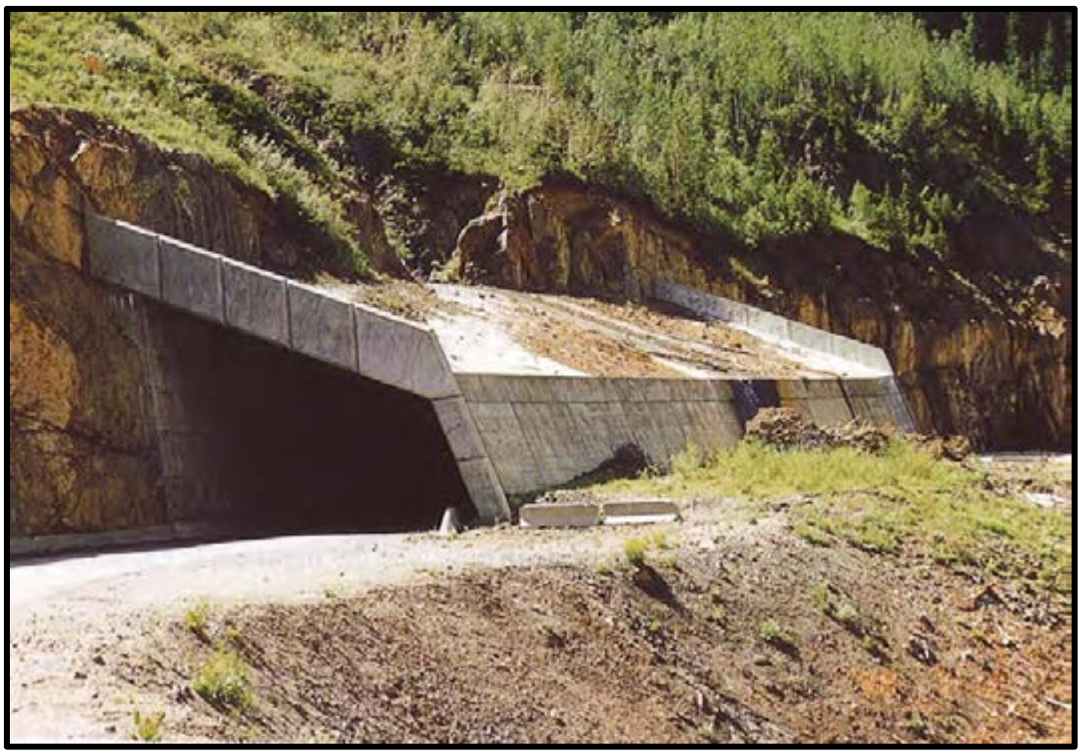

Figure 3 – Rock shed protecting roadway from rockfall

4.9 Rockfall Fence

A rockfall fence consists of panels made of steel cable suspended from steel posts. The fence is installed between the rockfall hazard area and the area to be protected. Anchors are installed into the ground to support the fence during an impact from a rockfall. Periodic maintenance would be required to remove accumulated rock and debris from behind the rockfall fence. An example of a rockfall fence is shown in Figure 4. A rockfall fence is estimated to cost $1,000 per linear foot.

Figure 4 – Example of a rockfall fence

4.10 Tracksite Cover

It is our understanding that a cover is being designed for the tracksite in Zone 3a identified by Bartlett (2018). Specific details of the cover were not provided to us at the time of this report. The NPS report (Pranger and Greco) suggest a climate-controlled shelter would eliminate direct precipitation, runoff, and freeze-thaw conditions on the tracksite. We agree that a climate-controlled cover will be beneficial to eliminate direct precipitation and freeze-thaw conditions and we share NPS's concerns regarding the cover. Groundwater and water flow through fractures in the rock would need to be considered to complement the cover design. Additional rockfall mitigation features may be required to protect the tracksite cover, tracks, and the public from rockfall originating from within and outside of the cover.

4.11 Summary of Rockfall Mitigation Costs

Table 4 summarizes the estimated construction costs for the rockfall mitigation options presented above.

Table 4 – Summary of Estimated Rockfall Mitigation Costs

Option	Estimated Construction Cost
Spot Scaling	$7,000 - $20,000 per site
Rock Dowels	$5,000 - $10,000 per site
Buttress	$350 - $500 per linear foot
Rockfall Catchment Area	Cost to formalize area
Pedestrian Barrier	Minimal compared to other options
Drainage Improvements	Site Specific
Rockfall Mesh	$250 - $350 per linear foot
Rockfall Shed	$10,000 per linear foot
Rockfall Fence	$1,000 per linear foot

5. PAVEMENT EVALUATION AND RECOMMENDATIONS

5.1 Pavement Evaluation Methods

The pavement evaluation was performed generally following the criteria and terminology of the Distress Identification Manual for Long-Term Pavement Performance Studies (Miller and Bellinger, 2003). Visual inspection was performed in the paved areas to obtain data and information to assess the overall condition of the pavement and define specific areas of distress. Based on the data collected, potential pavement rehabilitation options, and scoping level estimates of the construction costs have been prepared.

5.2 Pavement Condition

The asphaltic pavement is generally in poor condition and is nearing the end of its designed structural life. The majority of the area exhibits high severity alligator (fatigue) cracking, longitudinal, transverse, and edge cracking, delamination, raveling, potholes, and deformation. Pavement deterioration is generally related to the age of the pavement, inadequate repairs, poor drainage, and thickness inadequacies. A summary of the more extensive distress and visible deteriorations is provided in Appendix B. Representative photographs of the pavement deterioration are provided in Appendix C.

5.3 Pavement Rehabilitation Options

Asphalt pavement rehabilitation strategies may vary depending on how the roadway will be utilized in the future. Existing pavement has deteriorated to the condition that pavement maintenance of thin functional treatments and minor rehabilitation may not be suitable or feasible remedies. A major rehabilitation treatment is more conducive to the existing pavement conditions, and may include, but is not limited to Full Depth Reclamation (FDR), thin concrete overlays, cold-in-place recycling, hot-in-place recycling, and thick overlays as described in the following sections. A roadway width of 26 feet was assumed in estimating the construction cost of each option.

5.3.1 Full Depth Reclamation (FDR) and Overlay

FDR is a rehabilitation or a reconstruction technique in which the full thickness of asphalt pavement and a pre-determined portion of the underlying materials (base, subbase, and/or subgrade) are uniformly pulverized and blended to provide a homogeneous material without the use of heat. FDR is a two-phase operation. The first operation is to create the base material. Temporary traffic may be placed on the roadway after this operation. The final operation is to place an overlay on top of the base material. For pavement design, the full depth reclaimed material is considered a base material. FDR and asphalt overlay are estimated to cost $470,000 per mile of roadway.

5.3.2 Thin Concrete Overlay

Thin concrete overlay consists of placing a relatively thin layer of concrete pavement over the existing pavement. This technique can be used over badly deteriorated pavement. Thin concrete overlay is estimated to cost $550,000 per mile of roadway.

5.3.3 Cold-in-Place Recycling (CIR) and Overlay

CIR consists of partial depth pulverization of the existing asphalt and addition of a recycling agent, emulsified asphalt, or foamed asphalt. The material is then mixed, placed, and compacted. New hot mix asphalt is placed on top of the compacted material to form the driving surface. CIR and overlay are estimated to cost $420,000 per mile of roadway.

5.3.4 Hot-in-Place Recycling (HIR) and Overlay

HIR consists of softening of the asphalt bound surface through heating and scarifying with tines or a milling head. New lifts of hot mix asphalt are placed directly on top of the loose surface recycled material and compacted simultaneously as one layer. HIR and overlay are estimated to cost $440,000 per mile of roadway.

5.3.5 Thick Asphalt Overlay

Thick asphalt overlay consists of placing several layers of hot mix asphalt to form a relatively thick asphalt section. Thick asphalt overlay is estimated to cost $500,000 per mile of roadway.

5.4 Summary of Pavement Rehabilitation Costs

Table 5 summarizes the estimated costs for the pavement rehabilitation options presented above. A more specific rehabilitation strategy can be prescribed when a detailed pavement investigation, including subsurface investigation and laboratory testing, is performed. In addition, the proposed future use of the facility and the anticipated traffic loading will be critical factors in optimizing treatment selection and overlay thickness.

Table 5 – Summary of Estimated Pavement Rehabilitation Costs

Option	Estimated Cost*
FDR and Overlay	$470,000 per mile
Thin Concrete Overlay	$550,000 per mile
Cold-in-Place Recycling and Overlay	$420,000 per mile
Hot-in-Place Recycling and Overlay	$440,000 per mile
Thick Asphalt Overlay	$500,000 per mile
*A roadway width of 26 feet is assumed	

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conceptual Rockfall Mitigation

Table 6 presents recommended conceptual level rockfall mitigation options for eight sites in Dinosaur Ridge Recreation Area. The recommended rockfall mitigation options are the primary options for each site and listed in preferred order. At most sites, one or more mitigation options may be implemented to lower the rockfall hazard rating. Upon acceptance of the overall site plan, we recommend a detailed rockfall mitigation analysis and design at each site in conjunction with final design and implementation of the selected project to finalize the rockfall mitigation approach that will be most effective for preserving resources and protecting the public.

Table 6 – Recommended Conceptual Level Rockfall Mitigation Options

Site	Rockfall Hazard Rating	Recommended Rockfall Mitigation
Crocodile Creek	Moderate	• Spot scaling • Rock dowels
North of Dinosaur Tracksite	High	• Spot scaling • Clean catchment • Maintain pedestrian barrier • Drainage improvements
South of Dinosaur Tracksite	Moderate	• Spot scaling • Buttress • Pedestrian barrier
South side of cut at upper curve	Moderate	• Spot scaling • Clean catchment • Pedestrian barrier
North side of cut at upper curve	High	• Spot scaling • Extend rockfall mesh
Brontosaurus Bulges	Moderate	• Spot scaling • Rockfall fence • Drainage improvements
Between Brontosaurus Bulges and Dinosaur Bone Site	Moderate	• Spot scaling • Pedestrian barrier • Catchment area
Dinosaur Bone Site	Moderate	• Spot scaling • Drainage improvements

In addition to the mitigation options presented, JCOS may want to consider the following.

- Posting rockfall hazard signs to inform visitors of hazardous areas.
- Establishing a rockfall hazard inspection procedure to be performed annually (at a minimum) and following noted rockfall events. The inspection procedure may include visual observations recorded on established forms. Alternatively, remote sensing methods (LiDAR or photogrammetry) and change detection analyses may be used to identify active rockfall locations.

- Increasing the distance from rock slopes to pedestrian barriers for rated rockfall sites during precipitation and freeze-thaw events, when the frequency of rockfall events increases.

- Closing off pedestrian access at high rockfall hazard rated sites during, and immediately following, precipitation events

6.2 Pavement Recommendations

The Alameda Avenue pavement within Dinosaur Ridge Recreation Area is generally in poor condition and a major rehabilitation program is warranted. A detailed pavement investigation, including subsurface investigation and laboratory testing, is necessary to identify preferred pavement rehabilitation strategies.

7. LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the client for conceptual design purposes. The conclusions and recommendations submitted in this report are based upon the data provided by JCOS and Norris Design and our understanding of the proposed project. Extreme events such as major wildfire or flooding can change the nature and extent of geologic hazards present at the site. This work focused on observable site conditions as to the nature and extent of the typical geohazards within the site limits.

Rockfall and rockfall events are sporadic and unpredictable. This report does not attempt to predict the average recurrence interval, magnitude, or location of a rockfall event. These factors cannot be predicted. Consequently, neither the rockfall hazard in terms of probability of a rockfall at any specific location, nor the risk to people or structures to such events are assessed in this report. Furthermore, rockfall events can potentially occur at any time and at any location.

8. REFERENCES

Ayres Associates, 2017, Dinosaur Ridge Calculations Basis and Assumptions Memorandum, Project No. 32-1898.00, December 8, 2017.

Bartlett, S., 2018, A Survey of Rock Fall Hazards on Dinosaur Ridge, Submitted to the Board of Directors, The Friends of Dinosaur Ridge, August 13, 2018, and Addendum 1, August 14, 2018.

Miller, J.S. and W.Y. Bellinger, 2003, Distress Identification Manual for the Long-Term Pavement Performance Program (Fourth Revised Edition), FHWA-RD-03-031, Federal Highway Administration.

Muller Engineering Company, 2019, Dinosaur Ridge Recreation Area, Final Conceptual Drainage Report, January 2019.

Pranger, H. and Greco D., date unknown, Evaluation of the Erosion of Fossil Dinosaur Tracks at Dinosaur Ridge, Morrison Fossil Area National Natural Landmark, Morrison, Colorado, Geoscience and Restoration Branch – Geologic Resources Division (GRD), National Parks Service – Natural Resource Program Center (NRPC).

Appendix A

ROCKFALL HAZARD SITE LOCATION MAP

Yeh and Associates, Inc.
Consulting Engineers & Scientists

NO.	SHEET REVISION	BY	DATE

REUSE OF DOCUMENT

DRAWN BY: MJW DATE: 1/21/2019
CHECKED BY: BDA DATE: 1/21/2019
DESIGNED FOR:
PROJECT NUMBER: 218-188
SCALE
HORIZ: 1:400 VERT:

PROJECT:
DINOSAUR RIDGE RECREATION AREA

ROCKFALL HAZARD AREA
LOCATION MAP

SHEET
1
OF
1

Appendix B

PAVEMENT DISTRESS SUMMARY

				Distresses in Asphalt Pavement																					
	Dimensions			Alligator Cracking			Longitudinal and Transverse Cracking			Edge Cracking			Lane/Shoulder Drop-Off			Potholes			Patching and Utility Cut Patching			Weathering (Surface Wear)			
Segment	Segment Length (ft)	Road Width (ft)	Segment Area (ft^2)	Low (ft^2)	Medium (ft^2)	High (ft^2)	Low (ft)	Medium (ft)	High (ft)	Low (ft)	Medium (ft)	High (ft)	Low (ft)	Medium (ft)	High (ft)	Low (quantity)	Medium (quantity)	High (quantity)	Low (ft^2)	Medium (ft^2)	High (ft^2)	Low (ft^2)	Medium (ft^2)	High (ft^2)
YA-WAP-1	500	26	13000	348	558		215	651	15		300	407		225	325	18	1	2					3250	9750
YA-WAP-2	500	26	13000	341	600		418	457			269	150		318	262	4	1					4329	8671	
YA-WAP-3	500	26	13000																					
YA-WAP-4	500	26	13000																					
YA-WAP-5	500	26	13000	431	259		325	647			172	60		51	12			2				6500	6500	
YA-WAP-6	500	26	13000																					
YA-WAP-7	500	26	13000	301	162		375	1028		229	241	16							104			6500	6500	
YA-WAP-8	500	26	13000																					
YA-WAP-9	500	26	13000	385	300		250	1137			321	58							144			7800	5200	
YA-WAP-10	500	26	13000																					
YA-WAP-11	750	26	19500	380	342			1577		43	618	126		62	18				230			11700	7800	
Total	5750																							

Appendix C

PAVEMENT DETERIORATION PHOTOGRAPHS

APPENDIX - B

DINOSAUR RIDGE RECREATION AREA

Final Conceptual Drainage Report

January 2019

Prepared for:

Jefferson County Open Space
700 Jefferson County Parkway, Suite 100
Golden, CO 80401

Prepared by:

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777 South Wadsworth Boulevard
Suite 4-100
Lakewood, Colorado 80226
303.988.4939

Muller Project Number: 18-037.01

MULLER ENGINEERING COMPANY

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EXECUTIVE SUMMARY

Overall the intent of this project is to develop a site plan/conceptual master plan for the Dinosaur Ridge Recreation Area located within Jefferson County, Colorado. This site plan is being developed for the enhancement of the visitor's experience and safety, the preservation of geologic and paleontological sites, recreation management, and the improvement of park facilities and site amenities. Muller Engineering was selected to assist in developing this site plan/conceptual master plan by developing a conceptual level drainage report for the site. This conceptual level drainage report reviews improvements and impacts to site drainage that are part of the proposed roadway and trail improvements, Dinosaur Ridge Visitor Center, and Visitor Parking Lot. In addition, this drainage report discusses potential mitigation options for rockfall hazard sites, as determined by Yeh and Associates, where drainage improvements were identified as being feasible mitigation options.

To analyze drainage impacts to the site associated with the roadway and trail improvements 10-year flow rates for the existing and proposed drainage basins, and the capacities of five existing cross culverts and one side culvert were analyzed. From this analysis it was determined that one of these culverts is undersized and will need to be replaced, and existing corrugated metal pipes should be replaced with reinforced concrete pipes for design life purposes. Improvements to roadside ditches are also proposed due to severe erosion that is currently occurring onsite. Two concrete lined roadside ditch typical sections were developed that will prevent further erosion of the ditches. A proposed visitor center and parking lot are anticipated improvements to the Dinosaur Ridge Recreation Area, and a water quality and detention pond will be required to treat stormwater runoff from these two improvements. A preliminary pond layout was developed during this study that is capable of detaining stormwater for water quality treatment purposes.

Three rockfall hazard areas identified by Yeh and Associates as having drainage improvements as feasible mitigation options were noted in their report "Final Geologic Hazard Study and Pavement Recommendations, Dinosaur Ridge Recreation Area, Jefferson County, Colorado". These rockfall hazard areas are the area immediately north of the Track Site, Brontosaurus Bulges Site and the Dinosaur Bones Site. Drainage improvements consisting of an upper ditch, rundown and two cross culverts are proposed at these locations to help mitigate erosion and rockfall hazards.

Proposed drainage improvements were designed to meet current Jefferson County drainage criteria, with exceptions that are noted within this report. Information contained within this report is solely for master planning purposes and is not to be used for construction. Additional design of concepts presented herein will be required if concepts are carried forward for implementation.

GENERAL LOCATION AND DESCRIPTION

1.1 Project Location and Description

The Dinosaur Ridge Recreation Area is owned by Jefferson County Open Space (JCOS) and includes a 1.1-mile paved section of the West Alameda Parkway that is used as a trail. This trail has been closed to through traffic, but still allows scheduled tour buses. The Dinosaur Ridge Trail has more than 15 fossil and geologic sites (nodes) that can be accessed by foot, bike or guided bus tour. Figure 1 presents a vicinity map of the Dinosaur Ridge Recreation Area. Details regarding the site layout and node locations discussed within this report are presented in the Existing Drainage Map in Appendix B.

Figure 1: Dinosaur Ridge Vicinity Map

1.2 Project Background and Purpose

The overall intent of this project is to develop a site plan/conceptual master plan for the Dinosaur Ridge Recreation Area. This site plan is being developed for numerous reasons including the enhancement of the visitor's experience and safety, the preservation of geologic and paleontological sites, recreation management, and the improvement of park facilities and site amenities. Muller Engineering is assisting Norris Design with the conceptual level drainage study that is a portion of the overall site plan/conceptual master plan. This conceptual level drainage study reviews improvements and impacts to site drainage that are part of the proposed Dinosaur Ridge Visitor Center, Visitor Parking Lot, and roadway/trail improvements. Specifically, improvements to roadside ditches, cross culverts, and detention/water quality ponds were studied and are discussed within this report.

Yeh and Associates has performed a geotechnical hazard study for the site, "Final Geologic Hazard Study and Pavement Recommendations, Dinosaur Ridge Recreation Area, Jefferson County, Colorado" (2019), that is also a part of the overall site plan/conceptual master plan. This study identifies geological hazard areas at the site and potential geological mitigation options. Specific hazard areas discussed within the Yeh and Associates report are presented below in Table 1 and included the hazard zone and tier as established by Sam Bartlett in "A Survey of Rock Fall Hazards on Dinosaur Ridge" (2018).

Table 1: Rockfall Hazard Sites

Site	Rockfall Hazard Rating	Zone	Tier	Recommended Rockfall Mitigation
Crocodile Creek	Moderate	2	2	• Spot Scaling • Rock dowels • Buttress
North of Dinosaur Tracksite	High	3a	1	• Spot Scaling • Clean catchment • Maintain pedestrian barrier • Drainage Improvements
South of Dinosaur Tracksite	Moderate	3	3	• Spot Scaling • Rock dowels • Buttress • Pedestrian barrier
South side of cut at upper curve	Moderate	4	1	• Spot Scaling • Clean catchment • Pedestrian barrier
North side of cut at upper curve	High	5	1	• Spot Scaling • Extend rockfall mesh • Pedestrian/traffic barrier
Brontosaurus Bulges	Moderate	7/8	1	• Spot Scaling • Rockfall shed • Rockfall fence • Drainage improvements
Between Brontosaurus Bulges and Dinosaur Bone Site	Moderate	8	1	• Spot Scaling • Rockfall mesh • Pedestrian barrier • Catchment area
Dinosaur Bone Site	Moderate	8	1	• Spot Scaling • Drainage improvements

From Table 1 it can be seen that drainage improvements are potential mitigation options for the Track Site/North of the Track Site, Brontosaurus Bulges Site, and the Bones Site. Drainage improvement and mitigation options for these three sites were recommended by Yeh and Associates and investigated by

Muller Engineering and are discussed in section 3.1.3. A map depicting these rockfall hazard areas was prepared by Yeh and Associates and is presented in Appendix B.

2 DRAINAGE BASINS AND SUBBASINS

2.1 Major Drainage Basin

The site is split into two major basins, the West and East Basin. The basins are divided by the crest of the hogback and are bound by West Alameda Parkway on either the west or east side of the ridge. The West Basin is approximately 12.2 acres and drains west into Mount Vernon Creek. The East Basin is approximately 84.9 acres and drains east into Rooney Gulch. Both Mount Vernon Creek and Rooney Gulch ultimately discharge into Bear Creek approximately two miles downstream of the site.

2.2 Minor Drainage Basins - Existing

The East Basin is currently divided into four existing minor basins. Basin EX-1 is approximately 17.4 acres and discharges to an existing 18-inch corrugated metal pipe (CMP) culvert at the intersection of West Alameda Parkway and South Rooney Road (Culvert 1). A roadside ditch along South Rooney Road collects runoff from the basin and directs it south to Culvert 1. The basin has a maximum flow length of approximately 1,870 feet. Basin EX-2 is approximately 35.6 acres with a maximum flow length of 2,515 feet. Runoff from Basin EX-2 is collected in a roadside ditch, travels north, and then sheet flows across West Alameda Parkway at the trailhead near the intersection with South Rooney Road. Basin EX-3 is approximately 26.9 acres with a maximum flow length of 2,050 feet. A roadside ditch collects runoff from the basin and routes it north to a 24-inch CMP (Culvert 2). Basin EX-4 is approximately 5.1 acres with runoff from the basin being collected in a roadside ditch that travels north before discharging through an 18-inch CMP (Culvert 3). The maximum flow length of EX-4 is approximately 900 feet.

The West Basin is divided into two existing minor basins, EX-5 and EX-6. Basin EX-5 is 0.9 acres and has a maximum flow length of approximately 295 feet. EX-6 is 11.3 acres and has an estimated maximum flow length of 1,415 feet. In general, flows from both of the west minor basins are collected in road side ditches and/or curb and gutter, travel north, and then discharge through 18-inch CMPs (Culverts 4 and 5). Refer to the Existing Drainage Map in Appendix B for the basin boundaries and locations of culverts and ditches.

The major drainage basins, and subsequently minor basins, are primarily comprised of soil classified within the hydrologic soils group as Type D, which has a higher runoff potential when compared with soil types A, B, or C. The Natural Resources Conservation Service's (NRCS) soils report for the site is presented in Appendix C. Additional information related to the geologic mapping of the area can be found on the United States Geological Survey (USGS) Geologic Map of the area (1972). Both the East and West basins, and subsequent minor basins, are comprised entirely of either undeveloped or paved areas, and there is no development within either of the major basins. The properties of each of the minor drainage basins are summarized in Table 2.

Table 2: Existing Minor Basins

BASIN NAME	AREA (AC)	NRCS HYDROLOGIC SOIL GROUP	LAND USE TYPE %		FLOW LENGTH (FT)
			UNDEVELOPED	PAVED	
EX-1	17.4	D	99	1	1,873
EX-2	35.6	D	97	3	2,515
EX-3	26.9	D	96	4	2,050
EX-4	5.1	D	77	23	899
EX-5	0.9	D	74	26	294
EX-6	11.3	D	92	8	1,415

2.3 Minor Drainage Basins – Proposed

Based on the proposed drainage improvements, discussed in Section 3, the East and West major drainage basins were subdivided into minor basins for the proposed condition. There are a total of eleven minor basins for the proposed condition, with six on the east side of the hogback and five on the west side. Due to the site improvements discussed in Section 3, Basin PR-1 is the combination of the existing minor basins EX-1 and EX-2. Basin PR-1 has an area of 52.9 acres, with a maximum flow length of approximately 2,200 feet. In the proposed condition runoff is collected in a roadside ditch along South Rooney Road that drains south, and in a roadside ditch along West Alameda Parkway that drains north. Both ditches will discharge to a larger cross culvert in the same location as Culvert 1. In this condition runoff will no longer be allowed to sheet flow across the trailhead.

For the proposed condition Basin EX-3 has been divided into four proposed minor basins, PR-2, PR-3, PR-4, and PR-5. Basin PR-2 has an area of 10.5 acres and drains along its traditional path to an enlarged Culvert 2. The maximum flow length of PR-2 is approximately 1,130 feet. In 2017 Ayres and Associates analyzed placing a small wall within the PR-2 basin to divert flows around the Crocodile Creek area. Due to the length of wall and its proximity in the basin its effects were ignored for this study. Runoff from basins PR-3, PR-4, and PR-5 is collected in proposed upper and roadside ditches and then discharged into the new Tracks Culverts 1 and 2. The approximate area and flow length of each basin are presented in Table 3. There was no change to the drainage area or pattern of existing minor basins EX-4 and EX-5 for the proposed condition. These basins are now titled PR-6 and PR-7, respectively, for the proposed condition. Basin EX-6 was subdivided into four minor basins, Basins PR-8 through PR-11, based on proposed drainage improvements. Basins PR-8, PR-9, and PR-10 drain to roadside or upper ditches and then north to proposed cross culverts. The estimated areas and flow lengths for these basins are presented in Table 3. Basin PR-11 is approximately 5.0 acres and has an estimate maximum flow length of 630 feet. Runoff from PR-11 drains to a roadside ditch and drains north to an enlarged Culvert 5.

Land use within the proposed basins was assumed to remain similar to the existing site conditions, and improvements were assumed to not significantly impact the percent imperviousness of the major or minor basins. Soil types within the basins did not change from the existing condition as the proposed condition does not require an expansion to the major basins. The properties of each of the minor proposed drainage basins are summarized in Table 3.

Table 3: Proposed Minor Basins

BASIN NAME	AREA (AC)	NRCS HYDROLOGIC SOIL GROUP	LAND USE TYPE %		FLOW LENGTH (FT)
			UNDEVELOPED	PAVED	
PR-1	52.9	D	98	2	2208
PR-2	10.5	D	97	3	1131
PR-3	2.2	D	100	0	772
PR-4	0.4	D	63	37	233
PR-5	13.8	D	95	5	1449
PR-6	5.1	D	77	23	899
PR-7	0.9	D	74	26	294
PR-8	2.0	D	84	16	526
PR-9	3.2	D	100	0	660
PR-10	1.2	D	72	28	571
PR-11	5.0	D	95	5	632

3 DRAINAGE FACILITY DESIGN

3.1 Drainage Concepts for Site Improvements

3.1.1 Existing Culvert Improvements

To better understand the impacts that the proposed drainage improvements would have on the site, the existing drainage conditions first had to be understood. Accordingly, hydrologic calculations for the existing drainage basins were performed. Based on the size of the drainage basins and the *Jefferson County Storm Drainage & Technical Criteria* manual, the Rational Method was determined to be applicable and calculations were performed to estimate the 10-year flow rates for the drainage basins. The Urban Drainage and Flood Control District's (UDFCD) UD Rational spreadsheet was utilized for these calculations, along with publicly available light detection and ranging (LiDAR) data, soils data, and percent impervious estimates based on aerial imagery. These Rational Method and supporting calculations are included in Appendix C.

As mentioned in Section 2, the site is primarily comprised of soil classified within the hydrologic soils group as Type D, which has a higher runoff potential when compared with soil types A, B, or C. For the purpose of the Rational Method calculations, a Type D soil was conservatively assumed for small areas within the site that are comprised of a more pervious soil type. The rainfall depths were selected from the *Jefferson County Storm Drainage & Technical Criteria* manual. Based on Figure 501 from the manual, the Dinosaur Ridge Recreation Area falls within rainfall Zone IIa, and the corresponding rainfall depths were used in the calculation. The area-weighted average percent imperviousness was calculated for each minor basin based on aerial photography and assumed land use types. These calculations are included in Appendix C.

The percent impervious values for the two land use types, undeveloped and paved, were selected from Table 6-3 in the UDFCD Manual (Volume 1).

Once the peak 10-year storm discharges were determined, the capacity of the five existing cross culverts and one existing side culvert were studied. The existing culvert sizes, inverts and headwater elevations were estimated based on LiDAR contours and measurement taken during a field visit. This information was utilized in conjunction with Bentley's CulvertMaster program to determine the capacity of the existing culverts. If the calculated headwater elevation is greater than the maximum allowable headwater, the culvert was considered to be undersized. Table 4 presents a summary of the existing 10-year peak discharges as well as the existing culvert sizes. The CulvertMaster summary reports of the pipe calculations are included in Appendix C.

Table 4: Existing Culvert Capacity

CULVERT NAME	EXISTING SIZE	EXISTING Q_{10}	UNDERSIZED
	IN	CFS	Y/N
Culvert 1	18	11.4	Y
Culvert 2	24	17.0	N
Culvert 3	18	7.1	N
Culvert 4	18	1.7	N
Culvert 5	18	9.4	N
Side Culvert	18	7.1	N

Although only Culvert 1 is considered undersized for the 10-year event, all existing CMP culverts will be replaced with reinforced concrete pipes (RCP). Replacing CMP culverts with RCP culverts will allow for a longer design life while incurring only minimal added cost during construction operations that are anticipated as part of West Alameda Parkway improvements.

After the hydrology and site hydraulics for the existing condition were understood, a proposed condition that includes site improvements laid out in the conceptual master plan and required drainage improvements to address existing deficiencies was developed. Hydrologic calculations for this proposed condition were performed using the same methods as the existing conditions hydrologic calculations. Minor basins for the proposed condition were developed and are discussed in Section 2.3. The 10-year peak discharges for the proposed minor basins are summarized in Table 5.

Table 5: Proposed 100-Year Discharges

BASIN NAME	PROPOSED Q_{10}
	CFS
PR-1	34.7
PR-2	7.5
PR-3	1.4
PR-4	0.8
PR-5	9.8
PR-6	7.1
PR-7	1.7
PR-8	2.2
PR-9	2.0
PR-10	2.2
PR-11	3.9

Proposed culvert sizes were selected based on CulvertMaster calculations. CulvertMaster was used to calculate the required RCP pipe size based on the proposed 10-year peak discharge. The calculations were performed assuming an allowable headwater depth over height of one. All culverts are anticipated to be inlet control with the culvert freely discharging. Future design phases should confirm actual pipe capacity and size with more detailed survey information and design layouts. Table 6 presents the proposed culvert sizes that will be required to meet the 10-year storm discharges as determined in CulvertMaster. In cases where the required pipe size is not a standard culvert size, the next largest standard culvert size was selected. To provide additional capacity and avoid maintenance issues associated with clogging, an 18-inch diameter pipe was assumed to be the smallest allowable size.

Table 6: Proposed Culvert Sizes

CULVERT NAME	PROPOSED Q_{10}	PROPOSED SIZE
	CFS	IN
Culvert 1	34.7	42
Culvert 2	7.5	24
Culvert 3	7.1	24
Culvert 4	1.7	18
Culvert 5	3.9	18
Side Culvert	7.1	24

For Culverts 2 through 5 and the side culvert, sizes are anticipated to remain the same or to be slightly upsized to meet the proposed condition requirements. However, Culvert 1 will need to be significantly upsized as it will now collect the combined drainage area of Basins EX-1 and EX-2. This combined drainage area is a result of drainage improvements near the trail head. Currently, the roadside ditch that runs along West Alameda Parkway within Basin EX-2 ends at the trailhead where vehicles parallel park along the road. In the proposed condition the ditch will be extended so that flows will discharge through Culvert 1 instead of sheet flowing across West Alameda Parkway. This condition was proposed as a new parking lot is anticipated near the trail head, and this modification provides a great amount of hydraulic benefit as flows will no longer be overtopping West Alameda Parkway.

For this analysis the side culvert was conservatively sized to convey the Basin PR-6 peak 10-year discharge. However, it is unlikely that the culvert would be required to convey the full discharge from the basin, and during a more detailed design phase, the proposed culvert size could potentially be downsized.

Jefferson County drainage criteria states that drainage in a roadside ditch should not be carried more than 500 feet before discharging into a drainage way. The proposed improvements will not meet this criterion, as several of the cross culverts are spaced greater than 500 feet apart. However, since West Alameda Parkway is not a public road, it was determined that this criterion was not applicable at this time. If in the future West Alameda Parkway is once again desired to be a public roadway additional cross culverts could be added to meet the 500-foot maximum spacing criterion. Upsizing the culverts, instead of meeting the 500-foot maximum spacing criterion, was the selected design approach so that historical drainage patterns could be maintained, and downstream impacts could be minimized.

3.1.2 Roadside Ditch Improvements

Currently at the site the existing roadside ditches along West Alameda Parkway on the eastern side of the hogback are experiencing head cutting in areas. This is due to the steep slope of the ditches, approximately 8 percent in some locations, and the ditches not being adequately protected from high runoff velocities. In an attempt to mediate this issue, portions of the ditches have been filled with a concrete flow fill, as can be seen in photographs presented in Appendix A. For the future condition at Dinosaur Ridge it is proposed that these ditches be sized to adequately convey the 10-year storm event runoff as well as be adequately protected from the high runoff velocities. High runoff velocities are anticipated to continue to occur due to the slope of the ditches and proposed roadway grade remaining similar to its current configuration.

For the proposed condition two typical sections have been developed for the roadside ditches and are presented in Appendix D. Typical Section 1 is a concrete lined channel that includes a portion of sidewalk, allowing for pedestrian traffic to be separated from bike and bus traffic in a more distinguishable way than the current striping at the site. Typical Section 2 is similar to Typical Section 1 but also includes a railing. Typical Section 2 could be utilized at the project site in areas that are adjacent to geologic or paleontological features that are desired to be protected but are not at specific nodes along the trail. This section could also be utilized in areas where there is a public safety concern. For aesthetic reasons the vertical wall presented in Typical Section 2 could be faced with stone natural to the area to better blend with the site. The height of the wall presented in Typical Section 2 could be extended vertically in future phases or design. However, this option was not presented within this report as rockfall that would be trapped behind the wall could become a substantial maintenance issue in addition to creating the potential for stormwater runoff to pond behind the wall if penetrations through the wall were to become blocked.

Ditch depths required to convey the 10-year runoff event vary along different segments of West Alameda Parkway. In addition, ditch depths vary between Typical Section 1 and Typical Section 2. Geometry requirements related to the two typical sections and different segments of the site have been summarized in Table 7, and are presented in the Proposed Drainage Map within Appendix B. Bentley's FlowMaster was used to size the proposed roadside ditches. The FlowMaster reports for each ditch are included in Appendix C. Each ditch option has been sized to convey the 10-year event with 6 inches of freeboard. Capacity and freeboard requirements vary slightly from Jefferson County drainage standards for concrete lined channels but were deemed acceptable to prevent excessive disturbance to geologically sensitive areas.

Table 7: Proposed Roadside Ditches

DITCH NAME	PROPOSED Q_{10}	TYPICAL SECTION 1		TYPICAL SECTION 2	
		DEPTH	VELOCITY	DEPTH	VELOCITY
	CFS	FT	FPS	FT	FPS
Ditch 1	34.7	1.3	13.7	1.5	14.6
Ditch 2	7.5	0.9	9.8	0.9	10.5
Tracks Ditch 1	0.8	0.6	5.1	N/A	N/A
Tracks Ditch 2	9.8	0.9	12.6	0.9	13.4
Ditch 3	7.1	0.9	9.6	0.9	10.3
Ditch 4	1.7	0.7	5.1	0.7	5.4
Bulges Ditch	2.2	0.7	6.2	0.8	6.6
Bones Ditch	2.2	0.7	6.1	N/A	N/A
Ditch 5	3.9	0.8	6.1	0.8	7.6

For the purposes of this conceptual level study, it was assumed the proposed grade of West Alameda Parkway and longitudinal ditch slopes will match the existing conditions (estimated based on LiDAR data). If aesthetics are of concern colored concrete, grouted flagstone, or another similar material could also be used for the proposed ditches to better match the surrounding landscape.

In locations where the two proposed typical ditch segments are impractical or not necessary, Jefferson County standard curb and gutter could be implemented. Two locations where standard curb and gutter could be used would be near the Track Site (Tracks Ditch 1) or the Brontosaurus Bulges/Bones Site (Bones Ditch). Americans with Disability Act (ADA) compliant curbs ramps should be installed at each curb and gutter section as required.

3.1.3 Rockfall and Erosion Protection Improvements

As part of the overall site plan/conceptual master plan for the Dinosaur Ridge Recreation Area, geologic hazards were investigated by Yeh and Associates, and their findings are detailed in their 2019 report. In this report there were eight areas that were identified as having the highest rockfall and erosion hazards when compared to the other sites at Dinosaur Ridge. Of these eight sites, drainage improvements were suggested as one of the mitigation options for the area north of the Track Site, Brontosaurs Bulges, and the Bones Site. As a result of this recommendation, drainage improvements to these areas were studied, and the results are detailed herein.

In an attempt to reduce erosion and mitigate rockfall hazards, a wall above the Track Site currently collects stormwater and diverts it north around the Track Site to a corrugated plastic pipe rundown. This rundown then transfers stormwater runoff to the West Alameda Parkway ditch at the toe of the slope. However, during a visit to the site it was noted that this corrugated plastic pipe rundown has separated in numerous locations and is causing slope erosion on the northern boundary of the Track Site as concentrated stormwater runoff is directed to the exposed slope. See Appendix A for photographs of the separated rundown and erosion.

A similar but improved drainage concept is proposed for the Track Site to help mitigate erosion and rockfall hazards in the future. Again, a ditch above the Track Site to direct runoff around the site and into a new pipe rundown north of the site would be utilized in the proposed condition. A typical ditch section was developed and is presented in Appendix D as the *Upper Ditch Typical Section*. This ditch was analyzed to ensure it would properly convey runoff from the 10-year storm event around the Track Site while maintaining 6 inches of freeboard. With the freeboard constraint the required ditch depth is 1 foot. This proposed ditch then diverts runoff into a culvert rundown similar to the current configuration. However, it is recommended that this rundown be a 12-inch, or larger, corrugated metal pipe (CMP) culvert that is supported/anchored along its length or buried to prevent separation. As this rundown could potentially be aesthetically undesirable a dyed or painted shotcrete or other methods could be utilized to hide the rundown culvert over its relatively short length. At the end of the rundown a concrete or grouted riprap energy dissipation feature would be required to prevent erosion where it transfers flows into a new cross culvert, Tracks Culvert 1. Periodic maintenance of the ditch above the Track Site and the associated culvert rundown system would be recommended to ensure it is clean of sediment and debris and functioning as intended. For this conceptual level drainage report the upper ditch is shown as one continuous ditch. However, during future design phases it might be more desirable to break this upper ditch into smaller segments to better follow the topography at the site. Also, it is anticipated that a structure may be built at the Track Site in the future. This structure may require the upper ditch to be moved slightly further west, up the slope, but it is anticipated this realignment would likely only have a minor impact to the hydrology/hydraulics of the system.

A similar approach to protect the Brontosaurus Bulges Site and Bones Site is proposed with an upper ditch collecting runoff from above both sites and directing the flows into a rundown north of the Bones Site. The ditch and rundown culvert were analyzed and found to be 1 foot deep and 12-inch CMP, respectively. Again, the upper ditch could potentially be broken into smaller segments to better follow the topography at the site during future design phases. Also, there is a wire mesh drape extending partway up the slope that will need to be avoided in future design phases when the exact location of the ditch is determined. The Proposed Drainage Map in Appendix B shows the approximate locations of the proposed upper ditches and culverts for both the Track Site and the Brontosaurs Bulges/Bones Site. FlowMaster reports detailing the capacity for the upper ditches and rundown culverts are included in Appendix C.

A roadside ditch (Tracks Ditch 1) will collect runoff that falls directly onto the Track Site (Basin PR-4) and direct it to a new cross culvert (Tracks Culvert 1). See section 3.1.2 for this proposed ditch configuration and size. Tracks Culvert 1 will also collect flows from the 12-inch rundown pipe and was sized to convey the combined flows from PR-3 and PR-4. A second culvert (Tracks Culvert 2) will intercept runoff from the basin south of the Track Site (Basin PR-5) before it flows across the heavily trafficked Track Site, and discharge the flows offsite.

Two cross culverts are also proposed to be added to the Brontosaurus Bulges/Bones Site in a similar configuration to the Track Site. The Bones Culvert will collect flows from the rundown above The Brontosaurs Bulges and Bones Sites, as well as from the Bones Ditch. It was sized to convey the combined flows from Basin PR-9 and PR-10. The Bones Ditch will collect runoff that falls directly onto the Brontosaurus Bulges/Bones Site. See section 3.1.2 for this proposed ditch configuration and size. Another proposed culvert at the south end of Brontosaurus Bulges (Bulges Culvert) will collect runoff from basin PR-8 and divert it offsite. CulvertMaster was used to determine the minimum allowable pipe sizes for the proposed culverts based on the proposed 10-year discharges and an allowable headwater depth over height of one. Table 8 presents the proposed culvert sizes that will be required to meet the 10-year storm discharges as determined in CulvertMaster. To provide additional capacity and protect against clogging and maintenance issues, 18-inches was selected as the minimum allowable pipe diameter. The approximate culvert locations are shown in the Proposed Drainage Map in Appendix B.

Table 8: Proposed Tracks and Bulges/Bones Culverts

CULVERT NAME	PROPOSED Q_{10}	PROPOSED SIZE
	CFS	IN
Tracks Culvert 1	2.2	18
Tracks Culvert 2	9.8	24
Bulges Culvert	2.2	18
Bones Culvert	4.1	18

3.2 Detention and Water Quality Improvements

Proposed improvements to the Dinosaur Ridge Recreation Area, as outlined within the conceptual master plan, are to include a new visitor center and parking lot. Water quality treatment and 100-year storm runoff detention will be required as part of these improvements. Given the proposed location and existing topography of the site a single pond is proposed to provide water quality and detention for both the visitor center and parking lot. The proposed pond is located south of the parking lot and will discharge attenuated flows into Rooney Gulch. The proposed pond and drainage improvements related to the pond are located outside of the Federal Emergency Management Agency (FEMA) 100-year floodplain as shown in the Appendix B FIRM panel.

It is intended that stormwater runoff from the visitor center be carried to the pond via a 36-inch RCP beneath West Alameda Parkway and a corresponding ditch along the eastern edge of the parking lot. With a 1-foot bottom width, 3H:1V side slopes, and 1-foot of freeboard, the ditch will need to be 2.3 feet deep. The culvert and ditch were sized to only convey flows from the visitor center, as it was assumed all runoff from the parking lot would flow directly into the proposed pond. This assumption will need to be revisited in future design phases once final grading of the parking lot is known. The Proposed Drainage Map in

Appendix B shows the approximate location of the culvert, ditch, visitor center and parking lot areas. All offsite runoff was assumed to be diverted around the proposed visitor center and parking lot and therefore flows from these areas were not accounted for in water quality or detention calculations.

The UDFCD UD-Detention spreadsheet was used to estimate the required volume of the pond and is included in Appendix C. The Dakota Ridge Recreation Area map developed by Jefferson County Open Space (2018) was used to estimate the area of the proposed visitor center and parking lot. The map has been included in Appendix C. The visitor center will occupy approximately 6.3 acres with an assumed 85% imperviousness. The percent imperviousness was approximated based on the assumption that the Visitor Center basin will be a combination of drives and walks (90% imperviousness), roofs (90%) and lawns (2%). The parking lot will be approximately 2.4 acres, and it was assumed the entire area would be paved and have a corresponding 100% imperviousness. Therefore, the pond was designed for a watershed area of 8.75 acres with an area-weighted average imperviousness of 89%. The 1-hour, 100-year precipitation values were overridden to match the Jefferson County standard rainfall depths for Zone IIa. Using a 40-hour release rate, the required water quality pond volume is 0.285 acre-feet and the 100-year detention volume is 1.201 acre-feet. A potential pond layout is shown on the Proposed Drainage Map. The proposed pond has a maximum pool footprint of approximately 0.44 acres and would need to be four to five feet deep to store the required detention volume in addition to one foot of freeboard. The water quality outlet structure, emergency spillway and any other pond features will need to be further designed during later design phases.

3.3 Drainage Phasing Recommendations and Priorities

As the overall site plan/conceptual master plan for Dinosaur Ridge is implemented in the future it is likely that certain portions of the site drainage improvements could occur at various times. If drainage improvements to the Dinosaur Ridge Recreation Area are to be constructed in phases the following should be considered:

1) Drainage improvements to the Track Site as discussed in Section 3.1.3 are likely the most critical and should take priority to protect important paleontological features of the site from rockfall and erosion.
2) Drainage improvements to the Brontosaurus Bulges Site and Bones Site should be considered if they are required to address rockfall hazards and may take priority over other site improvements depending on the chosen rockfall mitigation option(s).
3) Existing CMP culverts and undersized culverts should be replaced with properly sized RCP culverts prior to any asphalt or roadway improvements.
4) Roadside ditch improvements should be implemented in conjunction with any asphalt or roadway improvements.
5) The proposed parking lot area should be constructed prior to drainage improvements for Culvert 1, or phased in such a way as to provide parking for visitors to the site.
6) The water quality/detention pond could either be built prior to, or in conjunction with, the parking lot and visitor center. If the pond is to be construction prior to the final design of either the parking lot or visitor center, it is recommended that it be oversized to accommodate any design changes that may occur.

4 CONCLUSIONS

Muller Engineering has performed a conceptual level drainage study for the Dinosaur Ridge Recreation Area and has developed a number of proposed drainage improvements for the site. The Rational Method was selected to estimate the 10-year flow rates for the existing and proposed drainage basins. The capacities of the five existing cross culverts and one side culvert were analyzed. It was determined that one of these culverts is undersized and will need to be replaced, and existing corrugated metal pipes should be replaced with reinforced concrete pipes for design life purposes. Improvements to the roadside ditches are proposed due to severe erosion that is currently occurring onsite. Two concrete lined roadside ditch typical sections were developed that will prevent further erosion of the ditches. Based on the report from Yeh and Associates, drainage improvements for three rockfall hazard areas were analyzed. These rockfall hazard areas are the Track Site, Brontosaurus Bulges Site and the Dinosaur Bones Site. An upper ditch, rundown and two cross culverts are proposed at these locations to help mitigate erosion and rockfall hazards. A proposed visitor center and parking lot are anticipated improvements to the Dinosaur Ridge Recreation Area. A water quality and detention pond will be required to treat stormwater runoff from these two improvements, and a preliminary pond layout has been developed.

Proposed drainage improvements were designed to meet current Jefferson County drainage criteria, with some exceptions that were noted. Should the drainage criteria change, the design of the improvements will also need to be updated. Furthermore, if additional geologic hazards are identified, additional drainage improvements may need to be designed. As the full site layout/conceptual master plan is further developed, recommendations within this report will need to be revisited and further designed. Information contained within this report is solely for master planning purposes and is not to be used for construction.

5 REFRENCES

1. Ayres and Associates, 2017, *Dinosaur Ridge Calculation Basis and Assumptions,* Memorandum, December 8, 2017.

2. Bartlett, S., 2018, A Survey of Rock Fall Hazards on Dinosaur Ridge, Submitted to the Board of Directors, The Friends of Dinosaur Ridge, August 13, 2018, and Addendum 1, August 14, 2018.

3. Bentley Systems, Incorporated, CulvertMaster, Version 03.03.00.04.

4. Bentley Systems, Incorporated, FlowMaster Version V8i (SELECTseries 1), Version 08.11.01.03.

5. *Friends of Dinosaur Ridge, Morrison, Colorado*, www.dinoridge.org/dinosaur-ridge-trail.html. Accessed October 26, 2018.

6. Jefferson County, *Jefferson County Transportation Design & Construction Manual,* revised July 17, 2018.

7. Jefferson County, *Jefferson County Storm Drainage Design & Technical Criteria*, revised July 17, 2018.

8. Jefferson County Open Space, *Dakota Ridge Recreation Area*, Revised February 27, 2018.

9. Urban Drainage and Flood Control District*, Urban Storm Drainage Criteria Manual,* Volume 1, revised August 2018.

10. United States Geological Survey (USGS), Geologic Map of the Morrison Quadrangle, scale 1:24,000, Jefferson County, Colorado, 1972.

11. Yeh and Associates, 2019, *Final Geologic Hazard Study and Pavement Recommendations, Dinosaur Ridge Recreation Area, Jefferson County, Colorado*, January 2019.

Appendix A

Existing Condition Site Photographs

Future Visitors Center Location - Looking North

18” Culvert #1 Passing Flows Southeast and Future Visitors Center Location - Looking North

Future Visitors Center and Parking Lot Locations - Looking North

Existing Drainage Ditch at Toe of Slope - Looking South

Existing Drainage Ditch and Erosion Repair - Looking South

Existing Drainage Ditch and Erosion Repair - Looking South

Existing Drainage Ditch and Erosion Repair - Looking North

Slope and Ditch Erosion Mitigation Efforts - Looking North

Track Site with Rockfall Mitigation and Drainage Pipe Rundown - Looking West

Track Site with Rockfall Mitigation and Drainage Pipe Rundown - Looking West

Separated Drainage Pipe Rundown and Slope Erosion - Looking West

Separated Drainage Pipe Rundown and Slope Erosion - Looking West

24" Culvert #2 Inlet Passing Flows East - Looking Northeast

24" Culvert #2 Outfall Location - Looking Southeast

18" Culvert #3 Inlet Passing Flows East - Looking Northeast

18" Culvert #3 Outfall Location - Looking East

18" Culvert #4 Inlet Passing Flows West - Looking West

18" Culvert #4 Outfall Location – Looking South

18” Culvert #5 Inlet Passing Flows West – Looking South

18” Side Culvert Passing Flows North Under Bike Path – Looking North

Existing Drainage Ditch Near the Brontosaurs Bulges Site - Looking Northwest

Existing Drainage Ditch/Berm at the Brontosaurs Bulges Site - Looking Northwest

Brontosaurus Bulges Site with Rockfall Hazard Area – Looking Northeast

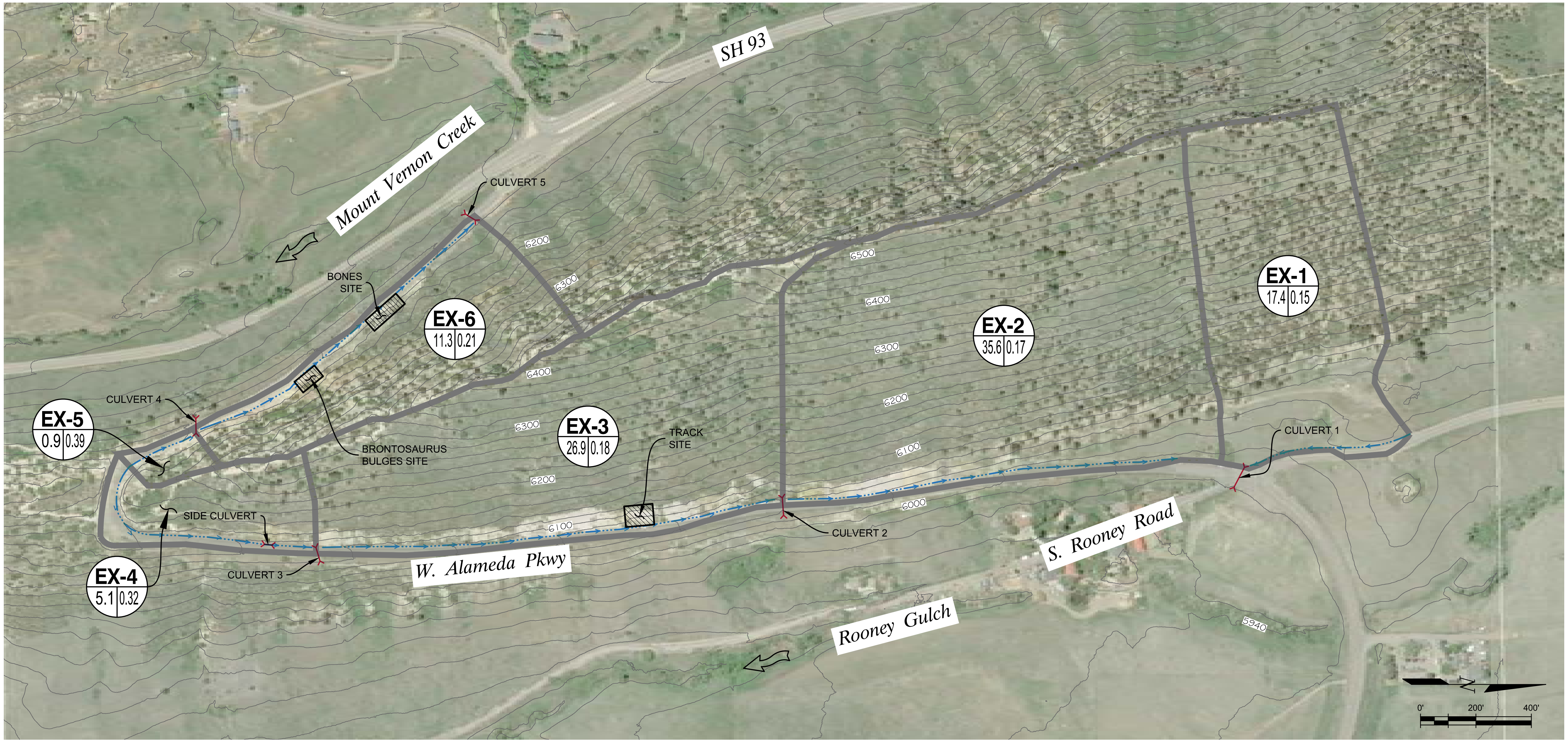
Brontosaurus Bulges Site with Rockfall Hazard Area – Looking Northeast

Rockfall Mitigation Southeast of the Bones Site – Looking Northeast

Rockfall Mitigation at the Bones Site – Looking Northeast

Appendix B

Basin Maps, FEMA FIRM Panel, and Rockfall Hazard Map



BASIN ID — EX-5
AREA (AC) — 0.9
C_{10} — 0.39

PREPARED UNDER THE SUPERVISION OF	DESIGNED: SJT	DRAFT	SHEET REVISIONS
	DRAWN: JHK	PROJECT NO. 18-037.01	NO. / DATE / DESCRIPTION / BY
	CHECKED: MAG		

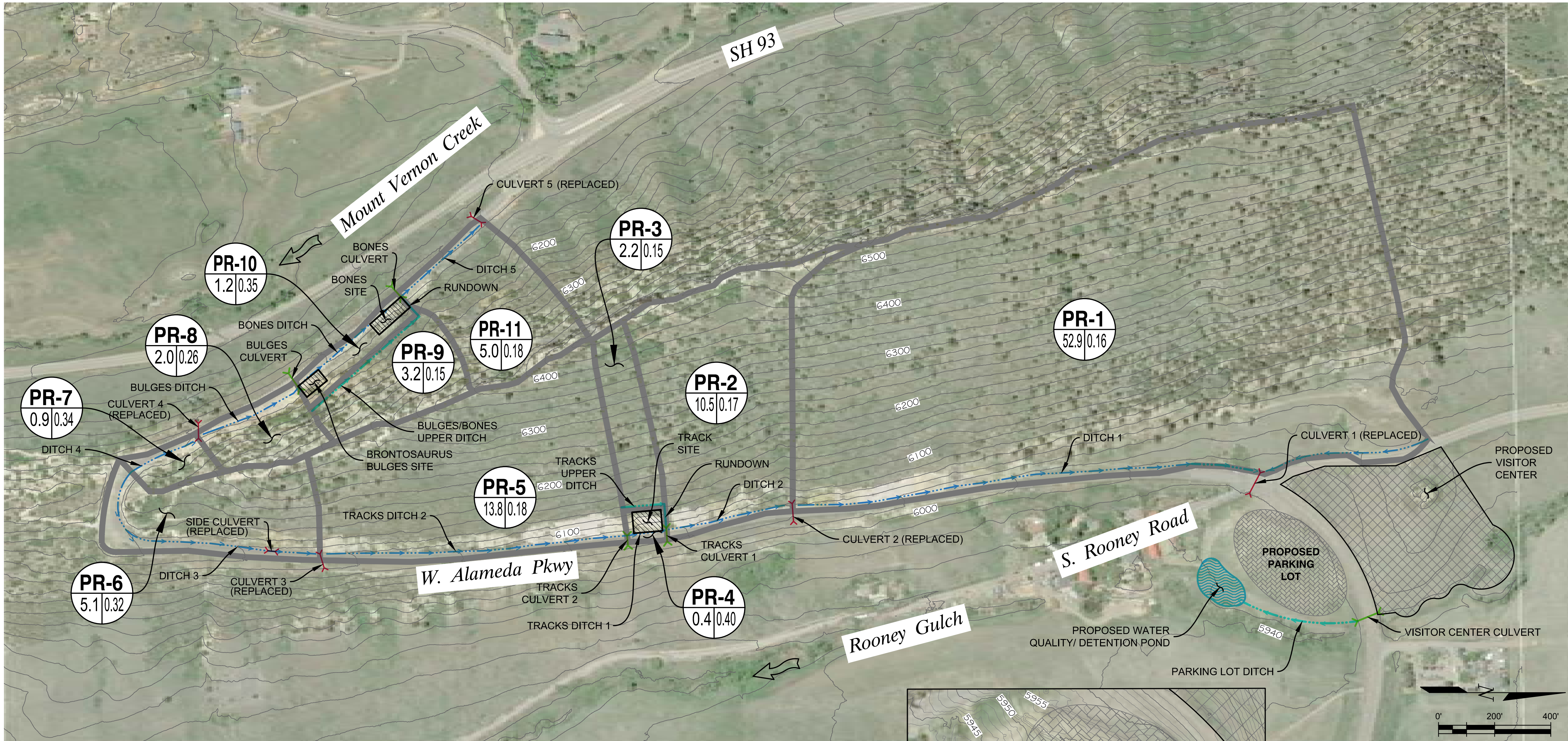
MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

JEFFERSON COUNTY COLORADO Open Space

DINOSAUR RIDGE RECREATION AREA
CIVIL
EXISTING DRAINAGE MAP

DATE: NOV. 2018
DRAWING NO.: FIGURE 1
SHEET NO.: 1 OF 1

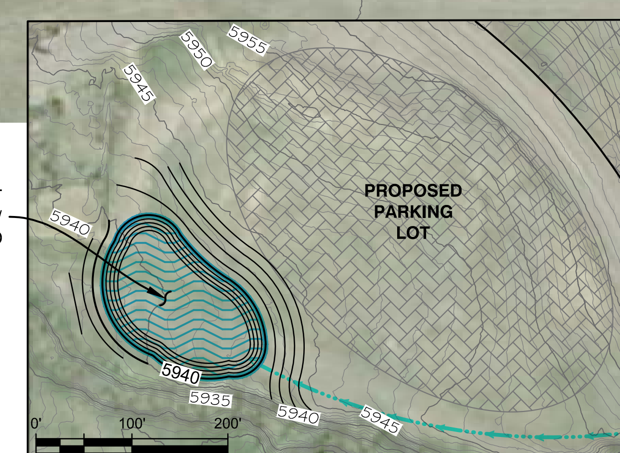
PLOTTED: 1/25/2019 4:47:55 PM
NAME: P:\2018 PROJECTS\18-037.01 DINOSAUR RIDGE - NORRIS DESIGN\CAD\DRAWINGS\18037.01-DRAINAGE MAP.DWG



BASIN ID — PR-7
AREA (AC) — 0.9
C_{10} — 0.34

NOTES:

1. PROPOSED VISITOR CENTER AND PARKING LOT BASIN AREAS NOT SHOWN AS PROPOSED TOPOGRAPHY/GRADING IS UNKNOWN.
2. PROPOSED VISITOR CENTER AND PARKING LOT BASINS WERE ASSUMED AS HATCHED AREA FOR WATER QUALITY/DETENTION POND SIZING. OFFSITE RUNOFF IS ASSUMED TO BE DIRECTED AROUND IMPROVEMENTS AND ALONG HISTORIC PATHS.



WATER QUALITY/DETENTION POND

PLOTTED: 1/25/2019 4:45:28 PM
NAME: P:\2018 PROJECTS\18-037.01 DINOSAUR RIDGE - NORRIS DESIGN\CAD\DRAWINGS\18037.01-DRAINAGE MAP.DWG

PREPARED UNDER THE SUPERVISION OF	DESIGNED: SJT	DRAFT
	DRAWN: JHK	
	CHECKED: MAG	PROJECT NO. 18-037.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

JEFFERSON COUNTY COLORADO Open Space

DINOSAUR RIDGE RECREATION AREA

CIVIL

PROPOSED DRAINAGE MAP

DATE: NOV. 2018
DRAWING NO.: FIGURE 2
SHEET NO.: 1 OF 1

National Flood Hazard Layer FIRMette

FEMA

39°41'25.63"N

105°11'54.36"W

105°11'16.91"W

39°40'57.94"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A, V, A99*
	With BFE or Depth *Zone AE, AO, AH, VE, AR*
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
	Future Conditions 1% Annual Chance Flood Hazard *Zone X*
	Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
	Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN Area of Minimal Flood Hazard *Zone X*
	Effective LOMRs
	Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
OTHER FEATURES	20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
	Coastal Transect
	513 Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
MAP PANELS	Digital Data Available
	No Digital Data Available
	Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 8/22/2018 at 5:50:09 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Yeh and Associates, Inc.
Consulting Engineers & Scientists

NO.	SHEET REVISION	BY	DATE

REUSE OF DOCUMENT
This document is the property of Yeh & Associates, Inc. The ideas incorporated on this document are instruments of professional service and shall not be used for any other project without written authorization from Yeh & Associates, Inc.

DRAWN BY: MJW — DATE: 1/21/2019
CHECKED BY: BDA — DATE: 1/21/2019
DESIGNED FOR:
PROJECT NUMBER: 218-188
SCALE
HORIZ: 1:400 — VERT:

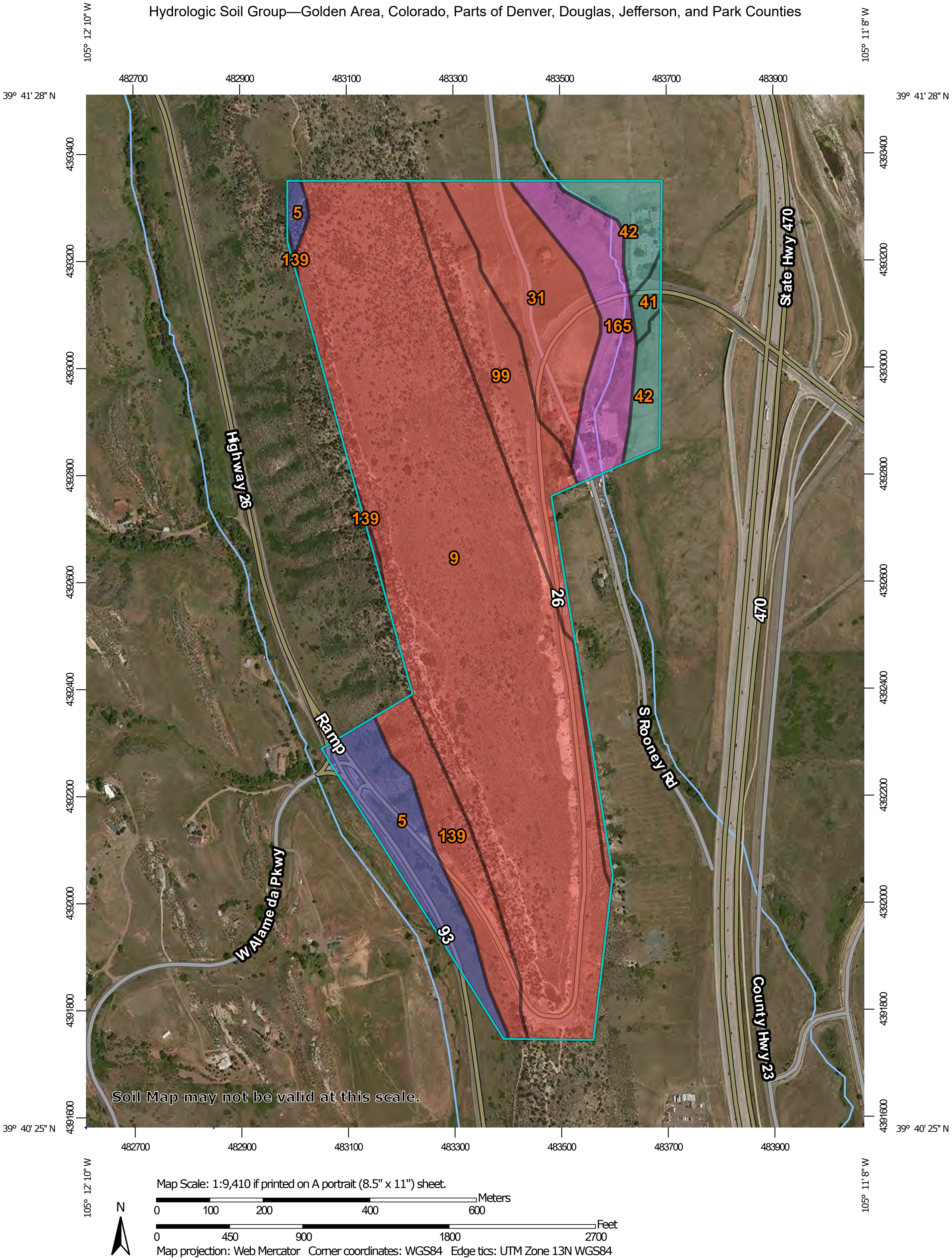
PROJECT:
DINOSAUR RIDGE RECREATION AREA

ROCKFALL HAZARD AREA
LOCATION MAP

SHEET 1 OF 1

Appendix C

Hydrologic and Hydraulic Calculations


105° 12' 10" W
105° 11' 8" W
39° 41' 28" N
39° 40' 25" N
482700
482900
483100
483300
483500
483700
483900
4393400
4393200
4393000
4392800
4392600
4392400
4392200
4392000
4391800
4391600
5
139
42
31
41
165
99
42
139
9
26
5
139
93
Highway 26
Ramp
W Alameda Pkwy
S Rooney Rd
State Hwy 470
470
County Hwy 23
Soil Map may not be valid at this scale.
Map Scale: 1:9,410 if printed on A portrait (8.5" x 11") sheet.
Meters
0 100 200 400 600
Feet
0 450 900 1800 2700
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties
Survey Area Data: Version 13, Sep 10, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 10, 2014—Aug 21, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
5	Argiustolls-Rock outcrop complex, 15 to 60 percent slopes	B	12.3	6.8%
9	Baller-Rock outcrop complex, 15 to 50 percent slopes	D	102.8	56.4%
31	Denver-Kutch-Midway clay loams, 9 to 25 percent slopes	D	16.6	9.1%
41	Englewood clay loam, 0 to 2 percent slopes	C	1.3	0.7%
42	Englewood clay loam, 2 to 5 percent slopes	C	7.8	4.3%
99	Midway stony clay loam, 15 to 40 percent slopes	D	17.7	9.7%
139	Rock outcrop, sedimentary	D	11.1	6.1%
165	Ustic Torriorthents, loamy, 15 to 50 percent slopes	A	12.6	6.9%
Totals for Area of Interest			**182.2**	**100.0%**

NOTE: AREA OF INTEREST (AOI) PRESENTED IN THIS SOILS REPORT DOES NOT DIRECTLY COINCIDE WITH ACTUAL SITE DRAINAGE AREA, BUT REPRESENTS AN OVERVIEW OF SOILS FOUND ONSITE.

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

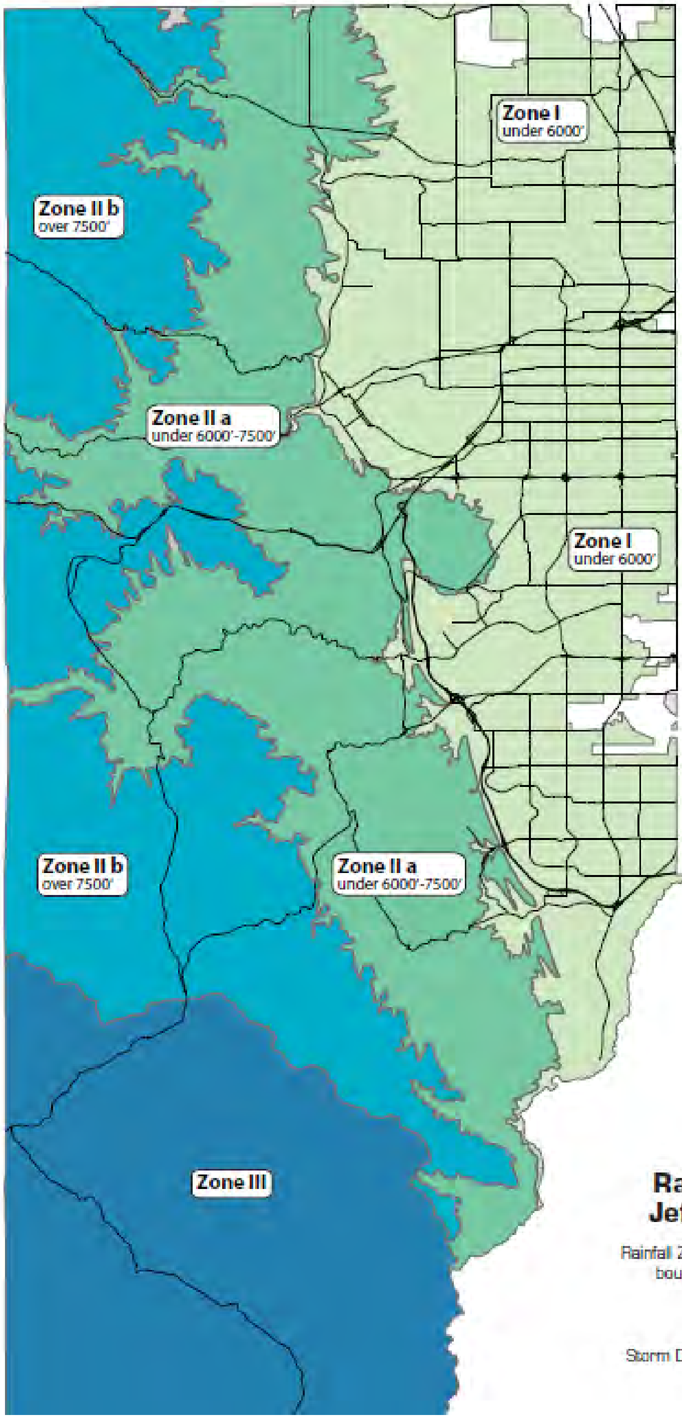


Figure 501
Rainfall Zones in Jefferson County

Rainfall Zone III extends to the southern boundary of Jefferson County.

Table 501
Design Point Rainfall Values

One-Hour Point Rainfall (In.)					
County Zone	2-Year	5-Year	10-Year	50-Year	100-Year
Jefferson I	1.02	1.42	1.68	2.32	2.66
Jefferson IIA	0.95	1.33	1.57	2.17	2.48
Jefferson IIB	0.85	1.19	1.39	1.93	2.20
Jefferson III	0.73	1.06	1.26	1.79	2.06

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential lots (lot area only)**:**	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

EX-1		
Sub-Basin	Imperviousness	Sub-Area
Paved	1	0.19
Undeveloped	0.02	17.17
Total		17.36
Area-Weighted Average Imperviousness		**0.03**

EX-2		
Sub-Basin	Imperviousness	Sub-Area
Paved	1	0.93
Undeveloped	0.02	34.64
Total		35.57
Area-Weighted Average Imperviousness		**0.05**

EX-3		
Sub-Basin	Imperviousness	Sub-Area
Paved	1	1.18
Undeveloped	0.02	25.69
Total		26.87
Area-Weighted Average Imperviousness		**0.06**

EX-4		
Sub-Basin	Imperviousness	Sub-Area
Paved	1	1.18
Undeveloped	0.02	3.87
Total		5.05
Area-Weighted Average Imperviousness		**0.25**

EX-5		
Sub-Basin	Imperviousness	Sub-Area
Paved	1	0.24
Undeveloped	0.02	0.68
Total		0.92
Area-Weighted Average Imperviousness		**0.28**

EX-6		
Sub-Basin	Imperviousness	Sub-Area
Paved	1	0.89
Undeveloped	0.02	10.40
Total		11.29
Area-Weighted Average Imperviousness		**0.10**

PR-1		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	1.12
Undeveloped	0.02	51.82
Total		52.94
Area-Weighted Average Imperviousness		**0.04**

PR-2		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	0.31
Undeveloped	0.02	10.16
Total		10.47
Area-Weighted Average Imperviousness		**0.05**

PR-4		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	0.14
Undeveloped	0.02	0.24
Total		0.38
Area-Weighted Average Imperviousness		**0.37**

PR-5		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	0.74
Undeveloped	0.02	13.06
Total		13.8
Area-Weighted Average Imperviousness		**0.07**

PR-6		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	1.18
Undeveloped	0.02	3.87
Total		5.05
Area-Weighted Average Imperviousness		**0.25**

PR-7		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	0.24
Undeveloped	0.02	0.68
Total		0.92
Area-Weighted Average Imperviousness		**0.28**

PR-8		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	0.32
Undeveloped	0.02	1.67
Total		1.99
Area-Weighted Average Imperviousness		**0.18**

PR-10		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	0.33
Undeveloped	0.02	0.84
Total		1.17
Area-Weighted Average Imperviousness		**0.30**

PR-11		
Sub-Basin	**Imperviousness**	**Sub-Area**
Paved	1	0.24
Undeveloped	0.02	4.72
Total		4.96
Area-Weighted Average Imperviousness		**0.07**

Calculation of Peak Runoff using Rational Method

Designer: SJT
Company: Muller Engineering
Date: 1/25/2019
Project: Dinosaur Ridge Conceptual Drainage Stud
Location: Morrison, CO

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Computed } t_c = t_i + t_t$$

$$\text{Regional } t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

$t_{minimum}$ = 5 (urban)
$t_{minimum}$ = 10 (non-urban)

$$\text{Selected } t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1-hour rainfall depth, P1 (in) =	0.95	1.33	1.57		2.17	2.48	

	a	b	c
Rainfall Intensity Equation Coefficients =	28.50	10.00	0.786

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C: 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
EX-1	17.36	D	3.0	0.02	0.06	0.15	0.34	0.41	0.50	0.60
EX-2	35.57	D	5.0	0.03	0.08	0.17	0.35	0.42	0.50	0.60
EX-3	26.87	D	6.0	0.04	0.08	0.18	0.35	0.42	0.51	0.61
EX-4	5.05	D	25.0	0.18	0.24	0.32	0.46	0.52	0.59	0.67
EX-5	0.92	D	28.0	0.20	0.26	0.34	0.48	0.53	0.60	0.68
EX-6	11.29	D	10.0	0.06	0.12	0.21	0.38	0.44	0.52	0.62

Subcatchment Name	Overland (Initial) Flow Time: Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized (Travel) Flow Time: Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)
EX-1	300.00	6582.00	6276.00	1.020	7.07	1573.00	6276.00	5966.00	0.226	20	9.50	2.76
EX-2	300.00	6523.00	6347.00	0.587	8.36	2215.00	6347.00	5970.00	0.187	20	8.65	4.27
EX-3	300.00	6296.00	6124.00	0.573	8.35	1750.50	6124.00	6039.00	0.050	20	4.49	6.50
EX-4	154.00	6218.00	6162.00	0.364	5.89	745.00	6162.00	6125.00	0.050	20	4.46	2.79
EX-5	98.00	6218.00	6164.00	0.551	3.98	196.00	6164.00	6158.00	0.031	20	3.50	0.93
EX-6	150.50	6249.00	6158.00	0.605	5.63	1264.50	6158.00	6112.00	0.036	20	3.81	5.52

Subcatchment Name	Time of Concentration: Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	Rainfall Intensity, I (in/hr): 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
EX-1	9.83	31.35	10.00	2.57	3.60	4.25		5.87	6.71	
EX-2	12.62	33.95	12.62	2.33	3.27	3.86		5.33	6.09	
EX-3	14.85	38.19	14.85	2.17	3.03	3.58		4.95	5.66	
EX-4	8.68	26.21	8.68	2.71	3.80	4.48		6.19	7.08	
EX-5	4.92	22.69	5.00	3.22	4.51	5.33		7.36	8.41	
EX-6	11.15	34.92	11.15	2.46	3.44	4.06		5.62	6.42	

Subcatchment Name	Peak Flow, Q (cfs): 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
EX-1	0.73	3.71	11.36		41.57	57.82	
EX-2	2.40	8.80	23.14		79.18	109.28	
EX-3	2.07	6.84	16.95		56.21	77.30	
EX-4	2.41	4.58	7.14		16.15	20.95	
EX-5	0.60	1.10	1.66		3.62	4.66	
EX-6	1.75	4.53	9.43		28.07	38.06	

Calculation of Peak Runoff using Rational Method

Designer: SJT
Company: Muller Engineering
Date: 1/25/2019
Project: Dinosaur Ridge Conceptual Drainage Study
Location: Morrison, CO

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Computed } t_c = t_i + t_t$$

$$\text{Regional } t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

$t_{minimum}$ = 5 (urban)
$t_{minimum}$ = 10 (non-urban)

$$\text{Selected } t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1-hour rainfall depth, P1 (in) =	0.95	1.33	1.57		2.17	2.48	

	a	b	c
Rainfall Intensity Equation Coefficients =	28.50	10.00	0.786

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
PR-1	52.94	D	4.0	0.02	0.07	0.16	0.34	0.41	0.50	0.60
PR-2	10.47	D	5.0	0.03	0.08	0.17	0.35	0.42	0.50	0.60
PR-3	2.23	D	2.0	0.01	0.05	0.15	0.33	0.40	0.49	0.59
PR-4	0.38	D	37.0	0.27	0.34	0.40	0.53	0.58	0.64	0.70
PR-5	13.80	D	7.0	0.04	0.09	0.18	0.36	0.43	0.51	0.61
PR-6	5.05	D	25.0	0.18	0.24	0.32	0.46	0.52	0.59	0.67
PR-7	0.92	D	28.0	0.20	0.26	0.34	0.48	0.53	0.60	0.68
PR-8	1.99	D	18.0	0.12	0.18	0.26	0.42	0.48	0.56	0.64
PR-9	3.18	D	2.0	0.01	0.05	0.15	0.33	0.40	0.49	0.59
PR-10	1.17	D	30.0	0.22	0.28	0.35	0.49	0.54	0.61	0.68
PR-11	4.96	D	7.0	0.04	0.09	0.18	0.36	0.43	0.51	0.61
Visitor Center	6.32	D	85.0	0.69	0.73	0.76	0.80	0.81	0.83	0.86

Subcatchment Name	Overland (Initial) Flow Time: Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized (Travel) Flow Time: Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)
PR-1	300.00	6523.00	6245.00	0.927	7.24	1908.00	6245.00	5966.00	0.163	20	8.08	3.93
PR-2	300.00	6466.00	6236.00	0.767	7.65	831.00	6236.00	6037.00	0.315	20	11.23	1.23
PR-3	300.00	6446.00	6195.00	0.837	7.61	472.00	6195.00	6117.00	0.287	15	8.03	0.98
PR-4	88.00	6132.00	6070.00	0.705	3.18	145.00	6070.00	6063.50	0.045	20	4.23	0.57
PR-5	300.00	6296.00	6124.00	0.573	8.29	1149.00	6124.00	6070.00	0.050	20	4.46	4.30
PR-6	154.00	6218.00	6162.00	0.364	5.89	745.00	6162.00	6125.00	0.050	20	4.46	2.79
PR-7	98.00	6218.00	6164.00	0.551	3.98	196.00	6164.00	6158.00	0.031	20	3.50	0.93
PR-8	150.00	6249.00	6158.00	0.607	5.24	376.00	6158.00	6144.50	0.036	20	3.79	1.65
PR-9	152.00	6304.00	6196.00	0.711	5.72	508.00	6196.00	6177.00	0.037	15	2.90	2.92
PR-10	84.00	6196.00	6144.50	0.613	3.49	487.00	6144.50	6127.00	0.052	20	4.57	1.78
PR-11	300.00	6384.00	6122.00	0.873	7.21	434.00	6122.00	6112.00	0.038	20	3.88	1.87
Visitor Center	300.00	6010.00	5989.00	0.070	6.13	332.00	5989.00	5965.00	0.072	20	5.38	1.03

Subcatchment Name	Time of Concentration: Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	Rainfall Intensity, I (in/hr) 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Peak Flow, Q (cfs) 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
PR-1	11.18	33.55	11.18	2.46	3.44	4.06		5.61	6.41		2.93	12.31	34.70		122.64	169.91	
PR-2	8.88	27.69	10.00	2.57	3.60	4.25		5.87	6.71		0.78	2.85	7.50		25.67	35.43	
PR-3	8.59	27.24	10.00	2.57	3.60	4.25		5.87	6.71		0.06	0.41	1.39		5.28	7.37	
PR-4	3.75	20.51	5.00	3.22	4.51	5.33		7.36	8.41		0.33	0.58	0.82		1.61	2.03	
PR-5	12.58	33.42	12.58	2.34	3.27	3.86		5.34	6.10		1.36	4.15	9.77		31.48	43.14	
PR-6	8.68	26.21	8.68	2.71	3.80	4.48		6.19	7.08		2.41	4.58	7.14		16.15	20.95	
PR-7	4.92	22.69	5.00	3.22	4.51	5.33		7.36	8.41		0.60	1.10	1.66		3.62	4.66	
PR-8	6.89	25.81	10.00	2.57	3.60	4.25		5.87	6.71		0.62	1.30	2.23		5.62	7.44	
PR-9	8.64	30.38	10.00	2.57	3.60	4.25		5.87	6.71		0.08	0.59	1.98		7.51	10.49	
PR-10	5.27	23.59	5.27	3.18	4.45	5.25		7.26	8.30		0.80	1.45	2.16		4.59	5.88	
PR-11	9.08	28.55	10.00	2.57	3.60	4.25		5.87	6.71		0.54	1.64	3.86		12.45	17.06	
Visitor Center	7.15	12.53	7.15	2.90	4.06	4.79		6.62	7.57		12.74	18.68	22.93		34.05	39.81	

Existing Culvert 1

Culvert Design Report

N/A

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	5,968.50	ft	Storm Event	Design	
Computed Headwater Eleva	5,968.55	ft	Discharge	11.36	cfs
Headwater Depth/Height	1.70		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	5,968.55	ft	Control Type	Inlet Control	
Outlet Control HW Elev.	5,968.44	ft			

Grades

Upstream Invert	5,966.00	ft	Downstream Invert	5,960.00	ft
Length	82.00	ft	Constructed Slope	0.073171	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.96	ft
Slope Type	Steep		Normal Depth	0.96	ft
Flow Regime	Supercritical		Critical Depth	1.29	ft
Velocity Downstream	9.53	ft/s	Critical Slope	0.037043	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	5,968.44	ft	Upstream Velocity Head	0.77	ft
Ke	0.50		Entrance Loss	0.39	ft

Inlet Control Properties

Inlet Control HW Elev.	5,968.55	ft	Flow Control	Submerged	
Inlet Type	Headwall		Area Full	1.8	ft^2
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Proposed Culvert 1

Culvert Design Report
N/A

Solve For: Section Size

Culvert Summary					
Allowable HW Elevation	5,969.50	ft	Storm Event	Design	
Computed Headwater Eleva	5,968.92	ft	Discharge	34.70	cfs
Headwater Depth/Height	0.83		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	5,968.55	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	5,968.92	ft			

Grades					
Upstream Invert	5,966.00	ft	Downstream Invert	5,960.00	ft
Length	82.00	ft	Constructed Slope	0.073171	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.90	ft
Slope Type	Steep		Normal Depth	0.84	ft
Flow Regime	Supercritical		Critical Depth	1.83	ft
Velocity Downstream	17.63	ft/s	Critical Slope	0.004124	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.50	ft
Section Size	42 inch		Rise	3.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	5,968.92	ft	Upstream Velocity Head	0.73	ft
Ke	0.50		Entrance Loss	0.36	ft

Inlet Control Properties					
Inlet Control HW Elev.	5,968.55	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	9.6	ft^2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Existing Culvert 2

Culvert Design Report

N/A

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	6,040.00	ft	Storm Event	Design	
Computed Headwater Eleva	6,039.56	ft	Discharge	16.95	cfs
Headwater Depth/Height	1.28		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,039.44	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,039.56	ft			

Grades					
Upstream Invert	6,037.00	ft	Downstream Invert	6,035.00	ft
Length	63.00	ft	Constructed Slope	0.031746	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.32	ft
Slope Type	Steep		Normal Depth	1.32	ft
Flow Regime	Supercritical		Critical Depth	1.48	ft
Velocity Downstream	7.68	ft/s	Critical Slope	0.023581	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,039.56	ft	Upstream Velocity Head	0.71	ft
Ke	0.50		Entrance Loss	0.36	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,039.44	ft	Flow Control	Transition	
Inlet Type	Headwall		Area Full	3.1	ft^2
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Proposed Culvert 2

Culvert Design Report

N/A

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	6,038.75	ft	Storm Event	Design	
Computed Headwater Eleva	6,038.64	ft	Discharge	7.50	cfs
Headwater Depth/Height	0.94		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,038.50	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,038.64	ft			

Grades

Upstream Invert	6,037.00	ft	Downstream Invert	6,035.00	ft
Length	63.00	ft	Constructed Slope	0.031746	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.63	ft
Slope Type	Steep		Normal Depth	0.62	ft
Flow Regime	Supercritical		Critical Depth	1.01	ft
Velocity Downstream	9.68	ft/s	Critical Slope	0.005527	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.75	ft
Section Size	21 inch		Rise	1.75	ft
Number Sections	1				

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Outlet Control Properties

Outlet Control HW Elev.	6,038.64	ft	Upstream Velocity Head	0.42	ft
Ke	0.50		Entrance Loss	0.21	ft

Inlet Control Properties

Inlet Control HW Elev.	6,038.50	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	2.4	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Existing Culvert 3
Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	6,127.00	ft	Storm Event	Design	
Computed Headwater Eleva	6,126.74	ft	Discharge	7.14	cfs
Headwater Depth/Height	1.16		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,126.59	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,126.74	ft			

Grades					
Upstream Invert	6,125.00	ft	Downstream Invert	6,122.00	ft
Length	51.00	ft	Constructed Slope	0.058824	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.77	ft
Slope Type	Steep		Normal Depth	0.77	ft
Flow Regime	Supercritical		Critical Depth	1.03	ft
Velocity Downstream	7.88	ft/s	Critical Slope	0.023347	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,126.74	ft	Upstream Velocity Head	0.47	ft
Ke	0.50		Entrance Loss	0.23	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,126.59	ft	Flow Control	Unsubmerged	
Inlet Type	Headwall		Area Full	1.8	ft²
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Proposed Culvert 3

Culvert Design Report

N/A

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	6,126.75	ft	Storm Event	Design	
Computed Headwater Eleva	6,126.59	ft	Discharge	7.14	cfs
Headwater Depth/Height	0.91		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,126.43	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,126.59	ft			

Grades

Upstream Invert	6,125.00	ft	Downstream Invert	6,122.00	ft
Length	51.00	ft	Constructed Slope	0.058824	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.53	ft
Slope Type	Steep		Normal Depth	0.51	ft
Flow Regime	Supercritical		Critical Depth	0.99	ft
Velocity Downstream	11.69	ft/s	Critical Slope	0.005434	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.75	ft
Section Size	21 inch		Rise	1.75	ft
Number Sections	1				

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Outlet Control Properties

Outlet Control HW Elev.	6,126.59	ft	Upstream Velocity Head	0.40	ft
Ke	0.50		Entrance Loss	0.20	ft

Inlet Control Properties

Inlet Control HW Elev.	6,126.43	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	2.4	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Existing Culvert 4
Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	6,160.50	ft	Storm Event	Design	
Computed Headwater Eleva	6,158.75	ft	Discharge	1.66	cfs
Headwater Depth/Height	0.50		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,158.57	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,158.75	ft			

Grades					
Upstream Invert	6,158.00	ft	Downstream Invert	6,151.00	ft
Length	53.00	ft	Constructed Slope	0.132000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.29	ft
Slope Type	Steep		Normal Depth	0.29	ft
Flow Regime	Supercritical		Critical Depth	0.48	ft
Velocity Downstream	7.01	ft/s	Critical Slope	0.016742	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,158.75	ft	Upstream Velocity Head	0.18	ft
Ke	0.50		Entrance Loss	0.09	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,158.57	ft	Flow Control	Unsubmerged	
Inlet Type	Headwall		Area Full	1.8	ft^2
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Proposed Culvert 4

Culvert Design Report

N/A

Solve For: Section Size

Culvert Summary					
Allowable HW Elevation	6,159.00	ft	Storm Event	Design	
Computed Headwater Eleva	6,158.88	ft	Discharge	1.66	cfs
Headwater Depth/Height	0.88		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,158.75	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,158.88	ft			

Grades					
Upstream Invert	6,158.00	ft	Downstream Invert	6,151.00	ft
Length	53.00	ft	Constructed Slope	0.132075	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.24	ft
Slope Type	Steep		Normal Depth	0.24	ft
Flow Regime	Supercritical		Critical Depth	0.55	ft
Velocity Downstream	11.33	ft/s	Critical Slope	0.006425	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.00	ft
Section Size	12 inch		Rise	1.00	ft
Number Sections	1				

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Outlet Control Properties					
Outlet Control HW Elev.	6,158.88	ft	Upstream Velocity Head	0.22	ft
Ke	0.50		Entrance Loss	0.11	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,158.75	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	0.8	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Existing Culvert 5

Culvert Design Report

N/A

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	6,115.50	ft	Storm Event	Design	
Computed Headwater Eleva	6,115.10	ft	Discharge	9.43	cfs
Headwater Depth/Height	1.40		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,115.10	ft	Control Type	Inlet Control	
Outlet Control HW Elev.	6,115.09	ft			

Grades					
Upstream Invert	6,113.00	ft	Downstream Invert	6,112.00	ft
Length	42.00	ft	Constructed Slope	0.023810	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.19	ft
Slope Type	Mild		Normal Depth	1.39	ft
Flow Regime	Subcritical		Critical Depth	1.19	ft
Velocity Downstream	6.29	ft/s	Critical Slope	0.029401	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,115.09	ft	Upstream Velocity Head	0.49	ft
Ke	0.50		Entrance Loss	0.24	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,115.10	ft	Flow Control	Submerged	
Inlet Type	Headwall		Area Full	1.8	ft²
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Proposed Culvert 5
Culvert Design Report
N/A

Solve For: Section Size

Culvert Summary					
Allowable HW Elevation	6,114.50	ft	Storm Event	Design	
Computed Headwater Eleva	6,114.19	ft	Discharge	3.86	cfs
Headwater Depth/Height	0.80		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,114.08	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,114.19	ft			

Grades					
Upstream Invert	6,113.00	ft	Downstream Invert	6,112.00	ft
Length	42.00	ft	Constructed Slope	0.023810	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.51	ft
Slope Type	Steep		Normal Depth	0.50	ft
Flow Regime	Supercritical		Critical Depth	0.75	ft
Velocity Downstream	7.32	ft/s	Critical Slope	0.005369	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,114.19	ft	Upstream Velocity Head	0.30	ft
Ke	0.50		Entrance Loss	0.15	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,114.08	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.8	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Existing Side Culvert
Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary						
Allowable HW Elevation	6,136.00	ft	Storm Event	Design	
Computed Headwater Eleva	6,135.74	ft	Discharge	7.14	cfs
Headwater Depth/Height	1.16		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,135.59	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,135.74	ft			

Grades					
Upstream Invert	6,134.00	ft	Downstream Invert	6,133.25	ft
Length	15.00	ft	Constructed Slope	0.050000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.81	ft
Slope Type	Steep		Normal Depth	0.80	ft
Flow Regime	Supercritical		Critical Depth	1.03	ft
Velocity Downstream	7.28	ft/s	Critical Slope	0.023347	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,135.74	ft	Upstream Velocity Head	0.47	ft
Ke	0.50		Entrance Loss	0.23	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,135.59	ft	Flow Control	Unsubmerged	
Inlet Type	Headwall		Area Full	1.8	ft^2
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Proposed Side Culvert
Culvert Design Report
N/A

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	6,135.75	ft	Storm Event	Design	
Computed Headwater Eleva	6,135.59	ft	Discharge	7.14	cfs
Headwater Depth/Height	0.91		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,135.43	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,135.59	ft			

Grades

Upstream Invert	6,134.00	ft	Downstream Invert	6,133.25	ft
Length	15.00	ft	Constructed Slope	0.050000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.64	ft
Slope Type	Steep		Normal Depth	0.53	ft
Flow Regime	Supercritical		Critical Depth	0.99	ft
Velocity Downstream	8.97	ft/s	Critical Slope	0.005434	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.75	ft
Section Size	21 inch		Rise	1.75	ft
Number Sections	1				

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Outlet Control Properties

Outlet Control HW Elev.	6,135.59	ft	Upstream Velocity Head	0.40	ft
Ke	0.50		Entrance Loss	0.20	ft

Inlet Control Properties

Inlet Control HW Elev.	6,135.43	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	2.4	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Ditch 1 (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	4.40000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	34.70	ft³/s

Results

Normal Depth	0.77	ft
Flow Area	2.53	ft²
Wetted Perimeter	5.85	ft
Hydraulic Radius	0.43	ft
Top Width	5.60	ft
Critical Depth	1.37	ft
Critical Slope	0.00287	ft/ft
Velocity	13.71	ft/s
Velocity Head	2.92	ft
Specific Energy	3.69	ft
Froude Number	3.60	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.77	ft
Critical Depth	1.37	ft
Channel Slope	4.40000	%
Critical Slope	0.00287	ft/ft

Ditch 1 (Typical 2)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	4.40000	%
Left Side Slope	0.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	34.70	ft³/s

Results

Normal Depth	0.97	ft
Flow Area	2.38	ft²
Wetted Perimeter	5.04	ft
Hydraulic Radius	0.47	ft
Top Width	3.91	ft
Critical Depth	1.71	ft
Critical Slope	0.00359	ft/ft
Velocity	14.55	ft/s
Velocity Head	3.29	ft
Specific Energy	4.26	ft
Froude Number	3.29	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.97	ft
Critical Depth	1.71	ft
Channel Slope	4.40000	%
Critical Slope	0.00359	ft/ft

Ditch 2 (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	5.20000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	7.50	ft³/s

Results

Normal Depth	0.36	ft
Flow Area	0.76	ft²
Wetted Perimeter	3.31	ft
Hydraulic Radius	0.23	ft
Top Width	3.19	ft
Critical Depth	0.68	ft
Critical Slope	0.00352	ft/ft
Velocity	9.81	ft/s
Velocity Head	1.50	ft
Specific Energy	1.86	ft
Froude Number	3.53	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.36	ft
Critical Depth	0.68	ft
Channel Slope	5.20000	%
Critical Slope	0.00352	ft/ft

Ditch 2 (Typical 2)

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

Input Data

Roughness Coefficient		0.013	
Channel Slope		5.20000	%
Left Side Slope		0.00	ft/ft (H:V)
Right Side Slope		3.00	ft/ft (H:V)
Bottom Width		1.00	ft
Discharge		7.50	ft³/s

Results

Normal Depth		0.43	ft
Flow Area		0.72	ft²
Wetted Perimeter		2.80	ft
Hydraulic Radius		0.26	ft
Top Width		2.30	ft
Critical Depth		0.82	ft
Critical Slope		0.00422	ft/ft
Velocity		10.48	ft/s
Velocity Head		1.71	ft
Specific Energy		2.14	ft
Froude Number		3.31	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth		0.00	ft
Length		0.00	ft
Number Of Steps		0	

GVF Output Data

Upstream Depth		0.00	ft
Profile Description			
Profile Headloss		0.00	ft
Downstream Velocity		Infinity	ft/s
Upstream Velocity		Infinity	ft/s
Normal Depth		0.43	ft
Critical Depth		0.82	ft
Channel Slope		5.20000	%
Critical Slope		0.00422	ft/ft

Tracks Ditch 1 (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	4.80000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	0.82	ft³/s

Results

Normal Depth	0.12	ft
Flow Area	0.16	ft²
Wetted Perimeter	1.75	ft
Hydraulic Radius	0.09	ft
Top Width	1.71	ft
Critical Depth	0.22	ft
Critical Slope	0.00475	ft/ft
Velocity	5.10	ft/s
Velocity Head	0.40	ft
Specific Energy	0.52	ft
Froude Number	2.93	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.12	ft
Critical Depth	0.22	ft
Channel Slope	4.80000	%
Critical Slope	0.00475	ft/ft

Tracks Ditch 2 (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	8.40000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	9.77	ft^3/s

Results

Normal Depth	0.37	ft
Flow Area	0.78	ft^2
Wetted Perimeter	3.34	ft
Hydraulic Radius	0.23	ft
Top Width	3.22	ft
Critical Depth	0.77	ft
Critical Slope	0.00340	ft/ft
Velocity	12.56	ft/s
Velocity Head	2.45	ft
Specific Energy	2.82	ft
Froude Number	4.50	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.37	ft
Critical Depth	0.77	ft
Channel Slope	8.40000	%
Critical Slope	0.00340	ft/ft

Tracks Ditch 2 (Typical 2)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	8.40000	%
Left Side Slope	0.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	9.77	ft^3/s

Results

Normal Depth	0.44	ft
Flow Area	0.73	ft^2
Wetted Perimeter	2.83	ft
Hydraulic Radius	0.26	ft
Top Width	2.32	ft
Critical Depth	0.93	ft
Critical Slope	0.00410	ft/ft
Velocity	13.41	ft/s
Velocity Head	2.80	ft
Specific Energy	3.23	ft
Froude Number	4.22	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.44	ft
Critical Depth	0.93	ft
Channel Slope	8.40000	%
Critical Slope	0.00410	ft/ft

Ditch 3 (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	5.10000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	7.14	ft³/s

Results

Normal Depth	0.36	ft
Flow Area	0.74	ft²
Wetted Perimeter	3.26	ft
Hydraulic Radius	0.23	ft
Top Width	3.15	ft
Critical Depth	0.66	ft
Critical Slope	0.00354	ft/ft
Velocity	9.62	ft/s
Velocity Head	1.44	ft
Specific Energy	1.80	ft
Froude Number	3.49	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.36	ft
Critical Depth	0.66	ft
Channel Slope	5.10000	%
Critical Slope	0.00354	ft/ft

Ditch 3 (Typical 2)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	5.10000	%
Left Side Slope	0.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	7.14	ft^3/s

Results

Normal Depth	0.42	ft
Flow Area	0.69	ft^2
Wetted Perimeter	2.77	ft
Hydraulic Radius	0.25	ft
Top Width	2.27	ft
Critical Depth	0.80	ft
Critical Slope	0.00424	ft/ft
Velocity	10.27	ft/s
Velocity Head	1.64	ft
Specific Energy	2.07	ft
Froude Number	3.28	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.42	ft
Critical Depth	0.80	ft
Channel Slope	5.10000	%
Critical Slope	0.00424	ft/ft

Ditch 4 (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	2.60000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	1.66	ft³/s

Results

Normal Depth	0.20	ft
Flow Area	0.33	ft²
Wetted Perimeter	2.29	ft
Hydraulic Radius	0.14	ft
Top Width	2.22	ft
Critical Depth	0.32	ft
Critical Slope	0.00430	ft/ft
Velocity	5.05	ft/s
Velocity Head	0.40	ft
Specific Energy	0.60	ft
Froude Number	2.32	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.20	ft
Critical Depth	0.32	ft
Channel Slope	2.60000	%
Critical Slope	0.00430	ft/ft

Ditch 4 (Typical 2)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	2.60000	%
Left Side Slope	0.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	1.66	ft³/s

Results

Normal Depth	0.23	ft
Flow Area	0.31	ft²
Wetted Perimeter	1.95	ft
Hydraulic Radius	0.16	ft
Top Width	1.69	ft
Critical Depth	0.36	ft
Critical Slope	0.00488	ft/ft
Velocity	5.38	ft/s
Velocity Head	0.45	ft
Specific Energy	0.68	ft
Froude Number	2.22	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.23	ft
Critical Depth	0.36	ft
Channel Slope	2.60000	%
Critical Slope	0.00488	ft/ft

Bulges Ditch (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	3.70000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	2.23	ft^3/s

Results

Normal Depth	0.22	ft
Flow Area	0.36	ft^2
Wetted Perimeter	2.37	ft
Hydraulic Radius	0.15	ft
Top Width	2.30	ft
Critical Depth	0.37	ft
Critical Slope	0.00413	ft/ft
Velocity	6.23	ft/s
Velocity Head	0.60	ft
Specific Energy	0.82	ft
Froude Number	2.79	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.22	ft
Critical Depth	0.37	ft
Channel Slope	3.70000	%
Critical Slope	0.00413	ft/ft

Bulges Ditch (Typical 2)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	3.70000	%
Left Side Slope	0.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	2.23	ft^3/s

Results

Normal Depth	0.25	ft
Flow Area	0.34	ft^2
Wetted Perimeter	2.02	ft
Hydraulic Radius	0.17	ft
Top Width	1.74	ft
Critical Depth	0.43	ft
Critical Slope	0.00474	ft/ft
Velocity	6.64	ft/s
Velocity Head	0.69	ft
Specific Energy	0.93	ft
Froude Number	2.66	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.25	ft
Critical Depth	0.43	ft
Channel Slope	3.70000	%
Critical Slope	0.00474	ft/ft

Bones Ditch (Typical 1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	3.60000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	2.16	ft³/s

Results

Normal Depth	0.21	ft
Flow Area	0.35	ft²
Wetted Perimeter	2.36	ft
Hydraulic Radius	0.15	ft
Top Width	2.29	ft
Critical Depth	0.37	ft
Critical Slope	0.00415	ft/ft
Velocity	6.12	ft/s
Velocity Head	0.58	ft
Specific Energy	0.80	ft
Froude Number	2.74	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.21	ft
Critical Depth	0.37	ft
Channel Slope	3.60000	%
Critical Slope	0.00415	ft/ft

Ditch 5 (Typical 1)

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

Input Data

Roughness Coefficient		0.013	
Channel Slope		3.50000	%
Left Side Slope		3.00	ft/ft (H:V)
Right Side Slope		3.00	ft/ft (H:V)
Bottom Width		1.00	ft
Discharge		3.86	ft³/s

Results

Normal Depth		0.29	ft
Flow Area		0.54	ft²
Wetted Perimeter		2.84	ft
Hydraulic Radius		0.19	ft
Top Width		2.74	ft
Critical Depth		0.49	ft
Critical Slope		0.00384	ft/ft
Velocity		7.11	ft/s
Velocity Head		0.78	ft
Specific Energy		1.08	ft
Froude Number		2.81	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth		0.00	ft
Length		0.00	ft
Number Of Steps		0	

GVF Output Data

Upstream Depth		0.00	ft
Profile Description			
Profile Headloss		0.00	ft
Downstream Velocity		Infinity	ft/s
Upstream Velocity		Infinity	ft/s
Normal Depth		0.29	ft
Critical Depth		0.49	ft
Channel Slope		3.50000	%
Critical Slope		0.00384	ft/ft

Ditch 5 (Typical 2)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	3.50000	%
Left Side Slope	0.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	3.86	ft³/s

Results

Normal Depth	0.34	ft
Flow Area	0.51	ft²
Wetted Perimeter	2.41	ft
Hydraulic Radius	0.21	ft
Top Width	2.01	ft
Critical Depth	0.58	ft
Critical Slope	0.00450	ft/ft
Velocity	7.59	ft/s
Velocity Head	0.90	ft
Specific Energy	1.23	ft
Froude Number	2.66	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.34	ft
Critical Depth	0.58	ft
Channel Slope	3.50000	%
Critical Slope	0.00450	ft/ft

Tracks Upper Ditch

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	5.50000	%
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Discharge	1.39	ft^3/s

Results

Normal Depth	0.45	ft
Flow Area	0.41	ft^2
Wetted Perimeter	2.02	ft
Hydraulic Radius	0.20	ft
Top Width	1.80	ft
Critical Depth	0.50	ft
Critical Slope	0.03297	ft/ft
Velocity	3.42	ft/s
Velocity Head	0.18	ft
Specific Energy	0.63	ft
Froude Number	1.27	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.45	ft
Critical Depth	0.50	ft
Channel Slope	5.50000	%
Critical Slope	0.03297	ft/ft

Tracks Rundown Pipe
Culvert Design Report
N/A

Solve For: Section Size

Culvert Summary					
Allowable HW Elevation	6,118.00	ft	Storm Event	Design	
Computed Headwater Eleva	6,117.87	ft	Discharge	1.39	cfs
Headwater Depth/Height	0.87		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,117.39	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,117.87	ft			

Grades					
Upstream Invert	6,117.00	ft	Downstream Invert	6,064.00	ft
Length	69.00	ft	Constructed Slope	0.768116	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.19	ft
Slope Type	Steep		Normal Depth	0.19	ft
Flow Regime	Supercritical		Critical Depth	0.50	ft
Velocity Downstream	13.00	ft/s	Critical Slope	0.020924	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.00	ft
Section Size	12 inch		Rise	1.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,117.87	ft	Upstream Velocity Head	0.20	ft
Ke	0.90		Entrance Loss	0.18	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,117.39	ft	Flow Control	N/A	
Inlet Type	Projecting		Area Full	0.8	ft²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Tracks Culvert 1

Culvert Design Report

N/A

Solve For: Section Size

Culvert Summary					
Allowable HW Elevation	6,064.75	ft	Storm Event	Design	
Computed Headwater Eleva	6,064.44	ft	Discharge	2.21	cfs
Headwater Depth/Height	0.75		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,064.32	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,064.44	ft			

Grades					
Upstream Invert	6,063.50	ft	Downstream Invert	6,061.10	ft
Length	48.00	ft	Constructed Slope	0.050000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.33	ft
Slope Type	Steep		Normal Depth	0.33	ft
Flow Regime	Supercritical		Critical Depth	0.59	ft
Velocity Downstream	8.51	ft/s	Critical Slope	0.005587	ft/ft

Section				
Section Shape	Circular	Mannings Coefficient	0.013	
Section Material	Concrete	Span	1.25	ft
Section Size	15 inch	Rise	1.25	ft
Number Sections	1			

USE 18 INCH RCP

Outlet Control Properties					
Outlet Control HW Elev.	6,064.44	ft	Upstream Velocity Head	0.23	ft
Ke	0.50		Entrance Loss	0.12	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,064.32	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.2	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Tracks Culvert 2

Culvert Design Report

N/A

Solve For: Section Size

Culvert Summary						
Allowable HW Elevation	6,072.00	ft	Storm Event	Design	
Computed Headwater Eleva	6,071.80	ft	Discharge	9.77	cfs
Headwater Depth/Height	0.90		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,071.62	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,071.80	ft			

Grades					
Upstream Invert	6,070.00	ft	Downstream Invert	6,068.25	ft
Length	35.00	ft	Constructed Slope	0.050000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.65	ft
Slope Type	Steep		Normal Depth	0.60	ft
Flow Regime	Supercritical		Critical Depth	1.12	ft
Velocity Downstream	10.93	ft/s	Critical Slope	0.005163	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,071.80	ft	Upstream Velocity Head	0.45	ft
Ke	0.50		Entrance Loss	0.23	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,071.62	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	3.1	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Bulges/Bones Upper Ditch

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	6.60000	%
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Discharge	1.98	ft^3/s

Results

Normal Depth	0.50	ft
Flow Area	0.49	ft^2
Wetted Perimeter	2.22	ft
Hydraulic Radius	0.22	ft
Top Width	1.99	ft
Critical Depth	0.57	ft
Critical Slope	0.03145	ft/ft
Velocity	4.01	ft/s
Velocity Head	0.25	ft
Specific Energy	0.75	ft
Froude Number	1.42	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.50	ft
Critical Depth	0.57	ft
Channel Slope	6.60000	%
Critical Slope	0.03145	ft/ft

Bones Rundown Pipe
Culvert Design Report
N/A

Solve For: Section Size

Culvert Summary						
Allowable HW Elevation	6,179.00	ft	Storm Event	Design	
Computed Headwater Eleva	6,178.90	ft	Discharge	1.98	cfs
Headwater Depth/Height	0.90		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,178.54	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,178.90	ft			

Grades					
Upstream Invert	6,178.00	ft	Downstream Invert	6,127.00	ft
Length	78.00	ft	Constructed Slope	0.653846	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.24	ft
Slope Type	Steep		Normal Depth	0.24	ft
Flow Regime	Supercritical		Critical Depth	0.60	ft
Velocity Downstream	13.62	ft/s	Critical Slope	0.023295	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.00	ft
Section Size	12 inch		Rise	1.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,178.90	ft	Upstream Velocity Head	0.25	ft
Ke	0.20		Entrance Loss	0.05	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,178.54	ft	Flow Control	N/A	
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels		Area Full	0.8	ft²
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	B	
C	0.02430		Equation Form	1	
Y	0.83000				

Bulges Culvert
Culvert Design Report
N/A

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	6,145.75	ft	Storm Event	Design	
Computed Headwater Eleva	6,145.44	ft	Discharge	2.23	cfs
Headwater Depth/Height	0.75		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,145.33	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,145.44	ft			

Grades

Upstream Invert	6,144.50	ft	Downstream Invert	6,141.20	ft
Length	66.00	ft	Constructed Slope	0.050000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.33	ft
Slope Type	Steep		Normal Depth	0.33	ft
Flow Regime	Supercritical		Critical Depth	0.60	ft
Velocity Downstream	8.54	ft/s	Critical Slope	0.005596	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.25	ft
Section Size	15 inch		Rise	1.25	ft
Number Sections	1				

USE 18 INCH RCP

Outlet Control Properties

Outlet Control HW Elev.	6,145.44	ft	Upstream Velocity Head	0.23	ft
Ke	0.50		Entrance Loss	0.12	ft

Inlet Control Properties

Inlet Control HW Elev.	6,145.33	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.2	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Bones Culvert
Culvert Design Report
N/A

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	6,128.50	ft	Storm Event	Design	
Computed Headwater Eleva	6,128.24	ft	Discharge	4.14	cfs
Headwater Depth/Height	0.83		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	6,128.11	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,128.24	ft			

Grades

Upstream Invert	6,127.00	ft	Downstream Invert	6,124.60	ft
Length	48.00	ft	Constructed Slope	0.050000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.43	ft
Slope Type	Steep		Normal Depth	0.43	ft
Flow Regime	Supercritical		Critical Depth	0.78	ft
Velocity Downstream	9.85	ft/s	Critical Slope	0.005459	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

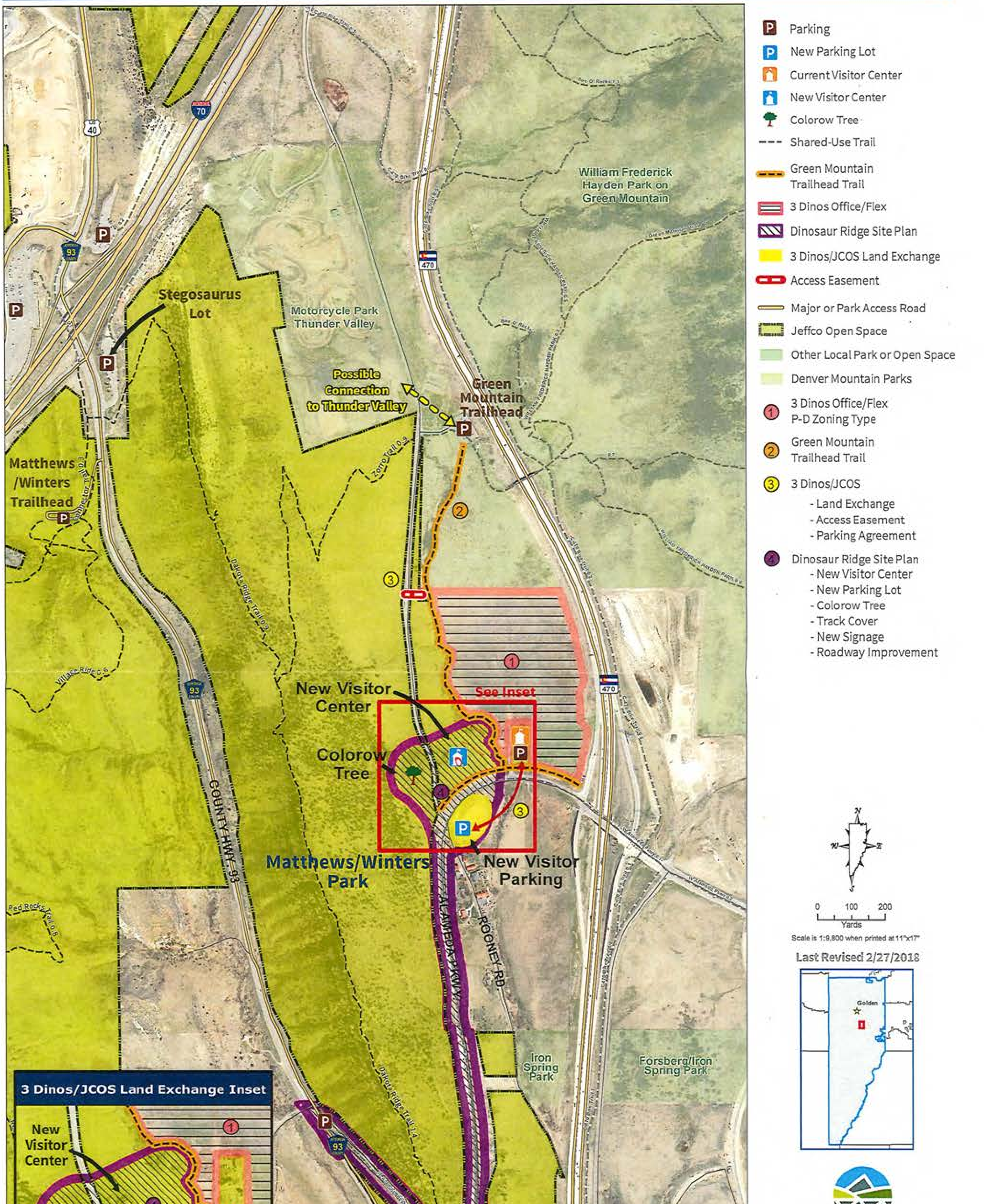
Outlet Control Properties

Outlet Control HW Elev.	6,128.24	ft	Upstream Velocity Head	0.31	ft
Ke	0.50		Entrance Loss	0.15	ft

Inlet Control Properties

Inlet Control HW Elev.	6,128.11	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	1.8	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Dakota Ridge Recreation Area



JEFFERSON
COUNTY COLORADO
Open Space

Data Sources: Jeffco Open Space, Jeffco ITS, USGS, NHD, CDOT

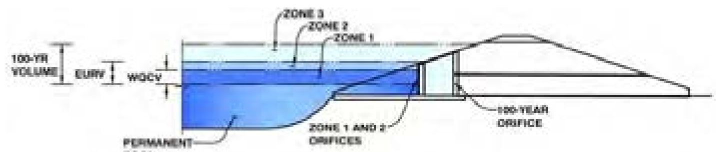
jeffco.us/open-space

Visitor Center/Parking Lot		
Sub-Basin	**Imperviousness**	**Sub-Area**
Visitor Center	0.85	6.32
Parking Lot	1	2.42
Total		8.75
Area-Weighted Average Imperviousness		**0.89**

UD-Detention, Version 3.07 (February 2017)

Project: Dinosaur Ridge Recreation Area

Basin ID: Visitor Center & Parking Lot



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	8.75	acres		
Watershed Length =		ft		
Watershed Slope =		ft/ft		
Watershed Imperviousness =	89.00%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	100.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.287	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.772	acre-feet		
2-yr Runoff Volume (P1 = 0.95 in.) =	0.597	acre-feet	0.95	inches
5-yr Runoff Volume (P1 = 1.33 in.) =	0.884	acre-feet	1.33	inches
10-yr Runoff Volume (P1 = 1.57 in.) =	1.057	acre-feet	1.57	inches
25-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet		inches
50-yr Runoff Volume (P1 = 2.17 in.) =	1.533	acre-feet	2.17	inches
100-yr Runoff Volume (P1 = 2.48 in.) =	1.792	acre-feet	2.48	inches
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet		inches
Approximate 2-yr Detention Volume =	0.561	acre-feet		
Approximate 5-yr Detention Volume =	0.832	acre-feet		
Approximate 10-yr Detention Volume =	0.976	acre-feet		
Approximate 25-yr Detention Volume =	0.000	acre-feet		
Approximate 50-yr Detention Volume =	1.133	acre-feet		
Approximate 100-yr Detention Volume =	1.201	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.287	acre-feet
Zone 2 Volume (100-year - Zone 1) =	0.915	acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =	1.201	acre-feet

Depth Increment = 1 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	11,578	0.266		
6037	--	1.00	--	--	--	13,334	0.306	12,323	0.283
6038	--	2.00	--	--	--	15,190	0.349	26,566	0.610
6039	--	3.00	--	--	--	17,147	0.394	42,887	0.985
6040	--	4.00	--	--	--	19,204	0.441	61,062	1.402
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Visitor Center/Parking Lot Ditch

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	3.90000	%
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	1.00	ft
Discharge	22.93	ft^3/s

Results

Normal Depth	1.01	ft
Flow Area	4.07	ft^2
Wetted Perimeter	7.39	ft
Hydraulic Radius	0.55	ft
Top Width	7.06	ft
Critical Depth	1.14	ft
Critical Slope	0.02199	ft/ft
Velocity	5.63	ft/s
Velocity Head	0.49	ft
Specific Energy	1.50	ft
Froude Number	1.31	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.01	ft
Critical Depth	1.14	ft
Channel Slope	3.90000	%
Critical Slope	0.02199	ft/ft

Visitor Center Culvert

Culvert Design Report

N/A

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	5,967.00	ft	Storm Event	Design	
Computed Headwater Eleva	5,966.46	ft	Discharge	22.93	cfs
Headwater Depth/Height	0.82		Tailwater Elevation	N/A	ft
Inlet Control HW Elev.	5,966.16	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	5,966.46	ft			

Grades

Upstream Invert	5,964.00	ft	Downstream Invert	5,959.00	ft
Length	80.00	ft	Constructed Slope	0.062500	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.79	ft
Slope Type	Steep		Normal Depth	0.75	ft
Flow Regime	Supercritical		Critical Depth	1.54	ft
Velocity Downstream	15.50	ft/s	Critical Slope	0.004310	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	1				

Outlet Control Properties

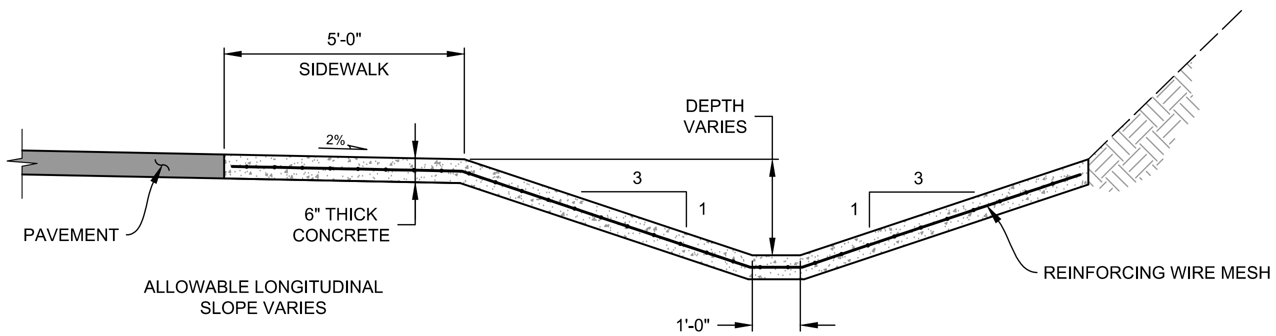
Outlet Control HW Elev.	5,966.46	ft	Upstream Velocity Head	0.61	ft
Ke	0.50		Entrance Loss	0.31	ft

Inlet Control Properties

Inlet Control HW Elev.	5,966.16	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	7.1	ft^2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

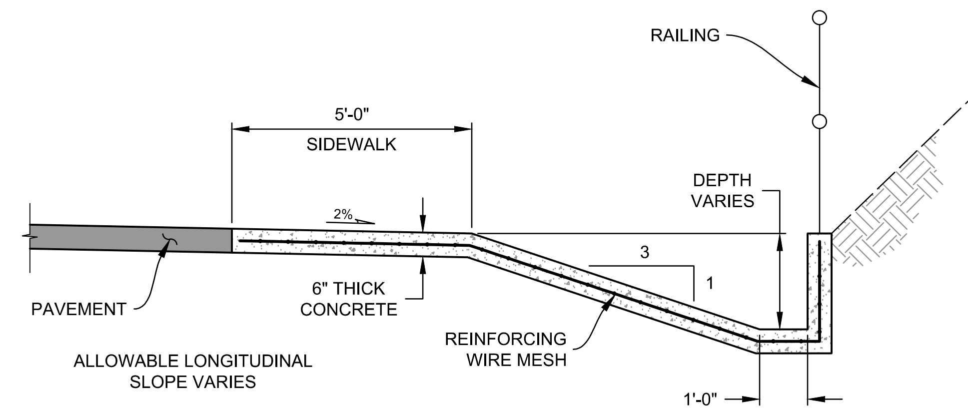
Appendix D

Conceptual Drainage Details



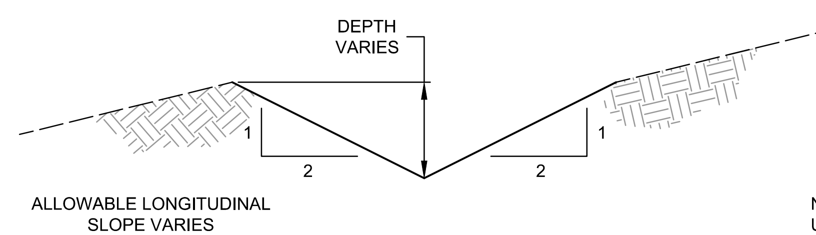
ROADSIDE DITCH TYPICAL SECTION 1

0' 2' 4'



ROADSIDE DITCH TYPICAL SECTION 2

0' 2' 4'



NOTE: GEOTEXTILE FABRIC SHALL BE APPLIED IN UPPER DITCHES.

UPPER DITCH TYPICAL SECTION

0' 2' 4'

PLOTTED: 1/28/2019 4:41:07 PM
NAME: P:\2018 PROJECTS\18-037.01 DINOSAUR RIDGE - NORRIS DESIGN\CAD\DRAWINGS\18037.01-DRAINAGE MAP.DWG

PREPARED UNDER THE SUPERVISION OF	DESIGNED: SJT	DRAFT
	DRAWN: JHK	
	CHECKED: MAG	PROJECT NO. 18-037.01

SHEET REVISIONS

NO.	DATE	DESCRIPTION	BY

MULLER
ENGINEERING COMPANY
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226

JEFFERSON
COUNTY COLORADO
Open Space

DINOSAUR RIDGE RECREATION AREA

CIVIL

DITCH TYPICAL SECTIONS

DATE	NOV. 2018
DRAWING NO.	FIGURE 3
SHEET NO.	1 OF 1