Appendix A
URBANTRANS
Transportation Management Alternatives

January 2003

This page intentionally left blank.

Transportation Management Alternatives

I-70 Mountain Corridor

Draft Environmental Impact Statement

Prepared by:

URBANTRANS CONSULTANTS

One Broadway Plaza, Suite A-200
Denver, CO 80203
720.570.3343
lutenk@urbantrans.com

and

J.F. Sato and Associates
Denver, CO

January 2003

Overview

Transportation Management focuses on reducing Corridor congestion and improving overall mobility on the existing I-70 facility. This alternative includes an integrated package of Transportation Management strategies that maximize the operational efficiency and person-moving capacity of the Corridor by better balancing the demand for travel on I-70 with the capacity of I-70 to handle travel demand. Many of these strategies rely heavily on public-private partnerships to achieve desired results.

Transportation Management includes the coordinated implementation of transportation demand management (TDM), transportation system management (TSM), and intelligent transportation system (ITS) strategies. As an introduction, the following brief definitions are provided:

- **Transportation Demand Management (TDM).** TDM is designed to most efficiently use existing transportation facilities by managing the actual "demand" placed on these facilities. Using integrated strategies that maximize available travel-mode choices, increase vehicle occupancy, reduce travel distances, and shift peak-period demand to non-peak periods, TDM programs extend the useful life of transportation facilities and enhance mobility options.
- **Transportation System Management (TSM).** TSM measures involve operational improvements to existing transportation facilities that maximize their person-moving capacity, reduce the severity and duration of temporary (for example, crash and weather) delays, and improve safety.
- **Intelligent Transportation Systems (ITS).** ITS involves the application of advanced technologies and communications to optimize the efficiency of transportation systems. ITS applications are often an integrated support element of both TDM and TSM strategies.

The Transportation Management strategies summarized in this section include TDM, TSM, and ITS strategies as part of an integrated package. Transportation Management can be implemented as a standalone alternative or integrated as a complement to other "build" alternatives.

I-70 Transportation Management
Existing and Forecast Conditions Assessment

Introduction

Transportation Management strategies attempt to reduce the severity and duration of congestion and to enhance overall mobility by improving the balance between the demand for travel on I-70 with the capacity of I-70 to handle travel demand. These strategies recognize that both travel demand and facility capacity can vary under a variety of circumstances.

Transportation Management strategies generally exclude extensive infrastructure investments aimed at expanding roadway capacity. Instead, these strategies focus on:

1. Management of travel demand to reduce the severity and duration of circumstances where travel demand exceeds existing roadway capacity. Modifications to travel demand can include adjustments to travel time (by time-of-day and/or day-of-week), travel route, trip distance (through changes in trip origins and destinations), and vehicle occupancy.
2. Management of existing Corridor capacity to address locations where relatively minor improvements to the roadway network or highway operations will help address temporary or long-term capacity bottlenecks. Temporary bottlenecks include those caused by incidents, weather, and construction factors.

Development and implementation of Transportation Management strategies along Colorado's I-70 Mountain Corridor must be tailored to fit the unique recreation-based nature of trip-making in the Corridor. Although the national base of experience in Transportation Management is more extensive for urbanized areas, recreation-centered corridors can be particularly appropriate for Transportation Management strategies because they often have highly predictable travel patterns, significantly increased travel demand during specific peak-periods, and relatively concentrated travel destinations. Additionally, corridors with a high volume of recreational trips often have high environmental amenity values tied to both the travel route and the trip destination, increasing the value of transportation strategies with lower environmental impacts.

The coordinated management of both demand and capacity fosters greater efficiency from existing transportation facilities, maximizing their overall person-moving and goods-moving capacity. Well-designed, well-coordinated Transportation Management strategies can provide win-win solutions to transportation challenges in recreation-centered corridors by improving the overall visitor experience, enhancing economic vitality, and reducing (or delaying) the need for major transportation infrastructure investments with potentially high economic and environmental costs.

Challenges for Transportation Management on I-70

The following factors present challenges to the development of Transportation Management strategies in the I-70 Mountain Corridor.

- **Lack of a coordinating organization for I-70 "functional area."** The I-70 Mountain Corridor represents a single functional area. Defined by common geographic characteristics and tourism-related economic generators and united by I-70 as a major transportation connector, residents and visitors live, work, and play throughout the entire I-70 Mountain Corridor, from west Denver to Glenwood Springs. This common "functional area" includes five counties, more than ten municipalities, multiple public and private transit operators, and one regional airport. However, there is no existing organization to coordinate activities that impact transportation across jurisdictions. This is a challenge because the development and implementation of many Transportation Management strategies rely on enhanced coordination between transportation providers and between the public- and private-sector organizations. In many corridors around the country, Transportation Management Associations (TMA) have been created. These associations bring the diverse interests along the corridor together to help implement Transportation Management strategies.
- **Transportation Management less proven in recreation-centered corridors.** There is significant experience and understanding of Transportation Management strategies within urbanized areas, particularly for commute-trips. There has been less experience with these strategies for recreation trips. Nonetheless, the last few years have seen a surge in interest in and implementation of Transportation Management measures in tourism environments, with the National Park Service leading the charge in parks like Acadia and Yosemite. The development of Transportation Management strategies for the I-70 Corridor is based on a review and analysis of 11 similar corridors throughout North America, from Lake Tahoe to Cape Cod (see **Appendix A**).
- **Currently high average vehicle occupancy.** The average number of passengers per vehicle in the I-70 Mountain Corridor today is approximately 2.4, considerably higher than national averages for all trips types but normal for recreation-centered corridors. Incremental increases in average vehicle occupancy (AVO) are often more difficult in areas where AVO rates are already high.

Opportunities for Transportation Management on I-70

The following factors present opportunities for the development of successful Transportation Management strategies in the I-70 Mountain Corridor.

- **Strong network of local transit systems and pedestrian-friendly communities.** Eagle County Transit, Summit Stage, localities, and ski areas currently operate successful, and free, transit services in a large percentage of the primary destination areas along the Corridor. Additionally, many of the primary destination communities along the I-70 Corridor feature pedestrian-friendly central areas. These services are a critical element for the success of many Transportation Management strategies, as they provide a background network of transportation infrastructure for those arriving without a vehicle.

- **Distinct and predictable trip types and patterns.** Recreation trips along the I-70 Corridor, particularly those originating from the Front Range, are largely distinct (in terms of trip purpose) and predictable (in terms of travel patterns and departure times). Additionally, travel route options are limited, and destinations concentrated. Winter destinations are more concentrated than summer destinations. Compared to the varied and disperse nature of urban commute-trips, trip-making in recreation-centered corridors like I-70 is more focused, which allows more effective targeting of Transportation Management strategies to specific travel markets.
- **High value on travel experience among recreation, "choice" trips.** The *1999-2000 I-70 User Study* found that 63 percent of travelers on I-70 (Winter 2000) made "similar trips" on I-70 once a month or less. For trips taken less frequently, particularly recreation trips (which are typically optional, or "choice" trips), travelers often place a higher value on travel "experience." Other factors such as travel cost and travel time, while still relevant, are often less of a priority than they would be for trips like commute-trips that are undertaken much more frequently. When the travel destination is recreation/enjoyment, transportation to the destination becomes part of the overall experience. As such, there are opportunities for Transportation Management strategies to tailor travel options that stress convenience and enjoyment (even over travel time and travel cost factors).
- **Peak-shifting is already occurring.** Travel patterns along I-70 have already shifted to off-peak hours in response to growing traffic congestion during peak-periods. While this shift in demand provides a degree of congestion relief, these shifts are occurring in response to a "negative" influence: peak-period congestion. There is reason to believe that some trips are eliminated altogether from the I-70 Corridor, which has a detrimental impact on economic vitality for both private- and public-sector interests in the Corridor. There is an opportunity to "control the message" and begin to shift the influential factors from negatives (congestion, difficult driving conditions, etc.) to positives (convenient travel options, off-peak travel incentives, etc.).
- **Incremental improvements mitigate/delay the need for investments with high economic and environmental costs.** Transportation Management measures target-specific roadway locations and time periods where demand exceeds capacity. As such, to be effective, these strategies do not need to achieve large-scale shifts in corridor-wide travel behavior. Relatively small shifts in demand can "smooth the peak" and improve overall operations and

efficiency. Additionally, even minor shifts in demand (and reductions in temporary delays) can delay the need for major infrastructure investments by getting more out of existing facilities.

Comparable North American Case Studies and Best Practices

The following section provides an overview of best practices from 11 North American case studies researched for this project to establish a context for the development and evaluation of Transportation Management strategies for the I-70 Mountain Corridor. **Appendix A** provides a full description of these case studies.

Case Study Locations

1. The Lake Tahoe Region, California/Nevada
    - Various corridors including Nevada State Route 28, California's I-80, California Highway 50
2. Whistler-Blackcomb, British Columbia
    - Highway 99
3. Cape Cod National Seashore, Massachusetts
    - Route 6
4. Florida Keys
    - US 1, from Miami to Key West
5. US National Parks
    - Great Smoky National Park - Cades Cove Loop
    - Acadia National Park
    - Grand Canyon National Park
    - Zion National Park
    - Yosemite National Park
6. Washington State
    - I-405 corridor
7. I-93: Salem to Manchester, New Hampshire

Best Practices Overview

Despite the unique geographic features, level of planning efforts and differing political environments, the case study research identified the following specific programmatic and marketing best practices for the implementation of Transportation Management strategies in high recreation-travel corridors:

Programmatic and Institutional Best Practices

- **Regional coordination:** Coordinate with local and public planning agencies (including departments of transportation, parks departments, city and county jurisdictions, metropolitan planning organizations, etc.), businesses (including tourist agencies, resorts, ski resorts, etc.), and residents (including peak-season and year-round residents) when planning Transportation Management strategies.
- **Integration of commute-oriented strategies:** Include commute-oriented employee mobility strategies within the overall tourism-focused Transportation Management plan.
- **Incentives over disincentives:** Focus on incentives over disincentives to increase vehicle occupancy and encourage off-peak travel as a means to maintain or improve the visitor experience for recreational-oriented trips.
- **Affordability, convenience, and enjoyment:** Make transportation choices easy to use, affordable, and fun for visitors. Non-auto-oriented travel options should be fully integrated into the overall visitor experience.

Marketing and Information Best Practices

The case study research revealed the importance of marketing and information programs to the effectiveness of Transportation Management programs:

- **Information early and often:** Market TDM and Transit programs at every level of the visitor's experience. The visitor should be aware of transportation options from when they start planning their trip to when they arrive. Provide detailed, easy-to-understand information to visitors regarding their travel choices and how to use them.
- **Take advantage of technology and existing information channels:** Use the Internet, tourist and travel agencies, and resort marketing programs to market both recreation and transportation messages.
- **Tailor messages to key target markets:** Include marketing efforts targeted at two distinct visitor audiences: those who arrive car free and those who drive.

Development of Transportation Management Strategies

The following issues are central to the development of all of the alternatives:

1. **Understand travel market segments and target travel markets with the best ability to solve the problem.** While there are a tremendous number of trip types using the I-70 Corridor, Transportation Management strategies designed to address specific transportation problems must (1) target the primary target markets contributing to these problems and (2) design travel options that appeal to these target markets. Program development should be focused, not scattershot. As such, market segmentation research should be a key precursor to the development of travel alternatives and marketing messages. Examples of very general market segments using the I-70 Corridor might include:
    a. Front Range Winter Day-trippers
    b. Front Range Winter Overnighters
    c. Out-of-town Winter Overnighters
    d. Front Range Summer Day-trippers
    e. Front Range Summer Overnighters
    f. Out-of-town Summer Overnighters
    g. I-70 Employees/Daily Commuters
2. **Focus on a positive visitor experience.** The Transportation Management strategies focus on incentives over disincentives in the design and promotion of recreation-oriented travel choices and non-peak-period travel.
3. **Capture trips before they enter the I-70 Corridor.** Strategies to promote high-occupancy travel options (whether private carpools/vanpools, private shuttles, or public transportation) should capture trips from Colorado's Front Range and Denver International Airport (DIA) before entering the I-70 Corridor. For example, development of park-n-rides for Front Range travelers should occur close to trip origins within the Front Range, rather than along the I-70 Corridor itself. Benefits include maximizing vehicle occupancy on the I-70 Corridor and reducing parking demand at constrained destinations.

Transportation Management Strategies – Description and Assessment

1. Peak-Spreading and Vehicle-Occupancy Incentives

Brief Description: The use of incentives to shift travel demand by time of day and day of week and to increase average vehicle occupancy. Incentives include financial incentives, travel time and convenience incentives, and reward/point program incentives ("frequent flier points").

Consider demand/capacity relationships across all impacted sectors. While travel demand and available roadway capacity on the I-70 Corridor are important to understand, designing an effective Transportation Management program must consider demand/capacity relationship in other business sectors that influence the demand for travel on I-70. Examples include ski lift seats, resort/community parking spaces, lodging beds, restaurant seats, campground spaces, car rental seats, airline seats, etc. A successful Transportation Management program must consider ways that the demand/capacity balance in each of these areas interacts to shape the visitor experience and affect transportation demand on I-70. This analysis will form the basis for win-win public-private partnerships where mutually beneficial overlaps in these demand/capacity ratios exist.

Overview of Strategies:

1. "Colorado Mountain Plus" Club
2. "Colorado Mountain Plus" Smart Card
3. Alternative Recreation Schedule Arrangements
4. Travel Industry Partnership Program
5. Marketing and Education Campaigns
6. "Try Another Way" Challenge Campaigns

Estimated Cost Range:

- Basic Implementation:
  - Start-up: $250,000 - $500,000
  - Annual: $300,000 - $1,500,000
- Aggressive Implementation:
  - Start-up: $500,000 - $750,000
  - Annual: $1,500,000 - $3,000,000

Estimated Effectiveness Range (reduction in peak-period travel demand):

- Basic Implementation:
  - Summer: 2 – 4%
  - Winter: 4 – 8%

- Aggressive Implementation:
  - Summer: 3 – 6%
  - Winter: 6 – 10%

Detailed Description of Strategies:

1. **"Colorado Mountain Plus" Club.** Development of an I-70 Mountain Corridor rewards program, based on concepts similar to "frequent flier" rewards programs (called the "Colorado Mountain Plus" program for discussion purposes in this document). A corridor-wide rewards program provides an array of benefits and efficiencies for the implementation of peak-spreading and vehicle-occupancy incentives, as well as other Transportation Management strategies. The program would likely be managed by a group like a Transportation Management Association (TMA), such as the proposed "Colorado Mountain Corridor TMA," described in the previous section. Program elements/benefits include:
   - Accrual of reward points and/or direct financial incentives for off-peak travel and increased vehicle occupancy. Managed at either trips origins (for example, airports) or trip destinations (for example, ski resorts).
   - Creates a consolidated "user group" for targeted communications related to transportation issues, incentive programs, travel packages, trip planning, emergency communications, etc. Potentially including:
     - Advanced traveler information services providing traffic updates and recommendations of preferred travel times.
     - Information on lodging discounts available for nights that encourage off-peak travel.
   - Provides advertising "market" for private-sector partners (one of the incentives for private-sector participation) and offers the potential for revenue generation.
   - Program used to integrate several other strategies described in the following sections.
   - Could include development of "organization-based" Colorado Mountain Plus memberships. Special programs and incentives for bulk participation of organized groups. Working through organized groups provides a natural complement for ridesharing promotion, allows leveraging of organization-owned parking spaces along the Front Range (see parking strategies), and provides for targeted marketing and education programs. Groups could include:
     - Companies
     - Youth/school/sports groups
     - College/university/alumni groups
     - Faith groups
     - Out-of-state "ski clubs"

2. **"Colorado Mountain Plus" Smart Card.** Development of integrated smart card technology that could serve as a:
   - Lift ticket or ski pass
   - All-providers transit pass (even for "free" services)
   - "Colorado Mountain Plus" debit card for rewards

   The development of the Colorado Mountain Plus Smart Card provides tremendous flexibility for the implementation of a Colorado Mountain Plus rewards program, and other incentive-based strategies identified in this plan. As a debit card (using Visa, MasterCard, or other systems), the system would allow the accumulation of credits (in dollars) from incentive programs that could be used for lift tickets, lodging, dining, equipment rentals, campground reservations, car rentals, etc.

3. **Alternative Recreation Schedule Arrangements.** Working closely with ski resorts, recreations areas, lodging groups, and others to explore alternative hours of eligibility for daily and multiday lift tickets, campground reservations, check-in and check-out times, etc., to facilitate off-peak travel patterns. Also includes exploring potential travel packages that combine lodging and activities in an arrangement that allows (or even bundles in) off-peak travel between I-70 destinations and the Front Range or DIA.

4. **Travel Industry Partnerships.** Working closely with travel industry stakeholders to explore potential off-peak travel and high-occupancy vehicle incentives, including:
   - <u>Car rental rideshare/non-peak incentive program</u>. Upgrade costs, as well as any administrative costs, partially compensated by free advertising through Colorado Mountain Plus program. Examples:
     - Free comp one-class upgrades for 3+ cars
     - Free upgrade and ski racks for 4+ cars
     - Free upgrade to SUV/Van for 5+ groups, with weekday pickup and return.
     - Free additional day for those returning on Monday.
   - <u>Partnerships with Airlines, Lodging, Restaurant Groups</u>. Targeted to out-of-town visitors. Work to bundle transportation between DIA and Mountain Corridor destinations into travel packages. Provide off-peak incentives. Work with lodging groups to provide incentives for stays that do not start/end during peak travel days (for example, free Sunday night stay).
   - <u>Partnership with Travel Agencies</u>. Work with travel agents booking Colorado vacations to bundle transportation into traveling planning services. Provide incentives for those arriving and departing at non-peak times (for example, free lift tickets, car rental days, lodging nights).

Provide incentives for larger groups to book high-capacity vehicles. Provide all those that book with prepackaged travel information and CO Mountain Plus Smart Card.

5. **Marketing and Education Programs.** Marketing and education programs are essential to the effectiveness of all Transportation Management programs, including marketing of the "Colorado Mountain Plus" rewards programs, of travel choices and how they work, and of the benefits of "off-peak" travel. Education programs can inform travelers of forecast off-peak "travel opportunities." Integrated marketing of travel destinations and of transportation choices is critical.
6. **"Try Another Way" Challenge Campaign.** A key barrier to use of various travel choices is often that travelers have not ever tried other options. This program includes twice a year "try another way" challenge campaigns to encourage travelers to try a different travel option on a specific day or week. This program would be tied to the Colorado Mountain Plus program and include rewards for participation, a significant prize giveaway for each campaign, links to organization-based Colorado Mountain Plus members.

2. Enhanced Traveler Information

Brief Description: The provision of enhanced traveler information services designed to allow travelers to make "smart" travel mode and travel time (by time-of-day and day-of-week) decisions before departing. Also includes programs to notify travelers of incident- and weather-related delays during their travels and to provide advanced public transportation schedule and routing information.

Provide integrated traveler information before the trip begins. Too often, advanced traveler information programs focus on providing travel information (regarding alternative modes, off-peak travel opportunities, weather/incident delays, etc.) to travelers during their trip. However, unless relevant information is received before departure, opportunities for modifications in travel behavior are more limited (particularly due to the limited nature of alternative routes along I-70). Additionally, traveler information and resort marketing programs should be integrated to maximize opportunities for comprehensive travel planning (integrating choices regarding travel dates, destinations, and duration with choices regarding travel mode and departure time). The "messaging" of resort marketing and travel information should be coordinated and unified.

Overview of Strategies:

1. "Colorado Mountain Plus" Website and Personalized Travel Information
2. "Colorado Mountain Plus" Travel Information and Operations Center
3. Intelligent Public Transportation Systems

Estimated Cost Range:

- Basic Implementation:
  - Start-up: $100,000 - $250,000
  - Annual: $100,000 - $400,000
- Aggressive Implementation:
  - Start-up: $500,000 - $5,000,000
  - Annual: $400,000 - $2,500,000

Estimated Effectiveness Range (reduction in peak-period travel demand):

- Basic Implementation:
  - Summer: .25 – 1%
  - Winter: .5 – 1.5%
- Aggressive Implementation:
  - Summer: 1 – 2%
  - Winter: 2 – 3%

Detailed Description of Strategies:

1. **"Colorado Mountain Plus" Website and Personalized Travel Information.** A website that provides users with consolidated trip planning resources (integrating transportation into total trip planning). The website becomes the central resource for advanced traveler information systems, centralizing travel information (including incident/weather updates, congestion reports, etc.) and allowing user personalization (creation of "My Mountain Plus" homepage). Registered users would be able to receive critical travel updates by cell phone or email. Advanced travel planning features would allow integrated planning for transportation connections (along I-70 and at the destination, both public and private), parking information, ski area and other recreation passes, lodging, dining, etc. This site would build on existing services, such as the "Colorado Trip" website developed by CDOT.

2. **"Colorado Mountain Plus" Travel Information and Operations Center.** Development of a consolidated travel planning reservation and information center that integrates the services of a "travel agent" and the services of a "mobility manager." Colorado Mountain Plus "customer service agents" would be available to provide trip planning information for all phases of a trip, including information on various I-70 transportation options and information on special off-peak travel packages. Information on using transportation options during the actual visit (for example, how to use the in-town transit services) could also be available.

3. **Intelligent Public Transportation Systems.** Investment in advanced vehicle locator and other GPS technologies to improve the availability of real-time information for many of the Corridor's local transit systems. Includes integration of this technology with web and other communications technologies.

Breckenridge Main Street Shuttle

3. Park-n-Rides

Brief Description: Utilization of public, private, and joint-venture park-n-ride / intermodal-transfer facilities to facilitate high-occupancy travel options for trips originating from the Front Range.

Overview of Strategies:

1. Front Range Park-n-Ride Joint Development
2. Public and Private Park-n-Ride Partnerships

Estimated Cost Range:

- Basic Implementation:
  - Start-up: $1,000,000 - $2,500,000
  - Annual: $50,000 - $150,000
- Aggressive Implementation:
  - Start-up: $3,000,000 - $10,000,000
  - Annual: $100,000 – $500,000

Estimated Effectiveness Range (reduction in peak-period travel demand):

- Basic Implementation:
  - Summer: .25 – .5%
  - Winter: 1 – 3%
- Aggressive Implementation:
  - Summer: 1 – 3%
  - Winter: 3 – 6%

Detailed Description of Strategies:

1. **Front Range Park-n-Ride Joint Development.** Phased development of 5 to 15 Front Range park-n-ride/intermodal-transfer-center projects customized for trips bound for the Mountain Corridor. Pursued as "joint developments" between a potential Colorado Mountain Corridor TMA, public transportation organizations, recreational gear rental companies, ski resorts, gaming companies, restaurateurs, and private transportation providers. Intermodal pickup and drop-off locations would serve private van and shuttle providers, lodging shuttles, gaming shuttles, and public transit vehicles. Facilitates bundling of transportation services with total travel planning ("free shuttle service from the Front Range with any seven night stay"). A portion of the parking capacity can be leased to Front Range public transit providers during off-peak periods. Additionally, incentives based on departure time and vehicle occupancy would be offered at these locations. Incentive programs should be marketed as part of overall trip planning programs and integrated with Colorado Mountain Plus program. Examples could include:
   - Rewards program dollars given by vehicle occupancy
   - Rewards program dollars given for non-peak departures
2. **Public and Private Park-n-Ride Partnerships.** Many Front Range parking facilities are used primarily during the work week. This program would facilitate partnerships with organizations that manage parking facilities along the Front Range to promote "private mini-park-n-rides." Partnering organizations could include private parking companies (for example, Lanier Parking), employers, schools, colleges/universities, etc. Partnerships between private parking companies and the Colorado Mountain Plus program could provide free parking and Colorado Mountain Plus Rewards for high-occupancy vehicles or those leaving at non-peak times. With the exception of the private parking facilities, use of the parking at other organizations would be targeted to the groups that typically use these spaces (for example, company employees would use their company's parking spaces on weekends), and ridesharing incentives would be facilitated through Organization-based Colorado Mountain Plus members.

4. Parking Operations and Incentive Plan

Brief Description: Programs to manage existing and future parking facilities at major I-70 Mountain Corridor destinations.

Overview of Strategies:

1. Priority Parking Access
2. Long-term Management of Parking Capacity

Estimated Cost Range:

- Basic Implementation:
  - Start-up: $50,000 - $200,000
  - Annual: $75,000 - $200,000
- Aggressive Implementation:
  - Start-up: $50,000 - $400,000
  - Annual: $300,000 – $600,000

Estimated Effectiveness Range (reduction in peak-period travel demand):

- Basic Implementation:
  - Summer: .5 – 1%
  - Winter: 1 – 3%
- Aggressive Implementation:
  - Summer: .5 – 2%
  - Winter: 4 – 15%

Detailed Description of Strategies:

1. **Priority Parking Access.** Coordinated program at ski resort lots, mountain community municipal lots, public recreation area lots, and other managed parking lots along the Mountain Corridor. Incentives include a combination of direct financial incentives, priority access to destinations, and the Colorado Mountain Plus rewards program. Incentives could be tied to both off-peak arrival times and high-occupancy vehicle targets. Examples could include:
   - Access to priority parking areas allowed for arrival before 7:00 AM
   - Access to priority areas provided for 4+ HOVs
   - Rewards points provided for 5+. Examples (illustrative only):
     - $5 on Colorado Mountain Plus debit card for each person in a car with more than 5 people
     - $7.50 for each person in 6+ vehicle
     - $10 for each person in 8+ vehicle
2. **Long-term Management of Parking Capacity.** Coordination between recreation areas and cities/counties in the Corridor to manage the long-term growth of parking capacity at recreation destinations. Continued expansion of unmanaged parking facilities at recreation destination will continue to facilitate growth in overall travel demand along I-70. Reductions in the future growth of parking capacity, coupled with improvements in transportation alternatives to and within Corridor destinations, provide a significant opportunity for reductions in the forecast growth of future travel demand.

5. Bicycle Improvements

Brief Description: Improvements to bicycle connectivity and safety within I-70 Mountain Corridor communities, including investments in bicycle facilities and road-crossings and improvements in bikes-on-transit infrastructure.

Overview of Strategies:
1. Municipal Bicycle Planning and Infrastructure
2. Bikes-on-Transit Investments

Estimated Cost Range:
- Basic Implementation:
  - Start-up: $0
  - Annual: $50,000 - $500,000
- Aggressive Implementation:
  - Start-up: $0
  - Annual: $500,000 - $1,000,000

Estimated Effectiveness Range (reduction in peak-period travel demand):
- Basic Implementation:
  - Summer: 0 – .5%
  - Winter: 0 – .25%
- Aggressive Implementation:
  - Summer: .5 – 1%
  - Winter: 0 – .5%

Detailed Description of Strategies:
1. **Municipal Bicycle Planning and Infrastructure.** Enhanced investment in local and regional bicycle facilities, including planning and construction.
2. **Bikes-on-Transit Investments.** Investments in transit-related bicycle facilities, including bike racks on buses, bike lockers at transit stops, etc.

6. Ramp Metering

Brief Description: The control of vehicles input into a freeway system by the use of traffic lights at on-ramps. Its objective is to achieve maximum flow and prevent the onset of congestion. This strategy has to be interactive with the changing demand patterns throughout the day (and week). Also, it has to react to incidents or lane closures and if its presence at a location changes the demand pattern, the metering should track and change accordingly.

Overview of Strategies:
1. Eastbound-on at Empire Junction
2. Eastbound-on at East Idaho Springs
3. Eastbound-on at SH 103

Estimated Effectiveness Range (reduction in peak-period travel demand):

Studies in the nation suggest an improvement in travel time of up to **7%**.

Detailed Description of Strategies:

1. Ramp metering at the eastbound on-ramp at Empire Junction could help mitigate the congestion caused by the merge. Public opinion could be a potential problem due to the increased delay at the on-ramp.
2. The eastbound on traffic at East Idaho Springs, if metered, could possibly prevent congestion on I-70. The presence of the frontage road as an alternate route would make it even more effective.
3. Metering at SH 103 would have a similar effect as at East Idaho Springs. The frontage road could serve as an alternate route here as well.

Conclusions:
Ramp metering is a viable solution only if there is some route choice for the traffic entering the highway. Adding a ramp meter at Empire Junction is not a reasonable alternative. If traffic entering eastbound I-70 from US 40 was limited to the amount of available capacity on I-70, the resulting queues would stretch for miles on US 40 and extreme increases in travel time for traffic coming from Berthoud Pass would result. The only alternative to waiting through the ramp meter would be to go west on I-70 and get onto I-70 at an unmetered location or take one of the frontage roads in this area. If traffic diverts to unmetered locations, then the I-70 traffic flow improvements would not be realized. The frontage roads in this portion of the Corridor are already heavily traveled during peak hours and pass through heavily populated areas. Encouraging traffic to travel on them is contrary to the goals of this study.

Ramp metering at the two Idaho Springs interchanges could be a viable alternative, if appropriate changes were made to provide an alternate route between Idaho Springs and the base of Floyd Hill. The necessary changes include five elements, as listed below, from the Minimal Action alternative:

- SH 103 interchange
- East Idaho Springs interchange
- Improve frontage road from East Idaho Springs to Hidden Valley
- Build new frontage road, with bike path, from Hidden Valley to the base of Floyd Hill/US 6
- Base of Floyd Hill/US 6 interchange

The primary purpose of the ramp metering would be to limit the traffic feeding on at the East Idaho Springs interchange. This traffic input, when combined with the eastbound flow already on I-70, is a prime contributor to the heavily congested traffic conditions often observed between Empire Junction and Idaho Springs.

The location at SH 103 would serve to limit traffic diverting from the East Idaho Springs interchange. The benefits of this alternative include:

- Improve mainline I-70 travel conditions
- Provide an alternate route to I-70 in this area
- Has very low existing population along the frontage road
- Resolve safety and capacity issues at the interchanges

7. Slow-Moving Vehicle Plan

Brief Description: Increase capacity on I-70 for peak-hour, peak-direction travel by limiting the left lane to those vehicles that could maintain a specified minimum speed throughout the steep grades that are present on this highway. The slower traffic will be restricted to the right lane to achieve the higher capacity. Additional facilities that would help improve slow-moving vehicle travel at all times, such as chain-up, rest area, WIM and AVI facilities, would also be proposed as part of this alternative.

Overview of Strategies:
1. Climbing lanes
2. Parking/chain up or down facilities for trucks

Estimated Cost Range:
- Basic Implementation:
  - Start-up: $4,000,000 – $6,000,000
  - Annual: $75,000 – $200,000

Detailed Description of Strategies:
1. Lane restrictions (slower vehicles in the right lane only) at the following locations could improve the traffic conditions on I-70: Dowd Canyon to West Vail, Bakerville to EJMT (westbound), EJMT to Herman Gulch (eastbound), Downieville to Empire Junction (eastbound), and Georgetown to Silver Plume (westbound). These lanes will also improve safety by decreasing accidents caused due to high-speed differentials between vehicles. Adequate signing will also be provided to ensure that the lane restrictions are conveyed to the roadway users. Adequate enforcement would be an essential element of this plan, without which the benefits could not be achieved.
2. Chain up or down and parking/rest areas for trucks will help in improving operations of these heavy vehicles by improving their performance.

8. Enhanced Incident Management

Brief Description: Mitigation of adverse effects of incidents on I-70 through real-time congestion and incident information for dispatchers, incident response vehicles, coordinated response to incidents with local agencies, dynamic routing of emergency vehicles based on current traffic conditions, computer aided dispatch system and wireless communication equipment for emergency response, and automated incident detection.

9. Winter Park Ski Train

Brief Description: The ski train is an effective way of going to the Winter Park ski resort. It runs on tracks owned and operated by the Union Pacific Railroad and therefore, is subject to their requirements. Currently, one ski train a day goes to Winter Park on Fridays, Saturdays, and Sundays. Given the requirements of Union Pacific Railroad, at most one more trip could be added to each of these days.

Detailed Description of Strategies:

1. The added trip could be potentially helpful to many people, but its limitations in number of trips and locations does not make it a very effective alternative for I-70 recreational traffic.

10. Buses/Shuttles in Mixed Traffic

Brief Description: Provision of support for rolling stock purchases and implementation of minimum revenue guarantees for private transportation providers providing connections between Denver International Airport and Front Range locations and the I-70 Mountain Corridor.

Overview of Strategies:

1. Capital Investments and Subsidies for Private Transportation Services

Estimated Cost Range:

- Basic Implementation:
  - Start-up: $50,000 - $75,000
  - Annual: $500,000 - $2,000,000
- Aggressive Implementation:
  - Start-up: $100,000 - $200,000
  - Annual: $2,000,000 - $6,000,000

Estimated Effectiveness Range (reduction in peak-period travel demand):

- Basic Implementation:
  - Summer: .25 – 1%
  - Winter: 1 – 3%
- Aggressive Implementation:
  - Summer: .5 – 2%
  - Winter: 2 – 4%

Detailed Description of Strategies:

1. **Capital Investments and Subsidies for Private Transportation Services.** Explore support for rolling stock purchases and minimum-revenue guarantees for private transportation providers serving long-range trips between DIA and

the Front Range and I-70 Mountain Corridor destinations. Private provider partners would participate in Colorado Mountain Plus programs.

11. Limited-Access Frontage Road

Brief Description: Limit travel on the frontage roads between Hidden Valley and Bakerville to usage by transit vehicles and Clear Creek County residents during peak travel hours. Electronic card-controlled access gates would control access. This would be an effort to increase transit usage in the Corridor by decreasing transit vehicle travel times.

Detailed Description of Strategies:

1. The limited access to the frontage road between Hidden Valley and Bakerville, it is hoped, would encourage the use of transit and thereby reduce traffic on I-70. This alternative would provide some encouragement to Corridor travelers to take transit, but the other mode choice variable that would be affected would be the travel time. Other important considerations, such as cost, frequency, and connectivity, would not be affected. It is unclear if this strategy would provide any net benefit.

Summary of Transportation Management Strategies

COST SUMMARY	BASIC		AGGRESSIVE	
	Start-Up	Annual	Start-Up	Annual
Peak-spreading and Vehicle-occupancy Increases	$250,000 - $500,000	$300,000 - $1,500,000	$500,000 - $750,000	$1,500,000 - $3,000,000
Enhanced Traveler Information	$100,000 - $250,000	$100,000 - $400,000	$500,000 - $5,000,000	$400,000 - $2,500,000
Park-n-Rides	$1,000,000 - $2,500,000	$50,000 - $150,000	$3,000,000 - $10,000,000	$100,000 - $500,000
Parking Operations Plan	$50,000 - $200,000	$75,000 - $200,000	$50,000 - $400,000	$300,000 - $600,000
Bicycle Improvements	$0	$50,000 - $500,000	$0	$500,000 - $1,000,000
Slow-moving Vehicle Plan	$4,000,000 – $6,000,000	$75,000 – $200,000		
Buses in Mixed Traffic	$50,000 - $75,000	$500,000 - $2,000,000	$100,000 - $200,000	$2,000,000 - $6,000,000

EFFECTIVENESS *(reduction in peak period travel)*	BASIC		AGGRESSIVE	
	Summer	Winter	Summer	Winter
Peak-spreading and Vehicle-occupancy Increases	2 – 4%	4 – 8%	3 – 6%	6 – 10%
Enhanced Traveler Information	.25 – 1%	.5 – 1.5%	1 – 2%	2 – 3%
Park-n-Rides	.25 - .5%	1 – 3%	1 – 3%	3 – 6%
Parking Operations Plan	.5 – 1%	1 – 3%	.5 – 2%	4 – 15%
Bicycle Improvements	0 - .5%	0 - .25%	.5 – 1%	0 - .5%
Slow-moving Vehicle Plan	NA	NA	NA	NA
Buses in Mixed Traffic	.25 – 1%	1 - 3%	.5 – 2%	2 – 4%

Recommended Transportation Management Strategies

Alternatives that have the capability to help respond to the purpose and need of the PEIS in an efficient manner include the following:

1. Peak-spreading and vehicle-occupancy incentives
2. Enhanced traveler information
3. Park-n-rides
4. Parking operations and incentive plan
6. Ramp metering
8. Enhanced incident management

We recommend that the following alternatives be screened out, as they do not have the capability to help respond to the purpose and need of the PEIS, in an efficient manner in:

5. Bicycle improvements
7. Slow-moving vehicle plan
9. Winter Park Ski Train
10. Buses/shuttles in mixed traffic
11. Limited-access frontage road

Implementation Considerations

The distinction between *designing* Transportation Management strategies for the I-70 Mountain Corridor and *implementing* these strategies should not be overlooked. Unlike many "build" strategies, the development, implementation, and management of many Transportation Management strategies rely heavily on the fully integrated involvement of the private sector. Resort organizations, major employers, developers, building managers, business associations, retailers, and others have tremendous influence over the traveling habits of employees, visitors, and shoppers. Public sector organizations responsible for transportation and planning in an area can make travel options available and more convenient, but the demand for these facilities and services is largely determined by operational policies set by the private sector. The synergism of multiple organizations and individuals banding together can often accomplish more than any one government agency, employer, developer, or resident could do alone.

Transportation Management Associations. Currently, there is no organization within the I-70 "functional area" (see page 4) with responsibility or investment in coordination and funding of Transportation Management strategies. The feasibility of a Transportation Management Association (TMA) should be explored to engage both public- and private-sector stakeholders in program design, funding, and implementation.

Transportation Management Associations – An Overview

Communities throughout the United States have struggled with many of the issues discussed above. Responding to the need to foster long-term public-private partnerships designed to implement Transportation Management programs and projects, many communities across North America and Europe have formed organizations called Transportation Management Associations (TMAs). There are currently six TMAs in the state of Colorado and more than 150 across North America.

What is a TMA? TMAs generally exist as independent, non-profit organizations, funded by key public- and private-sector stakeholder groups (for example, government agencies, major employers, developers, business/resort associations, public and private transportation providers, etc.). Representatives from each key stakeholder group form the TMA's steering committee, with a professional staff of one to four people responsible for planning and implementing Transportation Management programs (either alone or in partnership with other organizations). The independent nature of the TMA allows stakeholders to formulate an action plan that reconciles various individual interests and provides various tangible benefits to each participating organization.

Colorado Mountain Corridor Transportation Management Association (CMC-TMA)

A TMA serving the I-70 Mountain Corridor (referred to in this section, for discussion purposes, as the "CMC-TMA") could cover the I-70 Corridor between west Denver and Vail/Glenwood Springs, along with several of the communities with close ties to I-70 from an access perspective (for example, Breckenridge, Winter Park, etc.). CMC-TMA members would likely include all major public- and private stakeholder organizations that affect, and are affected by, transportation dynamics on I-70. For example, participants could include:

- Chambers of commerce and resort associations
- Ski resorts
- Lodging companies and associations
- City and counties
- Colorado Department of Transportation (CDOT)
- Public transportation providers (for example, Summit Stage, Eagle Transit, Regional Transportation District, etc.)
- Private transportation providers
- National Forest and State Park representatives
- Travel agency/travel planning representatives
- Airline and car rental representatives

- Gaming representatives
- Others

Potential Roles for a CMC-TMA

The following items represent potential roles and responsibilities for a Colorado Mountain Corridor TMA:

- **Transportation Service Coordination.** Providing a forum for coordination and collaboration among key transportation providers in the Corridor (for example, CDOT, Summit Stage, Eagle County Transit, ski resort transit systems, lodging shuttles, private transportation providers, etc.). Coordination would focus on achieving economies of scale and simplifying travel choices for visitors.
- **Coordinated Marketing and Education.** Integration of marketing for I-70 destinations with marketing of travel choices to and within the Corridor. Production of coordinated schedule/route maps that incorporate multiple transit providers. Development of advanced traveler information systems and integration of these systems with visitor information distribution channels.
- **Advocacy.** Collective advocacy for continued transportation and economic development investments throughout the Corridor, including advocacy at the national level for federal and foundation funding. Public-private partnerships with diverse stakeholder representation can be very effective in this regard.
- **Employee Mobility Programs.** Working closely with major employers in the Corridor to develop employee mobility programs to improve access to labor markets in response to the jobs-housing imbalance issues facing many resort communities along I-70. Programs could include employee shuttles, vanpools, and carpools coordinated among multiple employers in an area, and the development of enhanced transportation information for employees (including multi-lingual transit maps/schedules that cover all transit providers in an area).

TMA Development – Next Steps

Forming a TMA is similar to starting a new business. Before getting off the ground, extensive research should confirm the viability of the business concept. A TMA Feasibility/Formation Study (often sponsored by public-sector seed funding) typically includes evaluation of:

- the overall level of need, and logical boundaries, for a TMA,
- the types of services a TMA could provide,
- the level of support for a TMA from key stakeholder groups, and
- the availability of adequate financial commitments to support a TMA (both initially and over time).

Appendix A: North American Case Study Research

The following section details case studies from 11 North American case studies researched for this project to establish a context for the development and evaluation of Transportation Management strategies for the I-70 Mountain Corridor.

Case Study Locations

1. The Lake Tahoe Region, California/Nevada
   - Various corridors including Nevada State Route 28, California's I-80, California Highway 50
2. Whistler-Blackcomb, British Columbia
   - Highway 99
3. Cape Cod National Seashore, Massachusetts
   - Route 6
4. Florida Keys
   - US 1 from Miami to Key West
5. National Parks
   - Great Smoky National Park - Cades Cove Loop
   - Acadia National Park
   - Grand Canyon National Park
   - Zion National Park
   - Yosemite National Park
6. Washington State
   - I-405 corridor
7. I-93: Salem to Manchester, New Hampshire

Case Studies

1. Lake Tahoe Area

Multiple entry points to Lake Tahoe's popular skiing, casinos, and outdoor recreation activities allow an influx of visitors to the two main business centers within the basin. Travel on seven of the main access routes increased 20 percent from 1981 to 1995 and an additional 8.85 percent from 1995 to 1999. Various regional and local organizations within the Tahoe Basin have been involved with developing strategic Transportation Management strategies targeted to the visitor. Additionally, multiple corridor-oriented strategies have been developed.

General Regional Strategies

1. **Ski Resort Bus Service:** Heavenly Resort on South Lake Tahoe provides a free shuttle bus for skiers. The bus system picks skiers up at various lodging establishments and shuttles them to Heavenly Ski Resort. These buses are operated by the public bus system but exclusively for Heavenly Resort. North Lake Tahoe ski resorts offer similar shuttle services. The ski resort shuttles are advertised on various websites, both resort-oriented and general Tahoe visitor information oriented websites.
2. **Casino Transit:** Tahoe Casino Express operates luxury bus transit service from the Reno Airport to Lake Tahoe casinos. Last winter, the fee per rider one way was $19.00. Casinos initially subsidized the bus service, but it is currently self-sustaining and operated by a private company. The Casino Express provides ample room for ski and snowboard gear. A similar casino-oriented luxury bus service is currently being discussed for the Sacramento to Tahoe corridor.
3. **Internet Information:** As mentioned, ski resorts advertise their free shuttles on various Tahoe travel and informational websites. In addition, the Tahoe Transportation District's website provides information on a car-free Tahoe vacation and links to both private and public transportation options within and to the Tahoe basin.
4. **South Lake Shuttle**: The South Lake Tahoe Transportation Management Association (TMA) found that 90 percent of bus ridership was resident and only 10 percent tourist/visitor. Focusing on a general philosophy that any visitor-oriented transit options should be fun, easy, and innovative, the TMA looked to Disneyland for models of visitor mobility. They initiated a seasonal trolley system within the city and marketed it toward visitors. After a year of operation, a ridership survey revealed that 90 percent of trolley riders were tourists/visitors and 10 percent were residents. Furthermore, overall ridership has increased each year until 2001.
5. **North Shore Trolley**: Similar to the South Lake Shuttle, the North Shore Trolley is a summer-only form of public transportation marketed toward visitors. A recent ridership survey found that 60 percent of users were visitors

to the area and 50 percent of them had access to cars. The Trolley, which was initially operated by the Truckee/North Tahoe TMA (TNTTMA), is currently managed by the county and paid for by private businesses.

6. **Ski Resort Coalition**: Recognizing the direct interest the ski resort community has in ensuring efficient and accessible transportation options in the North Lake Tahoe area, the TNT/TMA convened a ski resort coalition. This coalition has been involved with improving and enhancing public and private transit for employees and visitors. Together, they advocated and paid for expanded service along SR 89 during the winter, which resulted in increased ridership. In addition, the ski resort coalition takes on some responsibility for funding innovative and enhanced transportation options. Although the ski resorts in North Lake Tahoe are involved in the regional employer rideshare program, each ski resort offers employees unique incentives for taking public transportation. For example, some provide discounted meal tickets while others provide recreation-related incentives.

Corridor Specific Strategies

1. **State Route 80:** SR 80 is the main corridor connecting the Sacramento and San Francisco Bay Area with the Lake Tahoe region.
   - **Proposed Rail:** Numerous I-80 corridor studies have been conducted including a study to determine the feasibility of developing rail service between Sacramento and Reno via Lake Tahoe. The California Department of Transportation (CalTrans) found that 80 percent of the 2.1 million travelers to Lake Tahoe are skiers and, therefore, tailored the rail study to address skier-oriented travel. Annual ridership on the I-80 corridor rail service was estimated to be approximately 230,000. Due to political and economic reasons, the plan was not approved.
   - **Choke-Point Management:** Currently, CalTrans is working on improving inter-regional travel (such as that to Lake Tahoe) by focusing on improving mobility through choke points in urban areas and enhancing bus service. CalTrans is starting to focus more on TDM strategies and their consequential modal shift, but much of the analysis is currently being completed and unavailable.
2. **Highway 89:** Highway 89 connects I-80 with Lake Tahoe. Recreation-inspired congestion on SR 89 is a concern, yet due to the high cost of environmental mitigation, highway expansion is not possible.
   - **Bicycle Trail:** A new bike trail takes cyclists off Hwy 89, designed partly with the intent of giving visitors a viable alternative to automobile once at Lake Tahoe. This trail will connect cyclists with a newly constructed trail that circumnavigates the Lake.
3. **State Route 28:** SR 28 is a popular winding scenic two-lane highway in East Lake Tahoe linking major destination areas in the Tahoe Region while

providing access to popular beaches, trails, and vistas. Recently, parking along SR 28 demand exceeded supply causing visitors to park on the fragile, “prone to erosion” shoulders. The combined effect of erosion and access limitations lead to the development of a Recreational Traffic Management study with the goal of managing recreational traffic along State Route 28 to US Highway 50. The Tahoe Regional Planning Agency (TRPA), the Truckee-North Tahoe Transportation Management Association (TNT/TMA), and the Nevada Department of Transportation (NDOT) partnered to design a plan that would:

- Minimize the environmental impact of recreational travel along the corridor
- Manage recreational traffic to reduce visitor impact on natural resources, encourage alternative modes of transportation
- Reduce the impact of recreational traffic and parking on the capacity and level of service of SR28.

Using traffic analysis data, resident and visitor surveys, and field observances, the study identified key facts regarding recreational travel on SR 28. These facts drove the creation of four main alternatives and the selection of the preferred alternative. The table below outlines the recommended alternative, costs, and effectiveness of the alternative.

SR 28 Recreational Traffic Management
Study Recommendations, Costs, and Effectiveness

Parking	Eliminate all shoulder parking Construct new lots where possible near destinations Construct new lots to be served by a peak season shuttle
Shoulder Parking Control	Use physical barriers such as guardrails and sign posts
Shuttle	Operate during peak periods Serve intercept lots and new lots
Enforcement Program	Two full-time seasonal parking control officers
Informational/Educational Program	Inform drivers accessing the area before they arrive Regional advertisements Brochure AM radio, highway signage
Total Construction Costs	$1,705,100
Total Annual Operating Costs	$204,900
Parking Revenues	$25,550
Parking Violation Revenues	$100,000
Daily VMT Reduction	Approximately 1,434 VMT, or 9.6 percent
NOx Reduction	2,681 grams per day or 0.01 percent of the estimated average summer day emissions

The plan concluded with detailed information regarding establishing an East Shore Recreation Traffic Oversight Committee. This committee would include members from key local, state, and federal organizations and would be responsible for developing an evaluation and monitoring plan. In addition, the plan recommends that a managing entity be assigned daily operational responsibilities of the plan. A local transit district was suggested as the managing entity.

Sources:

1. Nevada State Route 28 Recreational Traffic Management Study. 1995. http://tahoe.ceres.ca.gov/lsc/tbl_con.html
2. South Lake Tahoe TMA Executive Director, Dick Powers. Phone conversation November 1, 2002.
3. Virtual Tahoe transportation information. www.virtualtahoe.com
4. CalTrans. Mark Dinger and Karen Peneschi. Conversations October 27 and October 30.
5. Tahoe Transportation District Car-Free website. http://www.virtualtahoe.com/playground/GettingAround/TTD/TTD.html

2. Whistler-Blackcomb British Columbia, Canada

The two-lane Highway 99, otherwise known as the Sea to Sky Highway, is a popular tourist route. One of the most popular spots along the route is the Whistler-Blackcomb ski area; the largest ski area in North America with more than 7,000 acres of skiable terrain. In addition to its popularity as a ski resort, the area is well known for its mountain biking, hiking, and other non-winter activities. Congestion on Highway 99 and in the Village of Whistler during peak winter afternoon periods is excessive, and year-round congestion on Highway 99 is growing. Thus, Whistler is looking at various tourist- and employer-oriented strategies to improve travel times. In addition, Whistler, British Columbia, is in the bid process for the 2010 Winter Olympics.

Strategies

1. **Shuttle:** The Village of Whistler sponsors a free shuttle within the town of Whistler with service to the Blackcomb Mountain Base Lodge.
2. **Public Transportation:** The local transit provider, WAVE, provides public transportation around the greater Whistler area. WAVE serves more than 2 million riders on 23 buses and operates from 5:00 AM to 3:30 AM. Buses are equipped with ski racks in the winter and bike racks in the summer. Passes are available in various increments (1 or 30 days and/or 5, 10, or 20 rides). Free transit rides are provided on important days such as World Earth Day, Clean Air Day, International Car Free Day, and New Year's Eve. Wave provides service from Vancouver, British Columbia, and Vancouver Airport ($160 and $180 respectively) to Whistler.
3. **Preferential Parking:** Whistler Village provides priority parking to carpools and vanpools.
4. **Comprehensive Transportation Strategy:** The Transportation Advisory Group (TAG), a public-private partnership tasked with addressing transportation issues in Whistler, created a Comprehensive Transportation Strategy that, in addition to outlining new land use policies, transit enhancements, and roadway improvements, includes innovative TDM and parking management and strategies.

TDM Strategies

- **Skier Program:** Manage travel demands on peak skier days with a Peak Day Program that encourages alternative modes and discourages use of the private automobile by
  - Providing free transit service
  - Implementing pay parking strategies
- **Hours of Operation:** Explore modification of mountain operating hours on peak days to spread out traffic peaks along with more flexible ticketing options.

- **Commute Trip Reduction:** Establish and promote an Employer Trip Reduction Program. Research the possibility of combining a transit pass and lift pass for employees who use the bus.
- **Visitor Rideshare Program:** Organize a rideshare program for Whistler day visitors. Provide a van/shuttle service from Vancouver to Squamish, Pemberton, and Whistler.

Parking Management Strategies

- Limit skier parking to existing levels; no net gain in parking capacity except efficient parking operations.
- Expand pay parking.

Effectiveness

Effectiveness, either planned or resulting from the defined TDM strategies, was unavailable. Important to note is that the TAG recommends that TDM programs and enhancements to transit and non-motorized modes should occur before any roadway enhancements or construction occurs. They have set a flexible goal of a 15 percent reduction of automobiles in peak hours (reduction based on projected growth in traffic volumes as if no TDM measures were in place).

Sources:
Information gathered primarily from the following documents:

1. Comprehensive Transportation Strategy. Summary Report. The Transportation Advisory Group. http://www.whistler.ca/reading/documents/Transport%20Strategy.pdf
2. The Vancouver-Whistler 2010 Olympic bid: Transportation Solutions for the Winter 2010 Olympics . Buehrmann, Sebastian. http://www.sfu.ca/~geo449/transportation/Technologies%20and%20Solutions.pdf

3. Cape Cod National Seashore

The Cape Cod National Seashore and the unique 15 towns that line Route 6 draw thousands of visitors every year to explore and relax. Unfortunately, seasonal traffic congestion has decreased mobility along Route 6 for visitors and year-round residents. The Cape is known as a car-dependent area because of various factors including the lack of transportation service coordination, coupled with an overall lack of knowledge regarding public transportation options among residents and visitors. In an effort to recognize and respond to the growing congestion problems, the Cape Cod Transit Task Force is proposing a 25-year transportation plan that outlines a system-wide approach that focuses on public bus transportation. The Task Force is working toward a solid vision statement:

"I CAN get there from here WHEN I want to go."

Strategies

Key elements of the plan aimed at both recreational users and year-round residents of the Cape Cod area include:

- **Coordination:** Improve the coordination between the large numbers of transportation providers on the Cape.
- **Education:** Increase public awareness of transportation options available on and to the Cape including accessibility by bus, ferry, bike, rail, and road.
- **Efficiency:** Increase efficiency of transportation system and decrease duplication where it exists.
- **Exclusiveness:** Identify and address service gaps.

Increasing the frequency of the Cape Cod Regional Transportation Authority's bus service, including expanding to year-round Sunday service and adding services to both underserved areas and whale watch departure points, and building a new bus-only lane on Route 6 from Sandwich to Sagamore Bridge are two specific elements of the Task Force's proposal. The development of hub transportation facilities that serve as multimodal centers is also a key piece of the proposal.

Effectiveness:
Because the Cape Cod Task Force is in the planning stages and the alternatives are currently being analyzed, effectiveness (including proposed effectiveness) measures for the TDM strategies are unavailable.

Cost and Funding:
Estimated costs for entire program:

- Capital improvements: $41 million
- Operating improvements: $19.5 million

In addition to accessing traditional local, state, and federal funding sources, the Task Force includes the provision of additional revenues through the following ways:

- New tax revenues from Barnstable County.
- Adjustment of federal formulas to base Cape's funding on seasonal population.
- Use of dedicated revenue from new, seasonal, or year-round user fees on rooms, sales and/or gasoline.

Sources:
Information gathered primarily from Internet research including access to the following documents:

1. Cape Cod Five-Year Transportation Plan 2002-2007
2. Cape Cod Regional Transportation Authority; http://www.capecodtransit.org/

4. US 1 from Miami to Key West

Popular Key West and the Florida Keys are accessible by road via US 1 from Miami. With the exception of congestion along an 18-mile stretch of US 1, the four-lane signalized highway seems to handle capacity well. Discussions with individuals from Broward County and the Florida Department of Transportation resulted in the discovery that no TDM strategies have been planned or considered for US 1. Two reasons were given for this: (1) a perception that there is no need for TDM on the corridor and (2) TDM would require coordination between the numerous jurisdictions on the Florida Keys. Building consensus between these jurisdictions has proved difficult.

Main Sources:
Information gathered primarily from Internet research and phone conversations including:

1. Phone conversations with Ken Jeffries at FLDOT and Ernesto Polo at Broward County
2. South Florida Regional Planning Council. http://www.sfrpc.com/
3. Strategic Regional Policy Plan for South Florida. http://www.sfrpc.com/ftp/pub/srpp/srpp0895.pdf

5. National Parks

Each of the following case studies describes traffic issues within a National Park governed by the National Park Service. Given this governance structure, each case study shares the National Park Service's transportation mission to "preserve and protect resources while providing safe and enjoyable access within the National Parks by using sustainable, appropriate and integrated transportation solutions."[1] Each park is responsible for developing a General Management Plan, with the exception of congressionally mandated projects and emergency rehabilitation. These plans are to be linked with local land use and transportation planning efforts to the highest extent possible. To achieve the transportation mission, the National Park System is currently gathering and analyzing alternative transportation system (ATS) effectiveness data and traveler/visitor data. The data will be analyzed in fiscal year 2003 to determine effectiveness of the various ATS strategies implemented.

a. Great Smoky National Park- Cades Cove Loop

Receiving more than 2.5 million visitors a year, the Cades Cove Loop, located in the Great Smoky Mountains National Park, is one of the park's most popular tourist destinations. Visitors enjoy rare glimpses of wildlife, multiple national historical sites, and spectacular natural beauty. The annual number of vehicles on the 11-mile one-way loop has quadrupled since 1970. Heavy visitor use is damaging the natural and cultural resources of the park while impeding on the quality of the visitor's experience. Most travel on the Cades Cove Loop is auto oriented, and on days when the traffic is light, the 11-mile loop is an hour's drive. Yet, during busy seasons (such as summer and the month of October), this increases to an average drive of 3 hours.

Strategies

In partnership with the regional Metropolitan Planning Organization (MPO), the Great Smoky National Park is currently developing the Cades Cove Opportunities Plan (CCOP). This plan will outline key transit and transportation demand management (TDM) strategies, all consistent with National Park Service goals, policies, and procedures, aimed at increasing accessibility of Cades Cove and mobility options for visitors. Visitor experience and the preservation of the Cove are key to the CCOP. The CCOP lists various core technology alternatives including:

- Light rail
- Cog railway
- Open-air tram
- Conventional bus

[1] National Park Service Transportation Alternatives Department. http://www.nps.gov/transportation/alt/fotstatus.htm

- Electric shuttle bus
- Articulated bus
- Over the road coach

Each technology alternative was measured against the following criteria:

1. Operational (Will the strategy fit easily into existing infrastructure? Do proven applications exist? Will efficient loading and unloading of passengers occur?)
2. Impact on visitor's experience
3. Ability to meet visitor demand
4. Resource issues
5. Infrastructure requirements

Demand management strategies are also included in the CCOP as complementary strategies to the technology strategies listed above.

Traffic Management Strategies Considered in the CCOP

Access restrictions: Limit the number of cars permitted to enter the cove at any give time with the intent of ensuring the volume of cars in the Cove is less than capacity allowed.

ITS: Consider ATIS to inform visitors about wait time, parking availability, and/or roadway and weather conditions

Bike and Pedestrian Modes: Include bike racks on the chosen transit vehicles, improve access to sites and the Loop, and encourage the use of these modes through expanding onsite rental facilities and ranger bike tours and a public information campaign. Currently, the road is closed to motor vehicles Saturdays and Wednesdays from early May to late September until 10:00 AM to enable bicyclists and pedestrians to travel the loop safely.

Effectiveness

Because the CCOP is in the planning stages and the alternatives are currently being analyzed, effectiveness (including proposed effectiveness) measures for the TDM strategies are unavailable. The TDM strategies are designed to complement and enhance the preferred technology alternative, which is yet to be determined.

Main Sources:
Information gathered primarily from Internet research including access to the following documents:

1. Cades Cove Technology Assessment (August 2001); Regional Transportation Alternative Committee. www.knoxtrans.com/rtap/index.htm

2. Cades Cove Opportunities Plan website. http://www.cadescoveopp.com/
3. Park Announces Experimental Cades Cove Traffic Measures. www.nps.gov/grsm/gsmsite/newscovetraffic.html

b. Acadia National Park

Visitors to Acadia National Park located in Maine, just 6 hours north of Boston, enjoy rocky Atlantic shoreline and beaches, mountainous terrain and numerous wilderness lakes and ponds. Unfortunately, auto use in the park has begun to negatively impact both the park's natural resources and the visitor's experience. The park has made multiple efforts to reduce visitor auto dependency by initiating a few innovative and effective programs.

Strategies

1. **Shuttle Service:** In an effort to provide mobility to visitors and decrease the usage of automobiles within the park, in 1999 Acadia initiated a free shuttle service, the Island Explorer. The Island Explorer provides service between campsites, beaches, the main town, and hiking trailheads. Annual ridership surveys report increasing ridership and overall customer satisfaction. Currently, the shuttle is a seasonal service provided by a private concessionaire and is used by commuters, residents, and visitors.

Island Explorer Ridership

Year	*Riders*
1999	142,000
2000	193,057
2001	239,971

2. **Online Trip Planner:** Visitors planning a trip to Acadia National can access various alternative transportation options and information online. The online trip planner provides future visitors information regarding access to and within Acadia National Park, including the "8 Car-Free Ways to Get to Acadia" brochure, and a link to the free Island Explorer Shuttle service.
3. **Car-Free Day:** Every fourth Sunday in April Acadia sponsors a "car-free day."

Effectiveness

Annual surveying of shuttle riders provides information on the shuttle experience and ridership. These surveys report overall rider satisfaction and increasing usage, yet they do not include information regarding modal shift resulting from the shuttle service. As mentioned earlier, the National Park Service is currently gathering and analyzing ATS effectiveness data and traveler/visitor data.

Main Sources:
Information gathered primarily from Internet research including access to the following documents:

1. Acadia National Park Trip Planner. http://www.nps.gov/acad/planner.htm
2. Volpe Center- National Park Projects. http://www.volpe.dot.gov/index.html
3. Information provided by contact at Volpe Center regarding overall National Park System TDM and Transit effectiveness study efforts.

c. Grand Canyon National Park

Visitors to the Grand Canyon often experience a long wait at each of the park entrance stations. Each year, 5 million visitors make their way to Grand Canyon, resulting in overcrowding and traffic congestion particularly during spring, summer, and fall. The Grand Canyon's General Management Plan outlines the following strategies to combat congestion.

Strategies

1. **Proposed Rail:** The 1995 General Management Plan initially called for the development of a rail system within the park to meet visitor demand. Upon further research into visitor projections, the rail alternative was replaced by enhanced transit options.
2. **Shuttle System:** A free shuttle at the Canyon's South Rim transports visitors to various popular viewpoints along the South Rim. The Grand Canyon plans on enhancing the shuttle, which currently runs at 15-minute frequencies from 7:30 AM to sunset, and less frequently 1 hour before and after sunrise/sunset. The shuttle will eventually operate year-round, feature an evening taxi service, and be able to respond more flexibly to visitor needs.
3. **Parking Management:** Most day visitors to the Grand Canyon will soon need to leave their cars outside the park and ride the enhanced shuttle system within the park. In addition, the General Management Plan includes plans to better integrate internal park shuttle service and parking.
4. **Private Shuttles:** Greyhound provides private bus service from Flagstaff and Williams to the canyon.
5. **Online Travel Information:** Visitors anticipating a trip to the Grand Canyon can use the online trip planner. This trip planner clearly warns day-use visitors of congestion and parking problems within the park and encourages visitors to plan on long delays, use the shuttle, or plan their trip during less congested times.

Effectiveness

As mentioned earlier, the National Park Service is currently gathering and analyzing ATS effectiveness data and traveler/visitor data. Initial reports point to improved air quality within the Canyon since the inception of the policy.

Main Sources:
Information gathered primarily from Internet research including access to the following documents:

1. Grand Canyon National Park Trip Planner.
2. Volpe Center- National Park Projects. http://www.volpe.dot.gov/index.html
3. Grand Canyon National Park General Management Plan. www.nps.gov/grca/gmp/index.htm
4. Information provided by contact at Volpe Center regarding overall National Park System TDM and Transit effectiveness study efforts.

d. Zion National Park

Strategy

In spring 2000, Zion National Park, located in Utah, initiated an aggressive alternative transportation plan within the scenic and popular 6.5-mile Zion Canyon. From April through October, the Zion Canyon Scenic Drive is accessible only by shuttle bus or tram. Visitors intent on viewing the canyon must park their vehicles at the visitor center or outside the park in the nearby town of Springdale. The shuttle system connects with the nearby town of Springdale in a manner that discourages congestion in the town. Bike racks are available on the shuttle, which is free and operates at a 6-minute frequency.

Effectiveness

As mentioned earlier, the National Park Service is currently gathering and analyzing ATS effectiveness data and traveler/visitor data. Initial reports point to improved air quality within the park since the inception of the policy.

Main Sources:
Information gathered primarily from Internet research including access to the following documents:

1. Zion National Park Trip Planner. http://www.nps.gov/zion/trans.htm
2. Volpe Center- National Park Projects. http://www.volpe.dot.gov/index.html
3. Information provided by contact at Volpe Center regarding overall National Park System TDM and Transit effectiveness study efforts.

e. Yosemite National Park

Strategy

Similar to Zion National Park, Yosemite National Park has instituted aggressive alternative transportation policies. Parking for day-use and overnight visitors is available but limited. Once the parking lots are full, visitors must park outside the park and board free shuttles. A fee-for-service hiker bus is also available providing service to multiple trailheads throughout the park.

Effectiveness

The National Park Service is currently working to establish a traffic information system to improve its ability to understand visitor travel patterns and modal shift opportunities. Nevertheless, areas that institute policies such as the Yosemite and Zion policies often experience improved air quality immediately.

Main Sources:
Information gathered primarily from Internet research including access to the following documents:

1. The Yosemite Valley Plan SEIS, Volume II, Appendix G. www.nps.gov/yose/planning/yvp/seis/vo_II/appendix_g.html
2. Yosemite National Park trip planner. http://www.nps.gov/yose/trip/

6. Washington State I-405 Corridor

Located in Washington State, Interstate 405 is a 30.3-mile bypass to the east of Seattle known throughout the region for its congestion. Due to population and job growth in the cities of Bellevue, Renton, Redmond, and Kirkland, drivers "suffer 12 hours in gridlock a day in the Renton area."[2] Traffic and congestion primarily result from commute, freight movement, and travel to and from Seattle for special events. The Washington State Department of Transportation (WSDOT) gathered the jurisdictions and decision makers affected by the I-405 congestion to create a corridor improvement plan. Transportation demand management advocates in the area worked diligently to educate the various jurisdictions on the merits of TDM. After much research, analysis, and partnership building, the I-405 Final EIS included TDM as a sole alternative and as an integral part of each of the other three alternatives.

The Final EIS presents the preferred alternative, which includes the following solutions:

- Implement an enhanced transportation demand management (TDM) program.
- Expand capacity of the existing bus transit system.
- Implement new rapid bus transit.
- Implement new HCT within the corridor.
- Expand the capacity of the existing corridor.
- Expand capacity and improve the continuity of the adjacent arterial network.

[2] http://www.wsdot.wa.gov/projects/I-405/

TDM Strategies

1. **Vanpooling:** Maximize vanpooling in the corridor by increasing the vanpool program 100 percent and initiating the use of new “value-added” incentives (for example, frequent flyer miles for vanpoolers).
2. **Public Information, Education and Promotions Program:** Establish an ongoing public education and awareness program specific to the corridor (focus on issues and transportation alternatives). Provide personalized trip planning assistance.
3. **Employer-Based Programs:** Increase work choices such as telecommuting. Provide incentives to employers to offer work choices (for example, tax credits). Develop parking cash-out program incentives.
4. **Land Use TDM:** Support compact, mixed-use, non-motorized, and transit-friendly (re) development, such as transit oriented-development (TOD), in target areas (urban centers, suburban clusters, key arterials, transit station areas, transit centers, park-and-ride lots). Develop new parking management programs.
5. **Other Miscellaneous TDM Programs:** Including innovative transit and vanpool fare media, incentives, demonstrations, matching funds, etc. Non-commute trips TDM programs (research and demonstrations).
6. **Expanded TDM Package:** Include consideration of the range of regional pricing strategies including:
   a. Region-wide congestion pricing (RCP);
   b. Fuel taxes (revenue = RCP);
   c. Fuel taxes (revenue = 50% RCP);
   d. Mileage charge (revenue = RCP);
   e. Parking charges;
   f. High occupancy toll lanes

The expanded TDM package is considered an add-on piece to the other TDM strategies listed and requires further analysis and public and political support.

Effectiveness and Cost

The table below reflects the estimated reduction in travel demand at various times of the day. The second table demonstrates the estimated cost for each TDM element.

I-405 TDM Program Effectiveness

TDM Element	Estimated Reduction in Daily Travel Demand[3]	Estimated Reduction in AM Peak Period Travel Demand[4]	Estimated Reduction in PM Peak Period Travel Demand
Vanpooling	.9%	2.7%	1.6%
Public Information	.25-.75%	1.0-2.0%	.7%
Employer-Based	.5-1.0%	2.0-3.5%	1.5-2.5%
Land Use as TDM	1.0-2.5%	3.5-5.0%	2.0-3.5%
Miscellaneous Programs	.5-1.0%	1.25-2.5%	.75-1.25%
Total Estimated Travel Demand	3-6%	10-15%	7-10%
Pricing	15%	10-15%	7-10%
Total Estimated Travel Demand Reduction	***18-21% (Note: May include some double-counting of benefits)***	***Not Estimated***	***Not Estimated***

Table 3.12-12 from the I-405 Corridor Program Final EIS

Interstate 405 Funding (20 year; 2000 dollars)

TDM Package Elements	Percentage of Funding	20 Year Funding (2000 $$$)
Core Program*	4%	$19,650,000
Vanpooling	27%	$121,680,000
Public Information and Education	8%	$33,750,000
Employer-Based Strategies	30%	$135,800,000
Land Use	21%	$95,500,000
Other TDM Programs	10%	$45,620,000
TOTAL	***100%***	***$452,000,000***

Nevertheless, despite the inclusion of a TDM package in each of the four alternatives and the Preferred Alternative, the Final EIS clearly states TDM quantification as a concern:

> "The I-405 Corridor Program studied inclusion of a TDM program within the I-405 corridor. The empirical estimates of the TDM program's effectiveness were included in the documentation of impacts on travel demand within the study area. These effects could not be fully integrated into all of the transportation results due to limitations in the travel forecasting procedures. The Puget Sound Regional Council (the area's MPO) is conducting additional research to include more TDM effects into future versions of the model. Research to date suggests that the expanded program contained in the Preferred Alternative represents one of the most extensive corridor-based

[3] Results measured in terms of percent reduction in vehicle miles traveled (VMT)
[4] Pricing is included in Alternative 1 only. Regional congestion pricing effects have been studies as part of the PSRC's 2001 Update Metropolitan Transportation Plan (PSRC, 2000)

demand management and trip reduction programs anywhere in the United States."[5]

A series of Phase I priority improvements for the $1.77 billion in state transportation funds to be allocated for I-405 if voters approve Referendum 51 have been identified. The Phase I plan is based on a "worse first" approach that includes a rebuilt and reconfigured Interstate 405/SR-167 connection and adding new lanes through the Renton area, fixing the urban congestion hot spots along the corridor.

Main Sources:
Information gathered from Internet research, conversations with I-405 staff including access to the following documents:

1. I-405 Corridor Program Final EIS. http://www.wsdot.wa.gov/projects/I-405/feis/
2. Phone conversation with John Shadoff of Washington Department of Transportation (TDM coordinator for the I-405 FEIS).
3. I-405 Project website. http://www.wsdot.wa.gov/projects/I-405/default.htm

7. I-93 Salem to Manchester, New Hampshire

In an effort to improve transportation efficiency and reduce safety problems along a 19.8-mile section of Interstate 93, the New Hampshire Department of Transportation (NHDOT) recently completed a draft environmental impact statement (DEIS). The DEIS presented six alternatives, which included separate TSM, TDM, and alternative modes of transportation alternatives.

Transpirations System Management Alternative: The TSM alternative included three major strategies designed as short-term, moderate cost solutions to I-93 congestion.

1. ITS: Including variable message boards, highway advisory radio, website information, and emergency reference markers.	Incorporated into overall improvements of corridor. Planning efforts to ensure I-93 ITS complements current regional and statewide efforts.
2. Shoulder Lane Usage: Use of shoulder during peak periods.	Requires widening a 3.9-mile corridor to provide minimum 12-ft. shoulder. Requires widening four bridges. Due to high construction costs, this strategy was not pursued.

[5] Summary pp.14.

3. Ramp Metering	Due to the limited number of alternative routes and the limited impact of ramp metering, this alternative was not pursued.

Transportation Demand Management Alternative: The TDM alternative included three major strategies to combat I-93 congestion.

1. ITS: Including variable message signs, highway advisory radio, website information, and emergency reference markers.	Incorporated into overall improvements of corridor. Planning efforts to ensure I-93 ITS complements current regional and statewide efforts.
2. Employer Based Measures: Recognize the greatest success of TDM is through employers .	Most work-related travel is to workplaces in Massachusetts; therefore, these measures need to be implemented largely in Massachusetts by employers, government jurisdictions, and/or TMAs.
3. Congestion Pricing	Because peak-period congestion lasts 3 hours and because of the need for public support, this alternative was not pursued.

Alternative Modes of Transportation Alternative: The provision of alternative transportation modes was also considered.

1. Park and Rides: Build new park and rides to accommodate growth in transit usage.	Three new park-n-ride lots are included in the locally preferred alternative.
2. Bus Expansion: Expand current bus service. Connect service directly with new park and rides.	Included in the preferred alternative, particularly as a means to provide commuters with options during construction.
3. Bus Enhancement: Provide new access between New Hampshire employment centers on I-93 and those in Northern Massachusetts.	Included in the preferred alternative, particularly as a means to provide commuters with options during construction.
4. Congestion Pricing	Because peak-period congestion lasts 3 hours and because of the need for public support, this alternative was not pursued.

5. HOV Lanes: Shift lanes to HOV.	A New Hampshire only HOV lane does not produce sufficient ridership on buses or in carpools to warrant further testing.

Appendix B
TranSystems
I-70 Mountain Corridor Transit Alternatives
July 2000

This page intentionally left blank.

I-70 Mountain Corridor
Transit Alternatives

Prepared for:

Colorado Department of Transportation *J.F. Sato & Associates, Inc.*

DOT

道

Prepared by:

TRANSYSTEMS CORPORATION
CONSULTANTS

July 2000

I-70 MOUNTAIN CORRIDOR PROGRAMMATIC EIS:

Identification of Transit Alternatives

DRAFT FINAL REPORT

Prepared For:

J. F. Sato & Associates

Prepared By:

TRANSYSTEMS CORPORATION

July 26, 2000

List of Figures

IDENTIFICATION OF OPTIONS

Attributes of existing technologies were culled from various sources within the Transportation Research Board (TRB) of the National Academy of Sciences, Jane's World Railways, Jane's Urban Transport Systems, the American Public Transportation Association (APTA), the Association of American Railroads (AAR), the Federal Transit Administration (FTA), and the Federal Railroad Administration (FRA) of the United States Department of Transportation. Attributes of advanced guideway systems were provided by the technology proponents and in most cases have not been tested or verified under real-world operating conditions.

Technologies were divided into two families of transit with a number of groups within each family as well as various options within each group. These families and groups are:

- **Rubber Tire Transit (RTT) Family**

  1. Buses in Mixed Traffic
  2. Buses in High-Occupancy Vehicle (HOV) Lanes
  3. Buses in Transitways
  4. Buses in Fixed Guideway

- **Fixed Guide Transit (FGT) Family**

  1. Automated Guideway Transit
  2. Rail Transit
  3. Passenger Railroads
  4. Advanced Guideway Systems

Characteristics of each type technology are described along with various implementation options, photographs, and key points applicable to the I-70 Mountain Corridor. This paper attempts to initially screen these options.

The difficult mountain terrain traversed by the I-70 Mountain Corridor limits the performance of many transit technologies. Vehicles must operate up and down 6% grades, follow tight highway curvature, operate unobtrusively in a spectacular mountain setting, fit within a narrow highway right-of-way, and not significantly degrade the environment while also providing a serious alternative to highway expansion. The I-70 route is long and mostly rural or wilderness in character, which limits typical urban solutions.

A total of eight general technologies were found to meet the broad requirements for operation in the corridor. Many of them have at least some potential to truly provide a cost effective, environmentally friendly transit alternative.

RUBBER TIRE TRANSIT FAMILY

This section reviews various groups of RTT alternatives as well as options within each alternative. Options to utilize buses in the I-70 Mountain Corridor consist of a number of separate configurations of infrastructure and rolling stock. In this report the term "bus" is defined to mean any self-powered vehicle designed for commercial use and capable of operating on state roads carrying in excess of six passengers. Fuel may be diesel, gasoline, compressed natural gas (CNG), propane, or other available alternates. Buses using electric propulsion are "electric trolley buses" and are commonly referred to as "ETB." In addition, buses that use a combination of self-generated fuel and electric propulsion are "Hybrid Electric Buses" or "HEB."

In this report, four basic methods in which to operate buses will be explored. They are:

1. Buses in Mixed Traffic
2. Buses in High-Occupancy Vehicle (HOV) Lanes
3. Buses in Transitways
4. Buses in Guideway

Operation in Mixed Traffic means the bus is commingled with regular traffic on I-70. High Occupancy Vehicle (HOV) lanes refer to special traffic lanes that are intended for buses, car pools, and any vehicle carrying a minimum number of passengers set by the HOV operator (usually 2 or 3). HOV lanes may be either a regular highway lane distinguished with specially painted lines, symbols, and signage or a segregated roadway with its own access ramps. A transitway is a completely separate roadway limited to transit vehicles only. It may contain special bus guide rails to reduce lane width requirements and help speed operations.

Each of the scenarios that follow has significantly differing capital costs, operating costs, running times, and capacity limitations. Examples of each of these systems are currently available and in operation somewhere in the world.

Bus in Mixed Traffic

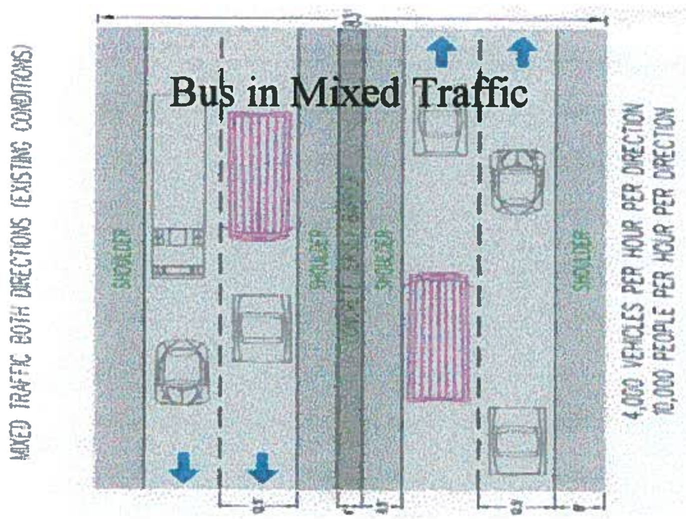
This alternative would use buses operating within the general traffic lanes of I-70 to provide additional highway traffic capacity. The additional highway capacity is obtained by using the buses as a replacement for numerous automobiles, thus freeing up lane space. See figure 1.

Buses could operate from pick-up/drop-off points in Denver or from specially built Park & Ride lots near the entrances to I-70. The capacity of this alternative is essentially tied to the capacity of the I-70 highway lanes. The buses would have no lane priority therefore speeds would be limited by traffic conditions. The buses would also operate slowly on the numerous grades on I-70 as typical available engine output limits the horsepower available.

The types of bus vehicles that could be used include standard 40-foot coaches, tractor-pulled units, articulated sets, or double-deckers. Either diesel fueled or alternate fueled power plants can be utilized. Smaller buses and van operations could also be used as a supplement to the service.

This is a typical suburban or over-the-road bus-operating scenario with examples available in any large metropolitan area. Some of the services described above are already being provided on a much smaller scale within the corridor.

Figure 1: Illustration of Bus in Mixed Traffic



Bus in HOV Lanes

There are two basic options for buses in HOV lanes. One is to separate the lane(s) from general traffic through special lane painting and marking. The second is a lane(s) separated from general traffic through the use of physical barriers (some times using concrete barriers called "Jersey Barriers."

Marked Lanes

This alternative would add a third lane to I-70 in each direction. The lane would be restricted to High Occupancy Vehicles (HOV) such as buses, vans, and automobiles carrying at least 3 persons. A simple paint stripe and signage would separate the HOV lane from adjacent traffic. See figure 2.

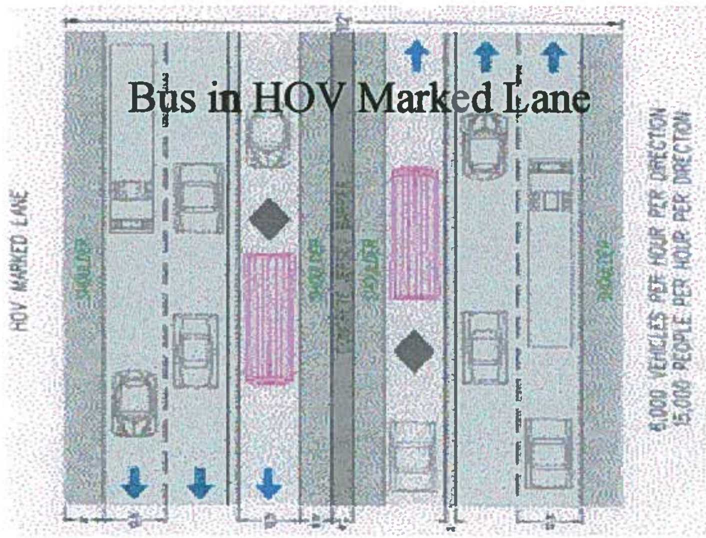
Bus service would operate similarly to the system described in the mixed bus section except that once the buses enter I-70 they would move to the inside HOV lane and travel to their destination with presumably less congestion than in the regular travel lanes. Congestion at interchanges would still be a factor, as would difficulties maintaining speed on grades. In addition, due to the existing high passenger occupancy levels per automobile on this corridor, so many vehicles would qualify for the HOV lanes that any travel advantage might be minimal. Continuous enforcement of the 3-person limit would be required and add to the operating costs of this alternative.

Body style and propulsion types described in earlier are also applicable to this alternative. ETBs cannot be used due to the multiple crossover movements required to access the inside HOV lane.

TranSystems Corporation Consultants

The eastbound and westbound HOV lanes could be operated as restricted to HOV qualified traffic at all times or only in the peak direction, with the opposite direction HOV lane opened for general use.

Figure 2: Illustration of a Marked HOV Lane



Segregated Lanes

In this option, the HOV lanes would be built as a separate highway facility, either in the median of I-70 or as a parallel roadway. A median barrier would completely separate this facility from the general highway lanes. Bus body style and propulsion types described in earlier for mixed traffic buses are applicable to this alternative. ETBs and HEBs could be used due to the separate interchanges, but high speed running in mixed traffic has not been tested for this option. The appearance of the overhead wires could be a problem. See figures 3 and 4 for illustrations of segregated lanes and an electronic trolley bus.

The segregated lanes require less HOV enforcement effort and are less affected by adjacent lane traffic problems. Diesel buses would operate slowly on the grades as engine output limits the horsepower available.

Bus service would operate similarly to the system described in the mixed bus section except that the buses would enter and leave the HOV lanes at special interchanges. They would travel to their destination with presumably less congestion than in the regular travel lanes. Congestion at regular interchanges would not be a factor, but difficulties maintaining speed on grades would still be a problem. As with the "marked lanes", due to the existing high passenger occupancy levels per automobile on this corridor, so many vehicles would qualify for the HOV lanes that any travel advantage might be minimal. Enforcement of the 3-person limit would still be required (but at a significantly less level due to the restricted entry points) and will add to the operating costs of this alternative.

A single pair of HOV lanes can be set to operate only in the peak direction as dictated by demand. This option requires considerable daily maintenance to clear and reverse the lanes, but keeps highway right-of-way use to a minimum. This scenario would require HEBs to return in mixed in traffic, without the electric power advantage on the grades.

Figure 3: Illustration of Segregated HOV Lane—Peak Direction

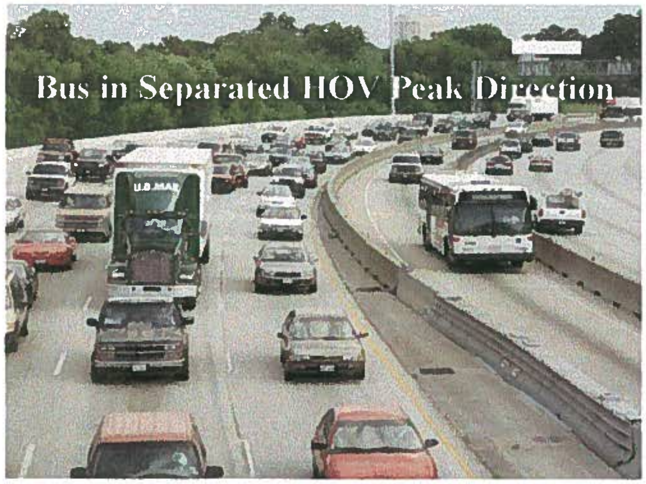
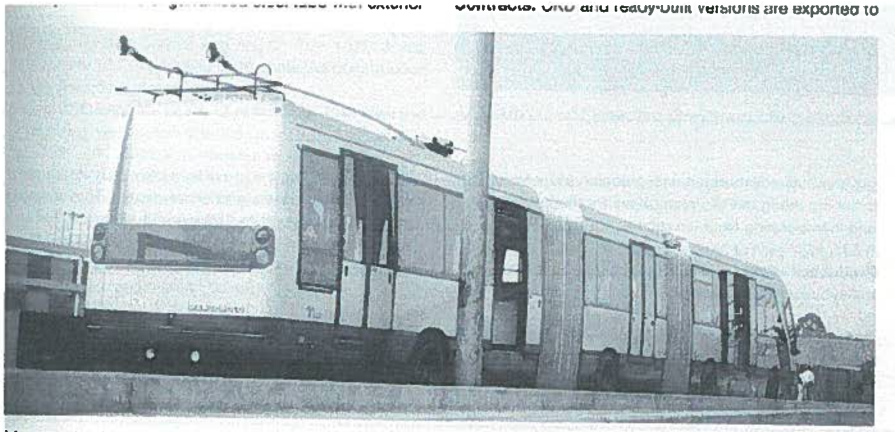


Figure 4: Photo of Electric Trolley Bus



Marcopolo double-articulated bus/trolleybus body – rear view 1999/0043494

Bus in Transitway

While somewhat similar to HOV lanes, transitways are exclusive to buses. In HOV treatments, private autos with the requisite number of people can use the facility. In transitways only buses (as defined earlier) can use the facility. See figure 5.

In this option, a separate roadway dedicated just to buses would be constructed in the median of I-70 or as a parallel roadway. With only professionally operated buses traveling at the same speed, only one lane with a shoulder is required. Enforcement would be minimal as Automatic Vehicle Identification (AVI) technology could be used to raise a barrier at the transitway entrances.

Bus service would operate similarly to the system described for mixed traffic except that the buses would enter and leave the transitway at special interchanges. They would travel to their destination with virtually no congestion. For diesel buses, difficulties maintaining speed on grades would still be a problem. Operation of ETBs and HEBs under electric power would be possible and their use would eliminate any slow operation on grades. The use of the overhead wires could be a problem.

A single direction transitway could be set to operate in the peak direction as dictated by demand. This option keeps highway right-of-way use to a minimum. This scenario would require HEBs to return in mixed in traffic, without the electric power advantage on the grades. ETBs could not be used for the return in mixed traffic.

A separate transitway can also be operated like a rail rapid transit system, using stations along the transitway for passenger boarding instead of leaving the transitway and circulating into the community. This scenario is known as Bus Rapid Transit (BRT) and will be an option to be reviewed under the screening.

Bus in Guided Transitway

In this option, a separate roadway dedicated just to special buses with guideway attachments would be constructed in the median of I-70 or as a parallel roadway. With only professionally operated buses traveling at the same speed, only one narrow guideway lane is required for each direction. No enforcement costs would be required, as conventional vehicles could not use the guideway. See figures 6 and 7.

Bus service would operate similarly to the system described for mixed traffic except that the buses would enter and leave the guided transitway at special interchanges. They would travel to their destination with virtually no congestion. For diesel buses, difficulties maintaining speed on grades would still be a problem. Operation of ETBs and HEBs under electric power would be possible and their use would eliminate any slow operation on grades. Due to the presence of the guideway, 3rd rail power pickup for ETBs and HEBs could be used in place of overhead wires.

A single direction guided transitway could be set to operate in the peak direction as dictated by demand. This option keeps highway right-of-way use to a minimum.

A guided transitway can also be operated like a rail rapid transit system, using stations along the transitway for passenger boarding instead of having buses leave the transitway and circulating into the community. This scenario is known as Bus Rapid Transit (BRT) and will be an option to be reviewed under the screening phase.

Figure 5: Illustration of a Transitway

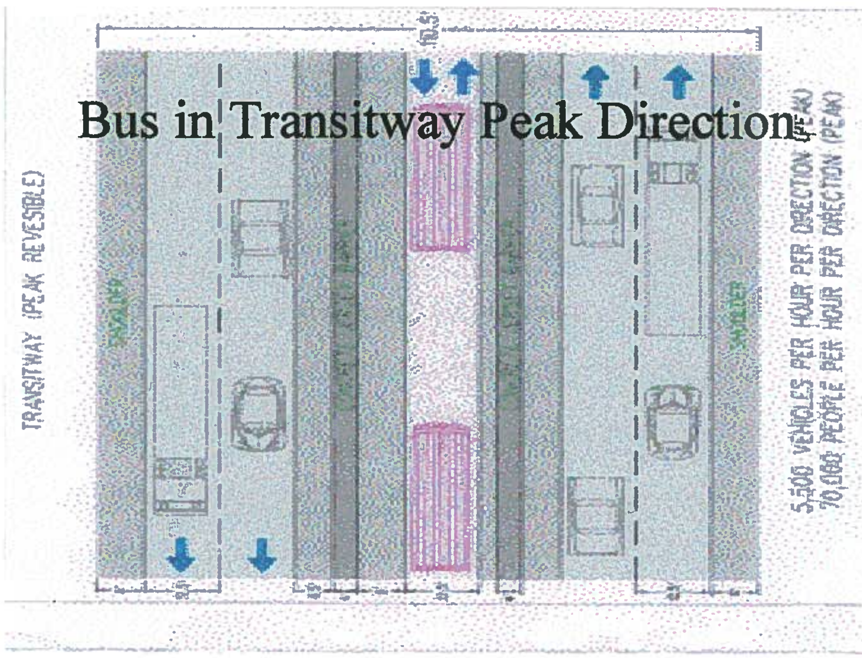


Figure 6: Illustration of Bus Guideway

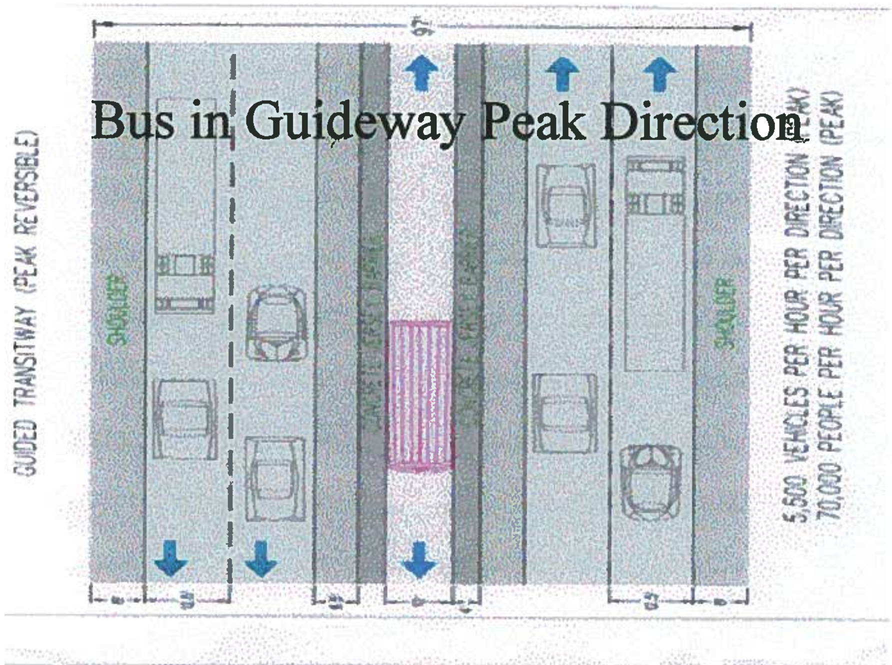
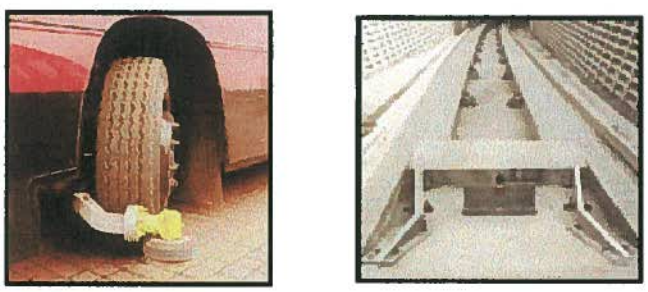


Figure 7: Illustrations of Guideway Bus



FIXED GUIDEWAY TRANSIT FAMILY

This section reviews various options for fixed guideway transit (FGT). These options include:

- Automated Guideway Transit
- Rail Transit
- Passenger Rail Transit
- Advanced Guideway Systems

Automated Guideway Transit (AGT)

These systems have the common characteristic that they provide service without a human operator. Their guideway therefore must be completely protected to ensure that the automated vehicles cannot contact people, automobiles, or other obstacles in the guideway. For this reason they generally operate only short distances and stay within the definition of an "urban" system. The Federal Railroad Administration (FRA) does not regulate them. They can be operated using conventional rail transit steel wheel vehicles, rubber tires with a guide mechanism, or on a monorail. They are usually differentiated five ways: (1) Where they operate, (2) Whether they can operate outside, (3) Whether they operate with more than one independent vehicle per guideway, (4) Whether they can operate multiple routes, and (5) The propulsion mode of the vehicle.

Automated Guideway Transit systems in airports are often referred to as APM (Airport People Mover) Systems. Automated Guideway Transit systems used for downtown circulation are often referred to as DPM (Downtown People Mover) systems. DPM systems are currently operating in Detroit, MI and Jacksonville, FL. Automated Guideway Transit used in universities (Morgantown), hospital campuses (Duke), amusement parks, and other institutions are usually referred to as either a people mover or by the technology used (i.e., the monorail, the tram, and the shuttle). Automated Guideway Transit systems used for general circulation in an urban area are called ICTS for Intermediate Capacity Transit System. Only one example of this technology exists as an automated operation not exclusively in a downtown area and that is in Vancouver, British Columbia.

Many Automated Guideway Transit systems are operated totally indoors through corridors in buildings. These systems, often found in airports, have far less difficulty providing a safe operating guideway than those operating outside do. In two cases the vehicles used in these indoor systems don't even have ceilings, with lighting provided on the roof of the tunnel. They are located in Houston Intercontinental Airport and the basement of the United States Capitol.

The complexity of Automated Guideway Transit increases substantially when more than one vehicle can operate on the same guideway. Simple cable hauled systems handling only one vehicle per guideway can be operated using common elevator technology. When more than one vehicle is on the guideway, a sophisticated signal system is necessary to provide safe separation between the vehicles and to control braking and acceleration. Obviously, systems that can operate multiple vehicles on a single guideway are more efficient and have a much greater capacity.

Some Automated Guideway Transit systems have the ability to operate on multiple routes on either a preprogrammed schedule or on a demand basis determined by the rider. Preprogrammed systems are referred to as GRT (Group Rapid Transit). Rider demand systems as referred to as PRT (Personal

Rapid Transit). Only one true PRT system is in operation at this time. It is an experimental system built in 1974 in Morgantown, West Virginia. It provides service to a large university campus and connects it to downtown Morgantown. Riders select their destination like floors on an elevator. Each small car carries the rider and accompanying parties directly to the station desired, bypassing any other station along the way.

Automated Guideway Transit can be powered by electric traction, cable hauled, or utilize linear induction motors. Sometimes Automated Guideway Systems are characterized by their vehicle capacity. Small systems can be referred to (inaccurately) as PRT systems, larger vehicles as GRT systems, and full size subway-like vehicles as ICTS.

AGT using Conventional Rail

This type of system is currently in operation in Vancouver, British Columbia. A manned version is also in operation in suburban Toronto, Ontario. The linear induction motors in use allow quick acceleration, but can be noisy. See figure 8.

Figure 8: Automated Guideway Transit—Conventional Rail

TranSystems Corporation Consultants

AGT using Monorail

This type of system is currently in operation at Downtown Jacksonville, FL and the Newark, NJ Airport. See figure 9.

Figure 9: Automated Guideway Transit – Monorail

Rail Transit

Options to utilize rail transit in the I-70 Mountain Corridor consist of either light rail or heavy rail transit systems. Each type of system can be constructed as a double-track line or as a single-track line with passing sidings. Either electric or diesel propulsion systems are available. The tracks can be located in the median of I-70 or on a parallel alignment, diverging only for heavy grades and to serve off line stations. In this report the term "Rail Transit" is defined to mean any conventional rail vehicle designed to operate on tracks not connected to the national railroad network. These systems, when operated in an "urban" area, are exempt from Federal Railroad Administration (FRA) regulation.

Rail Transit vehicles may self-generate their own power or utilize electric propulsion. The term "DMU" refers to light rail Diesel Multiple Unit vehicles that can be operated on non-electrified lines that are not regulated by the FRA. Generally, Light Rail Transit (LRT) and Heavy Rail Transit (HRT) systems utilize electric propulsion. LRT vehicles can, if necessary, operate on tracks in city streets with motor vehicle traffic. Light rail trains could also operate in mixed traffic through the Eisenhower Tunnel to avoid separate transit tunnel costs.

High capacity HRT systems must operate only on exclusive rights-of-way due to their large vehicle size, long train lengths, their inability to brake and accelerate within motor vehicle tolerances, and (often) the presence of a ground mounted electric third (power) rail. They do have many more options for power pick-up and automation than LRT systems but represent one of the highest costs per mile to construct.

Although examples of long distance rail transit systems can be found in Europe, none are compliant with FRA vehicle safety requirements. The use of this type of equipment in the I-70 Mountain Corridor would depend on whether the FRA considers the system "urban" or if a safety waiver could be obtained.

Light Rail Transit

This type of rail transit system is designed for medium capacity urban and suburban transportation. It differs from Heavy Rail Transit by its ability to operate in mixed street traffic if desired. These vehicles meet all highway operating standards for braking, acceleration, directional turn signals, and sight distances from the operators position. Usually, though, these systems are operated on either a reserved roadway median or an exclusive right-of-way. Their flexibility to operate in many environments and lower initial costs than Heavy Rail Transit has made them the fastest growing rail transit mode in the nation, with over ten new systems being opened in the last twenty years. See figure 10.

Although typically operated using a 600V-700V DC overhead wire, diesel propulsion and 3rd rail versions are also available. Vehicles can utilize low level or high level boarding platforms and are ADA accessible. Newer low-floor versions are also available to speed street level boarding. Vehicles are available from many suppliers.

Light Rail Transit cars are usually 75 – 90 feet long and often operate in train lengths of one to five cars. Train length is typically limited by the street block size when operating in mixed traffic, to avoid blocking intersections. The vehicle width is smaller than Passenger Railroad systems (typically 8.5 feet) to be able to operate on roadways.

Figure 10: Light Rail

Heavy Rail Transit

This type of rail transit system is designed for high capacity urban and suburban transportation. It differs from Light Rail Transit by its requirement for an exclusive right-of-way. These trains are too big and long to operate on highways and the operator cannot see nor brake sufficiently to deal with typical highway maneuvers. Heavy Rail Transit vehicles are capable of high acceleration and are one of the few modes in this report with sufficient power to operate over the I-70 grades at full speed. The PATCO system in Philadelphia currently operates over a 6% gradient on either side of the Ben Franklin Bridge. The BART system in San Francisco uses high performance motors that will out-accelerate an automobile with a ten-car train. See figure 11.

Although typically operated using a 600V-700V DC 3rd rail, diesel propulsion and overhead catenary versions are also available. Vehicles utilize high level boarding platforms and are ADA accessible. Stations are required for boarding and alighting. Vehicles are available from many suppliers.

Heavy Rail Transit cars are usually 70 - 90 feet long and often operate in train lengths of two to twelve cars. The vehicle width is sometimes smaller than Passenger Railroad systems but cars can be built to their standards if desired.

Figure 11: Heavy Rail

Passenger Railroads

Options to utilize Passenger Railroads in the I-70 Mountain Corridor consist of two separate configurations. In this report the term "Passenger Railroads" is defined to mean any conventional rail vehicle operating on track connected to the national railroad network. These systems are regulated by the Federal Railroad Administration (FRA).

Passenger Rail trains operate throughout the United States. All of these systems share many similarities since they must comply with various construction standards and operating regulations promulgated by the FRA. When operated between a major city and its suburbs the service is referred to as "Commuter Rail." When operated between major cities the service is referred to "Intercity Rail." Amtrak operates virtually all-intercity trains in the United States.

Intercity trains are further subdivided into Short Haul and Long Haul service. Short Haul trains are almost always day trains operating between cities less than 500 miles apart. Long Haul trains operate overnight and many travel across the entire country. Equipment configuration differs between Commuter Rail, Short Haul Intercity trains, and Long Haul Intercity trains. Commuter Rail trains have fairly constricted seating designed for short trips. Short Haul Intercity trains are more generous with seating space and usually provide food service. Long Haul Intercity trains provide seating with leg rests and deep reclines for overnight trips as well as full dining car service, lounge cars, and sleeping room cars.

A variant of Short Haul Intercity train service is High Speed Rail. These trains operate at very high speeds (over 125 mph) for premium fares. Only one system currently exists in the United States. It is currently in service in between Washington, New York, and (soon) Boston. Dozens of other states as also planning High-Speed Rail systems, with California and the Midwest (centered on Chicago) in the most advanced state. High Speed Rail systems require a straight, flat trackbed to achieve their speed goals and attendant ride quality.

Diesel locomotives or electric locomotives may haul passenger Rail trains. The trains may also be made up of multiple unit cars, each with their own diesel or electric traction motor(s). Electric power can be delivered through overhead catenary wires or a third (power) rail. Conventional railroad trains are limited to a maximum gradient of about 6%, although they are usually designed to operate with only a maximum of a 2% grade on most mainlines, with some exceptions. These systems are very flexible, as they are able to operate on both new alignments as well as existing trackage shared with freight trains.

Locomotive Hauled Trains

This option would provide rail service using existing trackage from Denver Union Terminal to Golden and then over a new alignment to the I-70 Corridor. The new tracks would run parallel to I-70 to Dotsero and then rejoin existing trackage that leads to Glenwood Springs and Grand Junction. The grades on this line would require use of a number of diesel locomotives to power each train in order to be able to traverse the grades in a reasonable period of time.

Electric locomotives could also be utilized to mitigate the grade problem and help maintain air quality standards. Overhead catenary would be necessary but could be designed to minimize visual impacts. 3rd rail systems could also be utilized but would require a completely separate, fenced right-of-way to avoid any dangers to trespassers and wildlife (although under running type 3rd rail is far less accessible than the exposed overrunning type. Due to the distance, 25,000V AC overhead wire systems are the most efficient. 600-700V DC 3rd rail systems could also be used with frequent substations necessary along with a continuous high voltage feeder system.

Passenger Rail trains can utilize either low level or high level boarding platforms and are ADA accessible. Stations are required for boarding and alighting. Locomotives and cars are available from many suppliers.

Passenger Rail train cars are 85 feet long, 10.5 feet wide and can be operated in trains as long as 20 cars. Cars can either be single deck (13.5 feet high) or double deck (16.2 feet high).

Multiple Unit Trains

This option would provide rail service using existing trackage from Denver Union Terminal to Golden and then over a new alignment to the I-70 Corridor. The new tracks would run parallel to I-70 to Dotsero and then rejoin existing trackage that leads to Glenwood Springs and Grand Junction.

Diesel powered and electric powered multiple unit trains could be used to provide service along this line. Multiple unit trains have a power advantage in that every car has its own driving motors. See figure 12. Overhead catenary would be necessary but could be designed to minimize visual impacts. 3rd rail systems could also be utilized but would require a completely separate, fenced right-of-way to avoid any dangers to trespassers and wildlife (although under running type 3rd rail is far less accessible than the exposed overrunning type). Due to the distance, 25,000V AC overhead wire systems are the most efficient. 600-700V DC 3rd rail systems could also be used with frequent substations necessary along with a continuous high voltage feeder system.

Passenger Rail multiple unit trains can utilize either low level or high level boarding platforms and are ADA accessible. Stations are required for boarding and alighting. Multiple unit cars are available from many suppliers.

Passenger Rail multiple unit train cars are 85 feet long, 10.5 feet wide and can be operated in trains as long as 20 cars. Cars can either be single deck (13.5 feet high) or double deck (16.2 feet high).

Figure 12: Multiple Unit Train

Advanced Guideway Systems

For the over hundred years there have been only two realistic modes in use for ground transportation: railway (urban and passenger) and highway. In the last twenty years research has been closing in on two types of magnetic levitation (maglev) systems that can be used for a new generation of high speed ground transportation. In addition, an older mode primarily used for transit applications, the monorail, has been proposed in various forms for higher speed intercity service.

The major advantage of both the maglev and monorail technologies is speed. Running times could be significantly shortened, but the infrastructure necessary to accomplish this time saving may mean significant new right-of-way acquisition. These Advanced Guideway Systems need right-of-way that is basically straight. Curve limitations will challenge the use of the I-70 Mountain Corridor for most high speed conventional rail, monorail, or maglev systems.

Monorail Systems

The monorail concept utilizes a single elevated beam to carry a train over any ground-based obstructions. Vehicles can ride above the beam, hang from the beam, or run astride of the beam. The concept has been in operation since the 1950s in amusement parks, downtown circulators, and airport AGT systems. In Japan, some monorail systems are used between downtown areas and airports. See figure 13.

Monorails are operated essentially as Heavy Rail Transit since they are grade separated and cannot run in mixed traffic. They have most of the attributes and limitations of Heavy Rail Transit, but have not been proven in a corridor as long or as remote as the I-70 Mountain Corridor.

A monorail system would need a circulation system at each end of the trip to provide reasonable access. Propulsion for the trains is electric using either conventional electric traction motors or a proposed linear induction motor system. Vehicles can be operated using rubber tires or steel wheels.

Magnetic Levitation Systems

Maglev systems have been under development since the 1960s. Two types are being actively tested. A German attraction based design where the magnets on the track are attracted to electromagnets on the car, which are used to levitate the car for high speed running. Also a Japanese repulsion based design where the magnets on the track push the car away to levitate it in a trough for high speed running.

The German design, which was being planned for a new line from Berlin to Hamburg, was recently defunded. The Japanese design is still undergoing full scale testing in a section of the planned track built outside of Tokyo.

Figure 13: Monorail

Appendix C
TranSystems
I-70 Mountain Corridor PEIS Level 2 Screening
June 2001

This page intentionally left blank.

I-70 Mountain Corridor

PEIS

Level 2 Screening

Prepared for:

Colorado Department of Transportation *J.F. Sato & Associates, Inc.*

DOT

道

Prepared by:

TRANSYSTEMS CORPORATION
CONSULTANTS

Draft

June 2001

TABLE OF CONTENTS

Section I

Summary

INTRODUCTION

The Level 2 Screening process is part of the effort of the Programmatic Environmental Impact Statement (PEIS) effort to select a Locally Preferred Alternative for increasing capacity in the I-70 Corridor between the Denver Metro area (generally starting in the vicinity of the intersection of I-70 and I-470) and Vail. The Level 2 process started with the alternatives recommended for further analysis in the Draft Final Report on Transit Alternatives (May, 2000), the Level 1 Screening process. This section will act as a roadmap to find information in the attached report.

PURPOSE AND SCOPE

The purpose of the Level 2 Screening process was to develop the data required to make an informed decision on refining/reducing the number of transit alternatives carried forward for detailed analysis for selection as the Locally Preferred Alternative in the PEIS. There are two general categories of alternatives that were analyzed:

Fixed Guideway Transit (FGT)
This family integrated the subcategories of Automated Guideway Transit, Rail Transit, Passenger Railroads and Advanced Guideway Systems identified in the Draft Final Report on Transit Alternatives (May, 2000). Both single track (with passing sidings) and double track alternatives were considered for all the conventional technology systems operating in the corridor. Because of the very real differences in the ability of modes to operate on different grades, along with the widely varying capital costs, the FGT systems were evaluated on alignments with various maximum grades. A conventional monorail, powered by electric traction motors, was tested on three different alignments as well as the Colorado Intermountain Fixed Guideway Authority (CIFGA) monorail concept (based on linear induction motor power) using anticipated performance data provided by CIFGA. Two alternatives for operation of diesel locomotive-hauled passenger railroad service on the Union Pacific route via the Moffat Tunnel were also evaluated.

The FGT alternatives that were analyzed (with the maximum grades of the alignments that were tested) are listed below:

1a Diesel Light Rail Transit, single track-4%
1b Diesel Light Rail Transit, single track-6%
1c Diesel Light Rail Transit, single track-Hwy
2a Diesel Light Rail Transit, double track-4%
2b Diesel Light Rail Transit, double track-6%
2c Diesel Light Rail Transit, double track-Hwy
3a Electric Light Rail Transit, single track-4%
3b Electric Light Rail Transit, single track-6%
3c Electric Light Rail Transit, single track-Hwy
4a Electric Light Rail Transit, double track-4%

4b	Electric Light Rail Transit, double track-6%
4c	Electric Light Rail Transit, double track-Hwy
5a	Diesel Heavy Rail Transit, single track-4%
5b	Diesel Heavy Rail Transit, single track-6%
6a	Diesel Heavy Rail Transit, double track-4%
6b	Diesel Heavy Rail Transit, double track-6%
7a	Electric Heavy Rail Transit, single track-4%
7b	Electric Heavy Rail Transit, single track-6%
8a	Electric Heavy Rail Transit, double track-4%
8b	Electric Heavy Rail Transit, double track-6%
9a	Diesel Locomotive hauled Passenger RR, single track-4%
9b	Diesel Locomotive hauled Passenger RR, single track-6%
10a	Diesel Locomotive hauled Passenger RR, double track-4%
10b	Diesel Locomotive hauled Passenger RR, double track-6%
11a	Electric Locomotive hauled Passenger RR, single track-4%
11b	Electric Locomotive hauled Passenger RR, single track-6%
12a	Electric Locomotive hauled Passenger RR, double track-4%
12b	Electric Locomotive hauled Passenger RR, double track-6%
13a	Electric Multiple Unit Passenger RR, single track-4%
13b	Electric Multiple Unit Passenger RR, single track-6%
14a	Electric Multiple Unit Passenger RR, double track-4%
14b	Electric Multiple Unit Passenger RR, double track-6%
15a	Electric Conventional Monorail Advanced Guideway System, double guideway-4%
15b	Electric Conventional Monorail Advanced Guideway System, double guideway-6%
15c	Electric Conventional Monorail Advanced Guideway System, double guideway-Hwy
16	CIFGA Monorail (Highway only)
17	Moffat Tunnel to Winter Pk. Diesel Locomotive hauled Passenger RR
18	Moffat Tunnel to Glenwood Diesel Locomotive hauled Passenger RR

Rubber-Tired Transit (RTT)

This family includes Diesel Bus (DB), Electric Bus (EB) which draw electric power from external sources through overhead catenary wire or guideway-mounted power rails, and Dual Mode Bus (DM) (previously termed Hybrid Electric Bus-HEB) capable of self-propulsion using an on-board diesel engine or operating with electric power like an EB. DB and DM buses were evaluated with operation on transitways and guideways in both the peak direction only (with return via mixed traffic in the regular highway lanes), as well as with versions operating in both directions. This option is not appropriate for EB because it is not feasible to operate from electric power wires over general use expressway lanes. In addition, a version for each technology was tested with Bus Rapid Transit (BRT) stations along the alignment, allowing buses to serve, at least, some points without leaving the line.

The RTT alternatives that were analyzed are listed below:

1	Bus and Improved Van in mixed traffic
2	Diesel Bus in marked HOV lane, peak

3 Diesel Bus in marked HOV lane, both
4 Diesel Bus in separated HOV Lanes, peak
5 Diesel Bus in separate transitway, peak
6 Diesel Bus in separate transitway, both
7 Diesel Bus in guided transitway, peak
8 Diesel Bus in guided transitway, both
9 Diesel Bus in guided transitway, both, BRT stations
10 Dual Mode Bus in separate transitway, peak
11 Dual Mode Bus in separate transitway, both
12 Dual Mode Bus in guided transitway, peak
13 Dual Mode Bus in guided transitway, both
14 Dual Mode Bus in guided transitway, both, BRT stations
15 Electric Bus in separate transitway, both
16 Electric Bus in guided transitway, both
17 Electric Bus in guided transitway, both, BRT stations

The criteria that were utilized in the analysis are described in Appendix A. While FGT and RTT alternatives were not directly compared, the same criteria and rating scheme was used. This will facilitate future cross-modal comparisons. Other environmental criteria were evaluated separately, and are not shown in this document.

The following sections of this report are key descriptive explanations that are important for understanding the methodology used.

- II. FGT Operating Plan
- III. RTT Operating Plan
- IV. Train Performance Calculator (used to calculate average speed for FGT alternatives and Energy Consumption; which are also inputs to cost models)

The rating of each alternative for each of the criteria is contained in the following Tables:

1. Evaluation Matrix – FGT Alternatives (complete tabulation ratings and discussion of non-quantitative criteria)
2. Evaluation Matrix – RTT Alternatives (complete tabulation ratings and discussion of non-quantitative criteria)
3. FGT Analysis Results (contains backup data for quantitative elements; System Capacity, Capital Costs and Energy Consumption)
4. RTT Analysis Results (contains backup data for quantitative elements; System Capacity, Capital Costs and Energy Consumption)

More detailed background information, in tabular form, is contained in the following Appendices:

A. Criteria and assumptions for FGT/RTT Level 2 Screening Process
B. Types of FGT Equipment Tested
C. FGT Electrification Costs
D. Feeder Bus Operations Summary

METHODOLOGY

A five level scheme was utilized for the rating of each alternative for each of the criteria. The levels used are:

1 Highest/Best
2 Best to Intermediate
3 Intermediate
4 Worst to Intermediate
5 Lowest/Worst

RESULTS AND FINDINGS

Summary sheets showing the ratings of all the tested alternatives follow.

FGT

Use of the Train Performance Calculator (TPC) confirmed that the difficult mountain terrain traversed by the I-70 Mountain Corridor limits the performance of many transit technologies. Vehicles were tested on alignments with maximum grades of 4%, 6% and, in some cases, the I-70 highway alignment (with a maximum grade of about 6.7%). Specifically, the expectation of the Level 1 Report that locomotive-hauled trains are not appropriate was borne out. The single-track alternatives were found to have inadequate capacity to serve as a viable approach to providing enough additional capacity to significantly relieve congestion on I-70. The diesel Heavy Rail Transit (HRT) alternatives were found to be unable to meet the minimum average speed requirements.

The remaining technology alternatives were able to perform adequately on the 6% or highway alignment. Thus, the 4% alignment alternatives, with their high costs due to major tunneling requirements, would not be needed.

The alternatives that are recommended to continue into the next phase are:

Diesel Light Rail Transit, double track-Highway
Electric Light Rail Transit, double track-Highway
Electric Heavy Rail Transit, double track-6%
Electric Multiple Unit Passenger RR, double track-6%

Electric Conventional Monorail Advanced Guideway System, double guideway-Highway
CIFGA Monorail-Highway.

RTT

Improved Bus/Van service in mixed traffic was screened out because its capacity and speed are too low to have a significant impact on I-70 congestion. Electric only buses were screened out because of their inability to provide through service either into the Denver Metro area or to points off the transitway in the Corridor. Bi-directional transitway alternatives without BRT stations (requiring buses to leave the transitway to reach all stations) were screened out because the topography of the I-70 communities allows the use of on-line stations without community access limitations. Peak direction only versions of the transitway were screened out because they take up almost as much right-of-way width as the more flexible bi-directional versions. Because of the advantage of BRT stations, all bi-directional transitway alternatives that continue will be assumed to utilize this design feature.

The alternatives that are recommended to continue into the next phase are:

Diesel Bus in separate transitway, both directions, BRT stations
Dual Mode Bus in separate transitway, both directions, BRT stations
Diesel Bus in guided transitway, peak direction
Diesel Bus in guided transitway, both directions, BRT stations
Dual Mode Bus in guided transitway, peak direction
Dual Mode Bus in guided transitway, both directions, BRT stations.

Diesel Buses will be assumed to be 45-foot buses (because of the inability of equipping an articulated diesel bus with a reasonably powerful enough engine to maintain high speeds on the long grades with full loads and acceptable noise levels). Dual Mode buses will be assumed to be 60-foot, articulated buses.

In the next Level of screening the most viable existing technology and promising new technology will be identified for further evaluation against other highway improvement options.

Fixed Guideway Transit Alternatives

Alternative	Need: System Capacity (peak hour) Est.	Need: System Capacity Rating	Need: System Attractiveness	Need: Average Speed (Assuming 10 Stops) Simulated MPH	Need: Average Speed Rating	Need: Connectivity (to existing/ planned systems)	Need: Feeder/ Distribution Requirements	Safety: System Safety (relative to eachother)	Implementation: Capital Costs (infrastructure and rolling stock)	Implementation: Technology Available	Implementation: Fuel Usage Avail.	Implementation: Fuel Usage Limit	Implementation: Energy Consumption (cost/seat mile)
Recommended Alternatives													
Highway Alignment - Diesel Power													
• Light Rail Transit - Double	2832			46.1									
Highway Alignment - Electric Power													
• Light Rail Transit - Double	2640			48.6									
• CIFGA Elevated Monorail - Double +	10,000			65.8									
• Advanced Guideway System - Conventional Monorail - Double	8400			57.1									
6% Alignment - Electric Power													
• Heavy Rail Transit - Double	9240			44.6									
• Passenger Railroad Electric Multiple Unit - Double	9636			42.8									
Screened Alternatives													
Highway Alignment - Diesel Power													
• Light Rail Transit - Single	1416			46.1									
Highway Alignment - Electric Power													
• Light Rail Transit - Single	1320			48.6									
6% Alignment - Diesel Power													
• Light Rail Transit - Single	1416			45.8									
• Light Rail Transit - Double	2832			45.8									
• Heavy Rail Transit - Single	4320	(unable to meet minimum average speed)											
• Heavy Rail Transit - Double	8640	(unable to meet minimum average speed)											
• Passenger Railroad - Locomotive Hauled - Single	--	(simulator calculations show train unable to operate reliably in corridor)											
• Passenger Railroad - Locomotive Hauled - Double	--	(simulator calculations show train unable to operate reliably in corridor)											
6% Alignment - Electric Power													
• Light Rail Transit - Single	1320			48.4									
• Light Rail Transit - Double	2640			48.4									
• Heavy Rail Transit - Single	4200			44.6									
• Passenger Railroad - Locomotive Hauled - Single	--	(simulator calculations show train unable to operate reliably in corridor)											
• Passenger Railroad - Locomotive Hauled - Double	--	(simulator calculations show train unable to operate reliably in corridor)											
• Passenger Railroad Electric Multiple Unit - Single	4380			42.8									
• Advanced Guideway System - Conventional Monorail - Double	8400			56.0									
4% Alignment - Diesel Power													
• Light Rail Transit - Single	1416			48.7									
• Light Rail Transit - Double	2832			48.7									
• Heavy Rail Transit - Single	4320			36.4									
• Heavy Rail Transit - Double	8640			36.4									
• Passenger Railroad - Locomotive Hauled - Single	--	(simulator calculations show train unable to operate reliably in corridor)											
• Passenger Railroad - Locomotive Hauled - Double	--	(simulator calculations show train unable to operate reliably in corridor)											
4% Alignment - Electric Power													
• Light Rail Transit - Single	1320			50.2									
• Light Rail Transit - Double	2640			50.2									
• Heavy Rail Transit - Single	4200			47.2									
• Heavy Rail Transit - Double	9240			47.2									
• Passenger Railroad - Locomotive Hauled - Single	--	(simulator calculations show train unable to operate reliably in corridor)											
• Passenger Railroad - Locomotive Hauled - Double	--	(simulator calculations show train unable to operate reliably in corridor)											
• Passenger Railroad Electric Multiple Unit - Single	4380			45.7									
• Passenger Railroad Electric Multiple Unit - Double	8760			45.7									
• Advanced Guideway System - Conventional Monorail - Double	8400			58.4									
Existing Rail Alignment - Diesel Power (UPRR Moffat Tunnel Route)													
• Passenger Railroad - Winter Park Service*	1400			23.2									
• Passenger Railroad - Glenwood Springs Service*	1400			28.7									

+ Data supplied by Colorado Intermountain Fixed Guideway Authority
* Transferred to Transportation Management Family for further evaluation

Legend

Lowest/Worst — Worst to Intermediate — Intermediate — Best to Intermediate — Highest/Best

- Alternative screened because of low capacity (below 2000 passengers/hour)
- Alternative screened because simulator calculations show that train is unable to operate reliably in corridor
- Alternative screened because the same technology performs similarly with less cost under a different alignment

06/06/01

I-70 Mountain Corridor PEIS
Screening & Summary Analysis of Fixed Guideway Transit Alternatives

Rubber Tire Transit Alternatives

Alternative	Direction	System Capacity (peak hour) Est.	System Capacity Rating	System Attractiveness	Average Speed Estimated MPH	Average Speed Rating	Connectivity (to existing/planned systems)	Feeder/Distribution Requirements	System Safety (relative to eachother)	Capital Costs (infrastructure and rolling stock)	Technology Available	Fuel Usage Avail.	Fuel Usage Limit	Energy Consumption (cost/seat mile)
		Need							**Safety**	**Implementation**				
Recommended Alternatives														
Transitway														
• Diesel Bus	Both/BRT	24,000	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Intermediate	Worst to Intermediate	Highest/Best	Highest/Best	Highest/Best	Lowest/Worst	Worst to Intermediate
• Dual Mode Bus (Diesel/Electric)	Both/BRT	32,000	Highest/Best	Best to Intermediate	60	Highest/Best	Highest/Best	Intermediate	Worst to Intermediate	Best to Intermediate	Best to Intermediate	Intermediate	Intermediate	Lowest/Worst
Guideway														
• Diesel Bus	Peak	24,000	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Intermediate	Intermediate	Highest/Best	Best to Intermediate	Highest/Best	Lowest/Worst	Worst to Intermediate
	Both/BRT	24,000	Highest/Best	Intermediate	53	Best to Intermediate	Highest/Best	Intermediate	Intermediate	Highest/Best	Best to Intermediate	Highest/Best	Lowest/Worst	Worst to Intermediate
• Dual Mode Bus (Diesel/Electric)	Peak	32,000	Highest/Best	Highest/Best	60	Highest/Best	Highest/Best	Intermediate	Intermediate	Best to Intermediate	Intermediate	Intermediate	Intermediate	Lowest/Worst
	Both/BRT	32,000	Highest/Best	Highest/Best	64	Highest/Best	Highest/Best	Intermediate	Intermediate	Best to Intermediate	Intermediate	Intermediate	Intermediate	Lowest/Worst
Screened Alternatives														
Bus/Van in Mixed Traffic														
• Bus/Van in Mixed Traffic*	Both		Highest/Best	Lowest/Worst	36	Worst to Intermediate	Highest/Best	Intermediate	Lowest/Worst	Highest/Best	Highest/Best	Highest/Best	Lowest/Worst	Worst to Intermediate
Transitway														
• Diesel Bus	Peak	24,000	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Intermediate	Worst to Intermediate	Highest/Best	Highest/Best	Highest/Best	Lowest/Worst	Worst to Intermediate
• Dual Mode Bus (Diesel/Electric)	Peak	32,000	Highest/Best	Intermediate	60	Highest/Best	Highest/Best	Intermediate	Worst to Intermediate	Best to Intermediate	Best to Intermediate	Intermediate	Intermediate	Worst to Intermediate
• Electric Bus	Both	32,000	Highest/Best	Intermediate	60	Highest/Best	Lowest/Worst	Intermediate	Worst to Intermediate	Best to Intermediate	Best to Intermediate	Lowest/Worst	Highest/Best	Lowest/Worst
Guideway														
• Diesel Bus	Both	24,000	Highest/Best	Intermediate	51	Best to Intermediate	Highest/Best	Intermediate	Intermediate	Highest/Best	Best to Intermediate	Highest/Best	Lowest/Worst	Worst to Intermediate
• Dual Mode Bus (Diesel/Electric)	Both	32,000	Highest/Best	Highest/Best	64	Highest/Best	Highest/Best	Intermediate	Intermediate	Best to Intermediate	Intermediate	Intermediate	Intermediate	Lowest/Worst
• Electric Bus	Both	32,000	Highest/Best	Intermediate	60	Highest/Best	Lowest/Worst	Intermediate	Intermediate	Best to Intermediate	Intermediate	Lowest/Worst	Highest/Best	Lowest/Worst
	Both/BRT	32,000	Highest/Best	Intermediate	64	Highest/Best	Lowest/Worst	Intermediate	Intermediate	Best to Intermediate	Intermediate	Lowest/Worst	Highest/Best	Lowest/Worst

*Transferred to Transportation Management Family for further evaluation

Legend

- Lowest/Worst
- Worst to Intermediate
- Intermediate
- Best to Intermediate
- Highest/Best
- Alternative screened due to very low capacity and average speed
- Alternative screened due to poor connectivity
- Alternative screened because the same technology performs similarly with less cost under a different version

06/06/01

I-70 Mountain Corridor PEIS Screening & Summary Analysis of Rubber Tire Transit Alternatives

Section II

FGT Operating Plan

MEMORANDUM

Date: June 6, 2001

To: Gary Johnson, William Stringfellow, Mark Walbrun, Ted Rieck

From: David Phillips

Subject: CONCEPTUAL FIXED GUIDEWAY TRANSIT OPERATIONS PLAN

This briefly documents the Mountain Corridor FGT conceptual operations plan. The purpose of the plan is to assist in the second level screening by providing a basis for grading the various alternatives against the criteria. This memorandum discusses the elements of the operations plan, key assumptions, as well as provides a summary of the plan to date. This plan is based on a conceptual level of analysis. Key assumptions are summarized in Appendix A.

This is a plan for operation of a mainline, trunk FGT system linking DUT and DIA in Denver with Vail (Town Center/Exit 176). Intermediate stops in the corridor will be at stations previously identified (Evergreen area, Idaho Springs, Empire, Loveland Pass, Keystone (for the 4% alignment that does not go through the Eisenhower Tunnels), Silverthorn, Frisco and Copper Mountain). All trains will operate through from DIA to Vail, stopping at DUT. Based on the preliminary ridership statistics, there is very little dropoff in ridership along the route, thus it is not appropriate to have any trains terminate at short destinations. Capital costs are figured only for the portion west of the connection with the Gold Line, east of Golden.

Connectivity

It is assumed that the connection to DUT and DIA will be over routes previously identified as the Locally Preferred Alternative (LPA) in the I-70 West (Denver to Golden) and the Denver to DIA Major Investment Studies (MIS). Connection with the Gold Line will be at a station point on the BNSF Railroad called Mt. Olivet, east of Golden. It is assumed that Mountain Corridor trains would not carry local passengers whose entire journey is east of Golden. The actual Golden stop might be located close to I-70, where a large Park and Ride lot could be constructed (as shown as Option 2 in the Gold Corridor MIS). It is assumed that the Gold Line and the DUT to DIA segments will be built so as to be able to accommodate through running of trains of the technology selected for the Mountain corridor, if rail is selected. This, principally, means that the decision on whether these lines are built as non-FRA compliant or FRA-compliant rail routes would be dependent on the Mountain Corridor's selection. Similarly, if the Mountain Corridor selects electrically-powered trains, it is assumed that the DUT-DIA Line (where non-FRA compliant DMUs were selected as the LPA) would be electrified. It is assumed that both lines would be built as double track routes. It is assumed that Advanced Guideway Systems (AGS) alternatives would require a transfer to the presently planned Gold Line LRT. No construction costs east of Golden are included, although it is apparent that there would be some differences between modal alternatives.

Specifically, there is the possibility that an additional (third) track might be required between Golden and DUT because of the number of local stops planned for Gold Line Trains. Mountain Corridor trains would operate nonstop in this segment, with passengers from these stops transferring to Mountain Corridor trains at Golden.

At the West end of the Corridor, it is assumed that DMU service is operated between Vail (at a joint station) and the Eagle Airport passenger terminals. This would operate over the presently-unused portion of Union Pacific (ex-D&RGW) Tennessee Pass line between Eagle and Dowds Junction, a new line (of about one mile) connecting to the airport passenger terminals and a new line (of about 5 miles, essentially in the I-70 corridor) between Dowds Junction and Vail. All alternatives with diesel/turbine-powered trains for the Mountain Corridor will be assumed to provide through (no transfer) service to Eagle; alternatives with electrically powered trains would require passengers to make a same platform transfer. No costs for construction or operation of the Intermountain Connection are included.

Feeder/Distribution Requirements

It is assumed that the distribution system in the corridor would be the same as the one developed for the RTT system. It is anticipated that most of this distribution network is in place and may only need to be augmented to support the trunk system. Since this is identical for the all FGT alternatives no analysis will be performed for FGT. The exceptions are the recently added alternatives using the Moffat Tunnel route, which do not serve any of the I-70 Corridor to Vail. Implementing this service would essentially imply creating the mixed traffic version of the RTT network. This major difference will be noted by rating the Moffat routes as "Low" and all the other FGT alternatives as "High."

Average Speed

Average speed was calculated using Railsim 7® Train Performance Calculator (TPC) software operating each equipment type over the 4% and 6% preliminary alignments (light rail was also tested on the existing "highway" alignment). This software also identified equipment that cannot successfully operate on the grades of the Corridor (principally on the 6% alignment). Several candidates from the Railsim 7® rolling stock library of each train type were run through the TPC with the best chosen to represent the alternative. See Section IV for a more detailed discussion of this methodology.

Service Levels

Service will be assumed to operate in both directions from about 5:00 a.m. to 11:00 p.m., seven days per week every day of the year. The following table summarizes proposed key operating features of the trunk FGT network based on preliminary ridership data and typical train capacities. Light rail, with its limited train length, is anticipated to operate double the number of trains (half these headways). Note that the holiday peak headways would only require to be operated in one direction. On the single track alternatives returning cars would be added to the trains in the reverse peak direction, operating every 20 minutes, will return the additional cars required by the 10 minutes peak direction headway.

Day Type	Days per year	headways First & last 2 hours (4 total)	headways Balance (14 hours)	Peak hour peak direction one-way number of trips	All day one-way number of trips
Normal	265	30 min	30 min	2	37
Peak	75	30 min	20 min	3	51
Holiday peak	25	20 min	6hrs @10min 8hrs @20min	6	85

Capacity

Capacity of alternatives was calculated based on the scheduled headways in the peak periods on holiday peak days. Because of the long trip length, it is assumed that seats are provided for all passengers. All cars are assumed to have rest room facilities and a 10% allowance for food service facilities on all alternatives except LRT and AGS. The target is the ability to accommodate peak hour, peak direction flows of 4200 passengers. For Second Level Screening we are assuming that ridership will be essentially constant over the course of the 50 years of the design life of the system. It is assumed that there will be passing sidings (or second main track) at all stations and at additional points. It is assumed that the closest feasible passing siding spacing is about every four miles; closer than that it would probably be more economical to install and maintain double-track. It has been calculated that this would provide capacity on single-track alternatives to operate 10-minute headways in the peak direction and 20 minutes in the opposite direction. Theoretical capacity on a long double track line such as this has been calculated at 5-minute headways. Capacity for AGS conventional monorail alternatives was calculated at 2-minute headways (as claimed by the manufacturer of the tested system) and, similarly, the CIFGA figure is that provided by CIFGA.

Because of the existing heavy freight traffic on the Moffat Tunnel Route, only one additional trip, operating on the busiest 100 days per year, is assumed. Even this may be difficult to actually operate.

Fare Collection/Crew consists

It has been assumed that station to station fares will be in effect for the Corridor, requiring roving staff to check/collect tickets. This is also appropriate considering the high percentage of occasional users in this Corridor where leisure travel dominates. A crew consisting of a train operator and two conductors has been assumed, except for LRT and the AGS conventional monorail. In the LRT case, it has been necessary to assume one conductor per car, because of the lack of end doors. This prevents a conductor from walking through the train. Food service staff has not been calculated. The small AGS conventional monorail trains have been assumed to only require one conductor.

Other steps

A worksheet was created for each FGT alternative for development of capital and operating costs for this schedule (see Table 3). All equipment types that were run through the TPC software were identified, including its key characteristics and any adaptations that have been assumed in our testing. Specifically, these worksheets were converted into Table 1 which documents assumed adaptations to capacity that were made (to modify equipment designed for routes with short-distance trips to accommodate longer distance trips with a wider seat pitch and an allowance for food service facilities, except on LRT). The results of the test for each equipment type are also be provided in this table. Running times will be based on the end-to-end running time developed in the TPC. Using the TPC, we identified the equipment types that are most suitable for use in the corridor for each modal alternative, and why.

Table 3 also shows peak vehicle requirements, train miles and full time equivalent (FTE) number of train crew members, and estimated revenue hours. Capital costs are also shown. Capital and operating costs over the 50-year design period were developed. All costs shown are in 2001 dollars.

Section III

RTT Operating Plan

MEMORANDUM

Date: June 6, 2001

To: Gary Johnson, William Stringfellow, Mark Walbrun, David Phillips

From: Ted Rieck

Subject: CONCEPTUAL RUBBER TIRE TRANSIT OPERATIONS PLAN

This briefly documents the RTT conceptual operations plan. The purpose of the plan is to assist in the second level screening by providing a basis for grading the various alternatives against the criteria. This memorandum discusses the elements of the operations plan, key assumptions, as well as provides a summary of the plan to date. This plan is based on a conceptual level of analysis. Key Assumptions are summarized in Appendix A.

This plan will eventually be divided into two parts. The first part is a plan for a mainline, trunk RTT system. This trunk system is intended to link key origins in metropolitan Denver with key destinations in the corridor. The second part (to be developed later) addresses a distribution system in the corridor. It is anticipated that most of this distribution network is in place and may only need to be augmented to support the trunk system. The transit system inventory collected in phase I of the PEIS was used.

The conceptual trunk portion of the plan will serve the basis of service for the varied RTT options. The same basic plan would be used for buses in mixed traffic, buses operating in some kind of HOV, as well as buses in a fixed guideway configuration. The operations and scoring will vary due to technology/operating methodology (e.g., stations for BRT options) and the anticipated operating speed (e.g., low with mixed traffic, high with transitways).

The distribution portion of the plan will be developed after the conceptual trunk system is internally accepted.

General Assumptions

There are four basic assumptions:

- There are three main points of origin in metro Denver, each to have its own route. They are Denver International Airport, downtown Denver (16th Street Mall area), and the park and ride at C-470 and I-70 (so-called "hogback". Each origin will have a dedicated service or route connecting it to destinations in the I-70 corridor. Thus, DIA to the corridor would be one distinct route, C-

470 to the corridor another, and, finally, downtown Denver to the corridor. With few exceptions, each route serves a distinct market and it not anticipated that one route would serve more than one origin. For example, the DIA route will not make stops at the C-470 Park and ride area.[1]

- There are nine targeted areas or "catchments." Collectively, the dedicated routes will serve these areas. It is anticipated that there will be one stop in the area. A localize distribution system (to be developed later) will take travelers to their final destination. It is anticipated that at high volume destinations, "skycap" type service, day storage and checked through luggage services would be provided.[2]
- There are three levels of service for each of the three dedicated services. The levels are high (peak), medium (base level service), and low (minimal service). Frequency and/or number of stops in the corridor distinguish each level. Peak service has fewest stops with the highest frequency.
- Most services are planned operate seven days per week, with the C-470 operating six days per week. Services operate from about 5:00 AM to 9:00 PM.

Table IIIa: Summary of key operating features of the Trunk Rubber Tire Transit Network

Service	Level	Frequency	Number of Pattern Stops	Days	Span of Operation	Special Features
DIA	Overall			7	5am to 9pm	*check through luggage*
	High	30	2-3			
	Medium	60	3-4			
	Low	60	3-4			
C-470 Park & Ride	Overall			6	5am to 9pm	"sky cap" at stops
	High	60	3-4			storage at stops
	Medium	60	4			
	Low	60	6			
Downtown Denver	Overall			7	5am to 9pm	"sky cap" at stops
	High	60	4-5			storage at stops
	Medium	60	4-6			
	Low	60	9			

Table IIIb, on page 4, illustrates for each of the three routes the level of service as well as a unique pattern(s). The table is divided into the three main routes or origins (DIA, C-470, and downtown Denver). Also shown are nine (eleven including Avon and Eagle) destinations. It shows three levels of service (high, medium, and low). For each service

[1] Exception would be during low service period where multiple origins could be served. For example, the downtown Denver route might serve C-470 origin during late evening hours.
[2] This address a key convenience issue raised by corridor bus operators.

level there may one, two or three patterns that serve different combinations of destinations. For example, the DIA route, at the high service level, pattern 1 would stop at Evergreen, Loveland, and end at Keystone. DIA high service, pattern 2 first stops at Silverthorne and then Frisco. Route 3 expresses to Copper before ending at Vail. A fourth pattern for the high service level is for the future stops at Avon and Eagle.

Underlying rationale for the patterns in Table IIIb is based on allowing quick, direct travel during the heaviest travel times. In the lesser travel times, stops become more numerous thus service less quick. Keeping stops and travel time to a minimum is a key consideration.

Table IIIc presents estimated operating statistics for the trunk system at three "speed" levels (again, low, medium and high). The speed levels will be coordinated with the tercile ratings of speed for each alternative. Thus, an alternative in the lowest tercile for speed will have the statistics associated with the "low speed service" section in table IIIc. The statistics illustrated are for each route and level of service, frequency (of individual patterns), designated catchment stops for each pattern, days of operation, span of service, peak vehicle requirement, full time equivalent (FTE) number of bus operators, and estimated revenue hours. The later statistics (vehicles, operators and hours) will be adjusted depending on demand. The statistics in the table assumes one bus can handle anticipated demand for each pattern trip. If ridership numbers come in greater than anticipated, multiple buses/trips for each pattern may be needed.

Table 2 shows the detailed evaluation matrix with assigned ratings for each alternative.

Table IIIb: Rubber Tire Transit Conceptual Trunk Service Design

Origin/Level/Pattern		Origin to C-470	Catchment Destination: Evergreen	Idaho Springs	Georgetown	Loveland	Keystone	Silverthorne	Frisco	Copper	Vail	Avon	Eagle
Distance Between Stations			9	11	12	12	10	6	2	7	19	9	18
Cumulative Distance			9	20	32	44	54	60	62	69	88	97	115
DIA		30	39	50	62	74	84	90	92	99	118	127	145
High													
	1												
	2												
	3												
	4												
Medium													
	1												
	2												
	3												
Low													
	1												
	2												
C-470		0	9	20	32	44	54	60	62	69	88	97	115
High													
	1												
	2												
Medium													
	1												
	2												
Low													
Downtown Denver		15	24	35	47	59	69	75	77	84	103	112	130
High													
	1												
	2												
Medium													
	1												
	2												
Low													

Legend:

- *Solid = stop served in near and intermediate term*
- *Diagonal = future service stop*
- *Stop Eliminated in the future*
- *Stop served on a Demand Response basis*

TableIIIc:

Operating Statistics for Three Service Speeds of Conceptual Trunk Service

Summary: Lowest Tercile Speed

Service	Service Level	Frequency	Pattern Stops	Days	Span of Operation	Peak Vehs	Est FTE Veh Operators	Annual Revenue Hours
DIA	*Overall*			7	5am to 9pm	42	89	153,100
	High	30	2-3					
	Medium	60	3-4					
	Low	60	3-4					
C-470 P&R	*Overall*			6	5am to 9pm	11	37	64,500
	High	60	3-4					
	Medium	60	4					
	Low	60	6					
Downtown Denver	*Overall*			7	5am to 9pm	13	39	68,000
	High	60	4-5					
	Medium	60	4-6					
	Low	60	9					
Totals						66	166	285,600

Summary: Medium Tercile Speed

Service	Level	Frequency	Pattern Stops	Days	Span of Operation	Peak Vehs	Est FTE Veh Operators	Annual Revenue Hours
DIA	*Overall*			7	5am to 9pm	34	72	124,400
	High	30	2-3					
	Medium	60	3-4					
	Low	60	3-4					
C-470 P&R	*Overall*			6	5am to 9pm	9	30	52,400
	High	60	3-4					
	Medium	60	4					
	Low	60	6					
Downtown Denver	*Overall*			7	5am to 9pm	11	32	55,300
	High	60	4-5					
	Medium	60	4-6					
	Low	60	9					
Totals						54	135	232,100

Summary: High Tercile Speed

Service	Level	Frequency	Pattern Stops	Days	Span of Operation	Peak Vehs	Est FTE Veh Operators	Annual Revenue Hours
DIA	*Overall*			7	5am to 9pm	29	61	104,832
	High	30	2-3					
	Medium	60	3-4					
	Low	60	3-4					
C-470 P&R	*Overall*			6	5am to 9pm	8	26	44,157
	High	60	3-4					
	Medium	60	4					
	Low	60	6					
Downtown Denver	*Overall*			7	5am to 9pm	9	27	46,557
	High	60	4-5					
	Medium	60	4-6					
	Low	60	9					
Totals						45	53	195,545

Section IV

Train Performance Calculator

Train Performance Calculator in PEIS Secondary Screening

Process of Train Performance Calculator

The Railsim 7® Train Performance Calculator (TPC) was utilized to model train performance. This particular Train Performance Calculator has gained the recognition within the industry as one of the most inclusive types being utilized today. The Norfolk Southern Railway has purchased Railsim 7® for use as a planning and costing tool. Railsim 7® is being utilized in a major capacity study between Newark, NJ and Penn Station, New York City for the various stakeholders there.

We utilized the TPC to project performance characteristics of several types of equipment over three different projected FGT alignments (Highway, 6% and 4%) from I-470 to Vail. Only westbound alignments were utilized in Secondary Screening. The TPC was used as a planning tool to:

- verify the capabilities of various technologies of rolling stock on the mountain grades
- ensure support of predicted ridership
- develop trip time predictions for the FGT alignments (required to calculate operating costs and fleet size requirement analyses, a key part of capital costs)
- predict energy consumption (kWh for electrically-powered trains and gallons for diesel-powered trains; kWh was also an input for sizing the electrical distribution system).

We utilized the TPC to compare and analyze the performance and trip times of alternative rolling stock types, including "off-the-shelf" versus custom-built models.

In summary, the TPC was used to generate detailed and highly accurate performance characteristics of a single train operating over a specified alignment. The performance data includes time, distance, velocity and acceleration, among the many types of output.

The TPC's Database Editor was utilized to enter the data for the various alignments (location of grades, curves, tunnels and stations) that collectively describe the profiles. We will be able to verify the effect on the changing performance characteristics of the rolling stock being tested of design changes within a proposed alignment.

The Report Generator function of the TPC summarize performance from the huge "raw" output files (numerous data points are recorded each second of the simulated run (typically two hours long). To date, text-based Train Summary Report have been produced for each run. The report provides an overview of the selected TPC run(s), by station. It includes a header identifying the report and the geographic limits of the run, as well as all option and parameter settings, station arrive and leave or pass times (for non-stop runs) based on cumulative running time from the beginning of the run, as well as distance operated, average velocity (with and without station stops), peak power demand and energy consumption for and End to End run. The TPC can also produce user-specified graphic plot reports.

Summary of Transit Modes Tested

Railsim 7® has an extensive library of rail equipment. There are 344 North American Locomotives, 128 North American Coaches, 64 North American Multiple Unit Cars, 220 North American Transit Vehicles, 292 World Wide Multiple Unit Cars, and 412 World Wide Transit Vehicles. With this roster to choose from, we were able to select the best type of equipment available to match the parameters required for PEIS Secondary Screening.

Where modifications to equipment types in the library were required we constructed custom-built train sets utilizing the capabilities of the TPC to build "user-defined" rolling stock, based on equipment in the library. Final testing screening for one such train set is shown in the table under the Electric Heavy Rail Transit mode. This approach was also utilized to simulate non-rail systems such as Advanced Guuideway Systems (AGS) and buses (both electric and diesel).

We tested Electric and Diesel Light Rail Transit trains, Electric and Diesel Heavy Rail Transit Cars, Railroad Passenger trains (FRA compatible) pulled both by diesel and electric locomotives, as well as Diesel and Electric Multiple Unit, Monorails and buses (both diesel and electrically-powered). The results are summarized as follows (see Appendix B for a complete presentation of the equipment tested and the simulator results):

<u>Electric Light Rail Transit</u> – This mode was tested on all three alignments (Highway, 6% and 4%). Due to the recent success of Light Rail Transit in the United States (including the new Denver RTD system) and the on-going modernization of existing LRT systems worldwide, there are many choices of equipment available for testing despite the severe grades and curves encountered within these three alignments. Nine different types of equipment were chosen for testing. Selection parameters were high maximum speed and horsepower. We assumed that all equipment tested would require many modifications to increase the existing seating capacity; most of these equipment types have been specified for city transit use, include a heavy reliance on standee less capacity, not appropriate for the long trips in this corridor.

The San Jose Santa Clara VTA 2000 Light Rail Vehicle outperformed the other eight candidates selected for testing. This turned out to be the fastest performance by any of the conventional rail modes, averaging 48.6MPH for a non-stop run and a 1:47 elapsed time over the Highway Alignment. Several others were close.

<u>Diesel Light Rail Transit</u> – Again, this mode was tested on all three alignments. This is a very new technology, with many fewer choices of examples; four types of equipment were chosen for testing.

The Siemens Regio Sprinter VT4N easily out-performed the other three candidates. This was primarily due to the fact that this train set was 18 tons lighter than its nearest competitor. This lighter weight allowed this trainset to have significantly higher acceleration and de-acceleration features. It performed better than a heavier train that had more horsepower and a higher maximum speed primarily because of its lighter weight.

Elapsed time over the Highway Alignment was twelve (12) minutes faster than any other train set tested. Final Statistics: 46.1MPH equated to 1:52" elapsed time.

Diesel Heavy Rail Transit - We were able to identify five sets of equipment for testing over the 4% alignment. Due to the low horsepower output of this type of equipment, performance statistics were not favorable as an alternative type of rail mode. Only two of the five train sets tested successfully completed a TPC run. The others either stalled on the 4% grades or had insufficient brakes for the long descents. Among the equipment that failed was The Colorado Transportation Associates turbine train, using the best available tractive effort and braking curves available.

The ABB Explorer/Endeavour DMU-3 was the better of the two sets that successfully completed the TPC run over the 4% alignment. Average speed over the run was 36.4MPH which equaled to a 2:30" elapsed time. 471 gallons of fuel was consumed.

Electric Heavy Rail Transit – These were defined as non-FRA compliant Multiple Unit trains. Thus five train sets were selected from either the North American transit or the worldwide multiple unit elements of the Railsim library. Apparently, because of the weight of this equipment, of the five sets tested, only one completed the TPC run, and only on the 4% alignment. Three of the sets stalled on the grades and one set had insufficient brakes to hold the train safely on the long descents. The performance of the one set that successfully completed the run was not competitive enough to be considered an alternative. The DB AG German 1999 Class 426 EMU averaged 34.4MPH which equated to a 2:38" elapsed time. Some trains with tilting capabilities were among those tested, but did not complete the runs. These were tested with 6 inches of cant deficiency.

We configured a user-defined high performance Electric Heavy Rail train which averaged 47.1MPH which resulted in a 1:56" elapsed time on the 4% alignment. KWH used were 6249 per run. On the 6% alignment it averaged 44.5MPH which resulted in a 1:56" elapsed time with a 6842 KWH consumption rate.

Electric Multiple Unit Passenger Railroad – This grouping of EMU's that was tested is North American equipment that is Federal Railway Administration (FRA) compliant. We chose four different types based on horsepower and weight.

The Montreal AMT MR90 was the only set of equipment of the four tested that successfully operated over the 4% alignment. The other three either had insufficient braking or stalled on the grades. The Montreal AMT MR90 averaged 45.7MPH which equated to a 1:59" elapsed time. KWH used was high at 6899. This was an eight car train with each car powered. This train set also completed the 6% alignment run with performance statistics of an average speed of 42.8MPH, a 2:01" elapsed time and used 6192 KWH.

Passenger Railroad Locomotive-hauled trains – The TPC allows the user to create various train consists. This category was defined to include only FRA compatible equipment. We tested various combinations of the most powerful passenger diesel and electric locomotives with bi-level coaches to keep weight per seat at a minimum and to satisfy passenger capacity requirements. The number of locomotives used was three to four per five or six car consist over the 4% alignment. The various trains tested either stalled or had insufficient brakes to successfully complete the TPC run. Some runs were also made with tilting trains, using 6 inches of cant deficiency; these also were unsuccessful. It became clear that locomotive-hauled equipment, with a small fraction of the train's axles powered (and equipped with dynamic brakes), is not a viable alternative in this corridor.

Advanced Guideway Systems – The TPC was also used to simulate monorail operation. A conventional monorail was constructed in Railsim 7® based on the System 21 monorail being developed by Futrex Inc. of Charleston SC. This is based on a side-hanging system using small (28 feet long, 11,500 pounds) cars. Published data indicates a top speed of 70 mph, 10% max grades, 10 car maximum train length and 90 second minimum headway. Testing was performed using 26 seats, 6 inches of cant deficiency and 200 hp/car. Results were average speeds, with stops, of 56 to 58.4MPH, depending on the alignment (including stops (59.9 to 60.6 without stops) and elapsed time of 1:31-1:33, with stops. Energy consumed varied from 1855 to 1925 kWh, depending on the alignment (with stops).

The CIFGA monorail was tested using data provided by CIFGA. An experimental train was configured using this information. At CIFGA's request, only the Highway Alignment was tested. A special alignment with the equivalent of 12 inches of conventional railroad superelevation was tested with 6 inches of cant deficiency (although these might result in considerable discomfort for passengers). Results were an average speed of 65.8MPH, an elapsed time of 1:19", and 3244 KWH of energy utilized.

Buses – User defined vehicles were also built to simulate buses, primarily to estimate electricity consumption, to allowing sizing an electric power distribution system for trolleybuses and dual mode buses. These were built based on the specifications of a 45-foot MCI 4500 series over the road coach equipped with a 500 hp electric traction motor. Railsim's Rubber-tired vehicle resistance coefficient was used for the bus runs. Electric buses consumed 476 KWH per trip.

FGT and RTT electrification costs are shown in Appendix C. Feeder bus operations requirements are detailed in Appendix D.

Conclusions

All equipment that was tested, with the possible exception of Electric LRT, will need minor modifications to the propulsion and braking systems. Use of the TPC demonstrated conclusively that only rail equipment with, at least, 2/3 of its axles powered (and equipped with dynamic brakes) had the high-performance capabilities needed to overcome the steep gradients of the Rocky Mountain topography. Typically, such high performance equipment is used in short-distance, commuter service and is designed to serve work trips. On-board enhancements that will be required to serve longer, leisure-oriented trips include more comfortable seating, food service, and larger luggage (ski equipment) compartments. These on-board amenities will be applied to any type of equipment chosen for this service. Wide car doors are needed to keep station dwell times to a minimum. High Level platforms, avoiding the need for stairs, will also improve the ability for this equipment to maintain exacting schedules. Magnetic track brakes will also be required for emergency backup operation on the steep mountain grades. These are also typically associated with high performance transit equipment. Tilting capability may appropriate given the extensive curvature of the alignment. While most tilt trains are locomotive-powered, a large order of high-speed EMU tilt trains is now being built for operation on the West Coast Mainline in England.

Design changes to passenger rail cars often affect the transfer of weight and balance that is critical to performance. Any rail equipment chosen for modification with on-board enhancements to operate within the I-70 corridor must keep the weight of the final design as light as possible. This fact alone is the most critical for this system to be competitive and efficient with the existing transportation modes now being utilized. Operating and Maintenance costs will directly affect the success of this system in that revenues from the farebox will be the primary source for the continuity and success of this service.

A successful passenger rail service can operate within the extreme mountain topography such as this with the associated winter conditions, as long as appropriate maintenance programs for the rolling stock and rail infrastructure is provided. In order for this alternative to be a viable transportation mode it must be safe, dependable, and efficient. A proactive approach to maintenance must be understood and adopted by the operator.

A spreadsheet is provided as Appendix B, which lists each equipment type tested. The top group shows the equipment selected from the Railsim 7® library and its key characteristics. The bottom group provided information regarding the train consist that was tested and the results of the run on each alignment.

Analysis Results

The results of the FGT analysis are documented in Table 3.

The results of the RTT analysis are documented in Table 4.

Table 1

Evaluation Matrix – FGT Alternatives

I-70 PEIS Alternatives - Secondary Screening: Evaluation Matrix
Fixed Guideway Transit (FGT) Alternatives

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
1	**Diesel Light Rail Transit, single track**	**Need**	System capacity		5	1416 passengers per hour in peak direction
			System Attractiveness	Highway	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and high interior noise (due to diesel/turbine power).
				6%	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and high interior noise (due to diesel/turbine power).
				4%	2	Lack of food service (as a result of no end doors), smooth ride (from low curvature) and high interior noise (due to diesel/turbine power).
			Average Speed	Highway	3	46.1mph
				6%	3	45.8mph
				4%	3	48.7mph
			Connectivity		2	Can run through from Eagle to DIA without requiring passengers to change vehicles, using Intermountain Connection, Gold Line (as identified in MIS) and DIA line.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		3	Lightest weight among rail alternatives. Some rail-highway grade crossings would be typical for LRT.
		Implementation	Capital Cost	Highway	2	$14.6M/mile
				6%	2	$15.3M/mile
				4%	3	$24.2M/mile
			Technology Available	Highway	1	Only adaptation required is seating and rest rooms.
				6%	1	
				4%	1	
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption	Highway	4	0.008/seat mile
				6%	4	0.008/seat mile
				4%	3	0.007/seat mile
2	**Diesel Light Rail Transit, double track**	**Need**	System capacity		5	2832 passengers per hour in peak direction
			System Attractiveness	Highway	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and high interior noise (due to diesel/turbine power).
				6%	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and high interior noise (due to diesel/turbine power).
				4%	2	Lack of food service (as a result of no end doors), smooth ride (from low curvature) and high interior noise (due to diesel/turbine power).
			Average Speed	Highway	3	46.1mph
				6%	3	45.8mph
				4%	3	48.7mph
			Connectivity		2	Can run through from Eagle to DIA without requiring passengers to change vehicles, using Intermountain Connection, Gold Line (as identified in MIS) and DIA line.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		3	Lightest weight among rail alternatives. Some rail-highway grade crossings would be typical for LRT.
		Implementation	Capital Cost	Highway	3	$26.8M/mile
				6%	3	$28.1M/mile
				4%	5	$45.4M/mile
			Technology Available	Highway	1	Only adaptation required is seating and rest rooms.
				6%	1	
				4%	1	
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption	Highway	4	0.008/seat mile
				6%	4	0.008/seat mile
				4%	3	0.007/seat mile

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
3	**Electric Light Rail Transit, single track**	**Need**	System capacity		5	1320 passengers per hour in peak direction
			System Attractiveness	Highway	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and low interior noise (due to electric power).
				6%	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	2	Lack of food service (as a result of no end doors), smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	Highway	3	48.6mph
				6%	3	48.4mph
				4%	2	50.2mph
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (assumes that this line would be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		3	Lightest weight among rail alternatives. Some rail-highway grade crossings would be typical for LRT.
		Implementation	Capital Cost	Highway	2	$14.1M/mile
				6%	2	$14.8M/mile
				4%	3	$23.8M/mile
			Technology Available	Highway	1	Currently available readily adaptable. LRT trains in U.S. have operated with dual voltage capability; this is presently operated in Karlsruhe & Saarbrucken, Germany (rolling stock was supplied by firms active in U.S. market)
				6%	1	
				4%	1	
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	Highway	3	0.007/seat mile
				6%	3	0.007/seat mile
				4%	2	0.006/seat mile
4	**Electric Light Rail Transit, double track**	**Need**	System capacity		5	2640 passengers per hour in peak direction
			System Attractiveness	Highway	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and low interior noise (due to electric power).
				6%	2	Lack of food service (as a result of no end doors), less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	2	Lack of food service (as a result of no end doors), smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	Highway	3	48.6mph
				6%	3	48.4mph
				4%	2	50.2mph
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (should be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		3	Lightest weight among rail alternatives. Some rail-highway grade crossings would be typical for LRT.
		Implementation	Capital Cost	Highway	3	$25.6M/mile
				6%	3	$26.7M/mile
				4%	5	$44.3M/mile
			Technology Available	Highway	1	Currently available readily adaptable. LRT trains in U.S. have operated with dual voltage capability; this is presently operated in Karlsruhe & Saarbrucken, Germany (rolling stock was supplied by firms active in U.S. market)
				6%	1	
				4%	1	
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	Highway	2	0.006/seat mile
				6%	2	0.006/seat mile
				4%	2	0.006/seat mile

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
5	**Diesel Heavy Rail Transit, single track**	**Need**	System capacity		3	4320 passengers per hour in peak direction
			System Attractiveness	6%	2	Food service, less smooth ride (from greater curvature) and high interior noise (due to diesel/turbine power).
				4%	2	Food service, smooth ride (from low curvature) and high interior noise (due to diesel/turbine power).
			Average Speed	6%	5	33.3mph
				4%	4	36.4mph
			Connectivity		2	Can run through from Eagle to DIA without requiring passengers to change vehicles, using Intermountain Connection, Gold Line (as identified in MIS) and DIA line.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		2	Stronger carbody construction; new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	5	$41.1M/mile
				4%	5	$49.0M/mile
			Technology Available	6%	3	Significant modifications would be required to handle 6% grades
				4%	1	No adaptation required.
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption	6%	5	0.010/seat mile
				4%	5	0.009/seat mile
6	**Diesel Heavy Rail Transit, double track**	**Need**	System capacity		1	8640 passengers per hour in peak direction
			System Attractiveness	6%	2	Food service, less smooth ride (from greater curvature) and high interior noise (due to diesel/turbine power).
				4%	2	Food service, smooth ride (from low curvature) and high interior noise (due to diesel/turbine power).
			Average Speed	6%	5	33.3mph
				4%	4	36.4mph
			Connectivity		2	Can run through from Eagle to DIA without requiring passengers to change vehicles, using Intermountain Connection, Gold Line (as identified in LPA) and DIA line.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		2	Stronger carbody construction; new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	5	$44.8M/mile
				4%	5	$61.1M/mile
			Technology Available	6%	3	Significant modifications would be required to handle 6% grades
				4%	1	No adaptation required.
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption	6%	5	0.010/seat mile
				4%	5	0.009/seat mile

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
7	**Electric Heavy Rail Transit, single track**	**Need**	System capacity		3	4200 passengers per hour in peak direction
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	6%	3	47.2mph
				4%	2	50.2mph
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (should be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		2	Stronger carbody construction; new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	4	$31.7M/mile
				4%	5	$40.6M/mile
			Technology Available	6%	2	Some modifications would be required to routinely handle 6% grades
				4%	1	No adaptation required.
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	6%	4	0.0080
				4%	3	0.0070
8	**Electric Heavy Rail Transit, double track**	**Need**	System capacity		1	9240 passengers per hour in peak direction
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	6%	3	47.2mph
				4%	2	50.2mph
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (should be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		2	Stronger carbody construction; new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	4	$37.2M/mile
				4%	5	$54.7M/mile
			Technology Available	6%	2	Some modifications would be required to routinely handle 6% grades
				4%	1	No adaptation required.
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	6%	3	0.007/seat mile
				4%	2	0.006/seat mile

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
9	**Diesel Loco. hauled Passenger RR, single track**	**Need**	System capacity		*	Not applicable
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to locomotive power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to locomotive power).
			Average Speed	6%	*	Not applicable
				4%	*	Not applicable
			Connectivity		2	Can run through from Eagle to DIA without requiring passengers to change vehicles, using Intermountain Connection, Gold Line (as identified in MIS) and DIA line.
			Feeder/Distribution Req'ts.		*	*
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	*	Not applicable
				4%	*	Not applicable
			Technology Available	6%	5	Locomotive-hauled trains lack adhesion for efficient operation on 6% grades
				4%	3	Significant modification would be required to routinely handle 4% grades
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption	6%	*	Not applicable
				4%	*	Not applicable
10	**Diesel Loco. hauled Passenger RR, double track**	**Need**	System capacity		*	Not applicable
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to locomotive power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to locomotive power).
			Average Speed	6%	*	Not applicable
				4%		Not applicable
			Connectivity		2	Can run through from Eagle to DIA without requiring passengers to change vehicles, using Intermountain Connection, Gold Line (as identified in MIS) and DIA line.
			Feeder/Distribution Req'ts.		*	*
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	*	Not applicable
				4%	*	Not applicable
			Technology Available	6%	5	Locomotive-hauled trains lack adhesion for efficient operation on 6% grades
				4%	3	Significant modification would be required to routinely handle 4% grades
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption	6%	*	Not applicable
				4%	*	Not applicable

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
11	Electric Loco. hauled Passenger RR, single track	Need	System capacity		*	Not applicable
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	6%	*	Not applicable
				4%	*	Not applicable
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (should be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		*	*
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	*	Not applicable
				4%	*	Not applicable
			Technology Available	6%	5	Locomotive-hauled trains lack adhesion for efficient operation on 6% grades
				4%	3	Significant modification would be required to routinely handle 4% grades
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	6%	*	Not applicable
				4%	*	Not applicable
12	Electric Loco. hauled Passenger RR, double track	Need	System capacity		*	Not applicable
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	6%	*	Not applicable
				4%	*	Not applicable
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (should be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		*	*
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	*	Not applicable
				4%	*	Not applicable
			Technology Available	6%	5	Locomotive-hauled trains lack adhesion for efficient operation on 6% grades
				4%	3	Significant modification would be required to routinely handle 4% grades
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	6%	*	Not applicable
				4%	*	Not applicable

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
13	**Electric Multiple Unit Passenger RR, single track**	**Need**	System capacity		3	4380 passengers per hour in peak direction
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	6%	3	42.8mph
				4%	3	45.7mph
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (should be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	3	$26.7M/mile
				4%	4	$35.4M/mile
			Technology Available	6%	2	Some modifications would be required to handle 6% grades
				4%	1	No adaptation required.
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	6%	3	0.007/seat mile
				4%	2	0.006/seat mile
14	**Electric Multiple Unit Passenger RR, double track**	**Need**	System capacity		1	8760 passengers per hour in peak direction
			System Attractiveness	6%	1	Food service, less smooth ride (from greater curvature) and low interior noise (due to electric power).
				4%	1	Food service, smooth ride (from low curvature) and low interior noise (due to electric power).
			Average Speed	6%	3	42.8mph
				4%	3	45.7mph
			Connectivity		3	Can run through from Vail to DIA without requiring passengers to change vehicles, using Gold Line (as identified in MIS) and DIA line (should be electrified). Connection to Intermountain Connection required west of Vail, unless it is electrified.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); new alignments would be constructed with no grade crossings.
		Implementation	Capital Cost	6%	4	$32.1M/mile
				4%	5	$49.5M/mile
			Technology Available	6%	2	Some modifications would be required to routinely handle 6% grades
				4%	1	No adaptation required.
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	6%	2	0.006/seat mile
				4%	2	0.006/seat mile

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
15	**Electric Conventional Monorail AGS, double guideway**	**Need**	System capacity		1	7800 passengers per hour in peak direction
			System Attractiveness	Highway	2	Ride quality would be affected by high speeds on line with heavy curvature; no food service.
				6%	2	
				4%	2	
			Average Speed	Highway	2	57.1mph
				6%	2	56.0mph
				4%	2	58.4mph
			Connectivity		5	Passengers would need to change at both ends of corridor, unless Gold Line, DIA Line and Intermountain Connection are built using same technology.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		2	Middleweight vehicles on new alignment
		Implementation	Capital Cost	Highway	5	$43.4M/mile
				6%	5	$43.6M/mile
				4%	5	$44.7M/mile
			Technology Available	Highway	3	Only one system (in Japan) operates at average speeds over 35mph; significant adaptation required. Simulation data based Futrex System 21, now in early prototype phase, which promises higher performance.
				6%	3	
				4%	3	
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	Highway	1	0.005/seat mile
				6%	1	0.005/seat mile
				4%	1	0.005/seat mile
16	**CIFGA Monorail, double guideway** Highway alignment only	**Need**	System capacity		1	10,000 passengers per hour in peak direction
			System Attractiveness		2	Ride quality would be affected by high speeds on line with heavy curvature; no food service.
			Average Speed		1	65.8mph
			Connectivity		5	Passengers would need to change at both ends of corridor, unless Gold Line, DIA Line and Intermountain Connection are built using same technology.
			Feeder/Distribution Req'ts.		3	Feeder systems in existence. Moderate change in local transit services required in the corridor
		Safety	System Safety		2	Middleweight vehicles on new alignment
		Implementation	Capital Cost		5	$51.8M/mile
			Technology Available		5	In concept planning phase
			Fuel Availability		5	Vehicles are electrically-powered.
			Fuel Limitations		1	Vehicles are electrically-powered.
			Energy consumption	Highway	2	0.028/seat mile

	Alternative	Area	Criteria	Alignment	Rating	Value/discussion
17	Added trains on existing	Need	System capacity		5	1400 on one train per day
	Moffat Tunnel route to		System Attractiveness		1	Food service, smooth ride (from low curvature) and low interior noise (due to locomotive power).
	Winter Park		Average Speed		5	23.2mph
			Connectivity		5	All Mountain Corridor stops would be served by buses operating in mixed traffic.
			Feeder/Distribution Req'ts.		5	Very large network of of buses required
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); alignment has few grade crossings.
		Implementation	Capital Cost		1	$0.2M/mile
			Technology Available		High	No adaptation required.
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption		5	0.0021/seat mile
18	Added trains on existing	Need	System capacity		5	1400 on one train per day
	Moffat Tunnel route to		System Attractiveness		1	Food service, smooth ride (from low curvature) and low interior noise (due to locomotive power).
	Glenwood Springs		Average Speed		5	28.7mph
			Connectivity		5	Most Mountain Corridor stops would be served by buses operating in mixed traffic.
			Feeder/Distribution Req'ts.		5	Very large network of of buses required
		Safety	System Safety		1	Strongest carbody construction (FRA compliant); alignment has few grade crossings.
		Implementation	Capital Cost		1	$0.1M/mile
			Technology Available		1	No adaptation required.
			Fuel Availability		1	Vehicles are fossil fuelpowered.
			Fuel Limitations		5	Vehicles are fossil fuelpowered.
			Energy consumption		5	$0.028/seat mile

Table 2

Evaluation Matrix – RTT Alternatives

I-70 PEIS Alternatives - Secondary Screening: Evaluation Matrix

Rubber Tired Transit (RTT) Alternatives

	Alternative	Area	Criteria	Rating	Value/discussion
1	Bus and Improved Van in mixed traffic	Need	System capacity	5	Capacity limited to existing highway capacity, which is already over capacity
			System attractiveness	5	Low average speed and least comfortable vehicles would make this alternative unattractive
			Average Speed	4	36 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	1	Vehicles provide own distribution
		Safety	System Safety	5	Operation with mixed traffic, not all drivers having CDL licensing and use of vans, with lightweight constuction lead to lowest rating
		Implementation	Capital Costs	1	$1.2M/mile
			Technology Available	1	Conventional technology
			Fuel Availability	1	Internal combustion power
			Fuel Limitations	5	Internal combustion power
			Energy consumption	4	$0.008/seat mile
2	Diesel Bus in marked HOV lane, peak	Alternative transferred to Highway HOV options			
3	Diesel Bus in marked HOV lane, both	Alternative transferred to Highway HOV options			
4	Diesel Bus in separated HOV Lanes, peak	Alternative transferred to Highway HOV options			
5	Diesel Bus in separate transitway, peak	Need	System capacity	1	24000 passengers per hour in peak direction
			System attractiveness	4	Confined space, lack of food service and noisy operation reduce attractiveness
			Average Speed	2	51 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	4	Buses with drivers with CDL on transitway (limited to buses only)
		Implementation	Capital Costs	1	$6.1M/mile
			Technology Available	1	Conventional technology
			Fuel Availability	1	Diesel power
			Fuel Limitations	5	Diesel power
			Energy consumption	4	$0.008/seat mile
6	Diesel Bus in separate transitway, both	Need	System capacity	1	24000 passengers per hour in peak direction
			System attractiveness	4	Confined space, lack of food service and noisy operation reduce attractiveness
			Average Speed	2	51 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	4	Buses with drivers with CDL on transitway (limited to buses only)
		Implementation	Capital Costs	1	$9.1M/mile
			Technology Available	1	Conventional technology
			Fuel Availability	1	Diesel power
			Fuel Limitations	5	Diesel power
			Energy consumption	4	$0.008/seat mile

	Alternative	Area	Criteria	Rating	Value/discussion
7	**Diesel Bus in guided**	**Need**	System capacity	1	24000 passengers per hour in peak direction
	transitway, peak		System attractiveness	4	Confined space, lack of food service and noisy operation reduce attractiveness
			Average Speed	2	51 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	1	$6.4M/mile
			Technology Available	2	Guideway technology has not been applied in snowy climates
			Fuel Availability	1	Diesel power
			Fuel Limitations	5	Diesel power
			Energy consumption	4	$0.008/seat mile
8	**Diesel Bus in guided**	**Need**	System capacity	1	24000 passengers per hour in peak direction
	transitway, both		System attractiveness	4	Confined space, lack of food service and noisy operation reduce attractiveness
			Average Speed	2	51 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	1	$7.4M/mile
			Technology Available	2	Guideway technology has not been applied in snowy climates
			Fuel Availability	1	Diesel power
			Fuel Limitations	5	Diesel power
			Energy consumption	4	$0.008/seat mile
9	**Diesel Bus in guided**	**Need**	System capacity	1	24000 passengers per hour in peak direction
	transitway, BRT stations		System attractiveness	4	Confined space, lack of food service and noisy operation reduce attractiveness
			Average Speed	2	53 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	1	$7.6M/mile
			Technology Available	2	Guideway technology has not been applied in snowy climates
			Fuel Availability	1	Diesel power
			Fuel Limitations	5	Diesel power
			Energy consumption	4	$0.008/seat mile
10	**Dual Mode Bus in**	**Need**	System capacity	1	32000 passengers per hour in peak direction
	separate transitway, peak		System attractiveness	3	Confined space and lack of food service affect attractiveness
			Average Speed	1	60 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	4	Buses with drivers with CDL on transitway (limited to buses only)
		Implementation	Capital Costs	1	$9.9M/mile
			Technology Available	2	Limited experience with dual mode buses, none at high speed
			Fuel Availability	3	Combination of diesel and electric power
			Fuel Limitations	3	Combination of diesel and electric power
			Energy consumption	4	$0.008/seat mile

	Alternative	Area	Criteria	Rating	Value/discussion
11	**Dual Mode Bus in separate transitway, both**	**Need**	System capacity	1	32000 passengers per hour in peak direction
			System attractiveness	3	Confined space and lack of food service affect attractiveness
			Average Speed	1	60 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	4	Buses with drivers with CDL on transitway (limited to buses only)
		Implementation	Capital Costs	2	$12.2M/mile
			Technology Available	2	Limited experience with dual mode buses, none at high speed
			Fuel Availability	3	Combination of diesel and electric power
			Fuel Limitations	3	Combination of diesel and electric power
			Energy consumption	5	$0.009/seat mile
12	**Dual Mode Bus in guided transitway, peak**	**Need**	System capacity	1	32000 passengers per hour in peak direction
			System attractiveness	3	Confined space and lack of food service affect attractiveness
			Average Speed	1	60 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	1	$8.5M/mile
			Technology Available	3	Limited experience with dual mode buses, none at high speed; guideway technology has not been applied in snowy climate
			Fuel Availability	3	Combination of diesel and electric power
			Fuel Limitations	3	Combination of diesel and electric power
			Energy consumption	5	$0.009/seat mile
13	**Dual Mode Bus in guided transitway, both**	**Need**	System capacity	1	32000 passengers per hour in peak direction
			System attractiveness	3	Confined space and lack of food service affect attractiveness
			Average Speed	1	60 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	1	$10.5M/mile
			Technology Available	3	Limited experience with dual mode buses, none at high speed; guideway technology has not been applied in snowy climate
			Fuel Availability	3	Combination of diesel and electric power
			Fuel Limitations	3	Combination of diesel and electric power
			Energy consumption	5	$0.009/seat mile
14	**Dual Mode Bus in guided transitway, BRT stations**	**Need**	System capacity	1	32000 passengers per hour in peak direction
			System attractiveness	3	Confined space and lack of food service affect attractiveness
			Average Speed	1	64 mph
			Connectivity	1	Internal combustion engine allows through service to all destinations
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	1	$10.6M/mile
			Technology Available	3	Limited experience with dual mode buses, none at high speed; guideway technology has not been applied in snowy climate
			Fuel Availability	3	Combination of diesel and electric power
			Fuel Limitations	3	Combination of diesel and electric power
			Energy consumption	5	$0.009/seat mile

	Alternative	Area	Criteria	Rating	Value/discussion
15	**Electric Bus in separate transitway, both**	**Need**	System capacity	1	32000 passengers per hour in peak direction
			System attractiveness	5	Lack of connectivity, confined space and lack of food service greatly reduce attractiveness
			Average Speed	1	60 mph
			Connectivity	5	Being restricted to operation on roadways with electric power supply forces transfers at both I-70 and Vail
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	4	Buses with drivers with CDL on transitway (limited to buses only)
		Implementation	Capital Costs	2	$16.5M/mile
			Technology Available	2	No experience with electric buses at high speed
			Fuel Availability	5	Electric power
			Fuel Limitations	1	Electric power
			Energy consumption	5	$0.0092/seat mile
16	**Electric Bus in guided transitway, both**	**Need**	System capacity	1	32000 passengers per hour in peak direction
			System attractiveness	5	Lack of connectivity, confined space and lack of food service greatly reduce attractiveness
			Average Speed	1	60 mph
			Connectivity	5	Being restricted to operation on roadways with electric power supply forces transfers at both I-70 and Vail
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	2	$14.2M/mile
			Technology Available	3	No experience with electric buses at high speed; guideway technology has not been applied in snowy climate
			Fuel Availability	5	Electric power
			Fuel Limitations	1	Electric power
			Energy consumption	5	$0.009/seat mile
17	**Electric Bus in guided transitway, BRT Stations**	**Need**	System capacity	1	32000 passengers per hour in peak direction
			System attractiveness	5	Lack of connectivity, confined space and lack of food service greatly reduce attractiveness
			Average Speed	1	64 mph
			Connectivity	5	Being restricted to operation on roadways with electric power supply forces transfers at both I-70 and Vail
			Feeder/Dist. Req'ts.	3	Requires moderate increase in local transit service to serve as feeder network
		Safety	System Safety	3	Buses with drivers with CDL on guided transitway (limited to buses only)
		Implementation	Capital Costs	2	$14.4M/mile
			Technology Available	3	No experience with electric buses at high speed; guideway technology has not been applied in snowy climate
			Fuel Availability	5	Electric power
			Fuel Limitations	1	Electric power
			Energy consumption	5	$0.009/seat mile

Table 3

FGT Analysis Results

I-70 PEIS Secondary Screening - FGT operating costs

Capacity

	Holiday Peak Day Peak hour ridership	Minumum headway	Max. number of trains per hour	Required Capacity per train
Single-track alternatives	4200	10 min	6	700
Double-track altermalives	4200	5 min	12	350
Added "Ski Train"	700	1 train	1	700

Alternatives	Holiday Peak headway (minutes)	Number of trains operated per hour	Capacity per car	Max. Number of cars per train	Capacity per train	Number of locos required per train	Capacity per hour	Capacity per hour with minimum headways	One-way running time (minutes) I-470 - VAL	One-way running time (minutes) DIA - VAL (45min DIA-GLD)	Round-trip running time DIA-VAL (minutes, incl. 15% recovery)	Holiday Peak Number of Trains required	Holiday Peak Number of cars required	Holiday Peak Number of locos required
Single-track alternatives														
1a Diesel Light Rail Transit-4%	10	6	59	4	236	NA	1416	1416	112	157	338	34	135	NA
1b Diesel Light Rail Transit-6%	10	6	59	4	236	NA	1416	1416	113	158	340	34	136	NA
1c Diesel Light Rail Transit-Hwy	10	6	59	4	236	NA	1416	1416	112	157	338	34	135	NA
3a Electric Light Rail Transit-4%	10	6	55	4	220	NA	1320	1320	109	154	331	33	132	NA
3b Electric Light Rail Transit-6%	10	6	55	4	220	NA	1320	1320	107	152	327	33	131	NA
3c Electric Light Rail Transit-Hwy	10	6	55	4	220	NA	1320	1320	107	152	327	33	131	NA
5a Diesel Heavy Rail Transit-4%	10	6	60	12	720	NA	4320	4320	150	195	419	42	503	NA
5b Diesel Heavy Rail Transit-6%	10	6	60	12	720	NA	4320	4320	156	201	432	43	519	NA
7a Electric Heavy Rail Transit-4%	10	6	50	14	700	NA	4200	4200	116	161	346	35	485	NA
7b Electric Heavy Rail Transit-6%	10	6	50	14	700	NA	4200	4200	116	161	346	35	485	NA
9a Diesel Loco. hauled Passenger RR-4%	stalled													
9b Diesel Loco. hauled Passenger RR-6%	stalled													
11a Electric Loco. hauled Passenger RR-4%	stalled													
11a Electric Loco. hauled Passenger RR-6%	stalled													
13a Electric Multiple Unit Passenger RR-4%	10	6	73	10	730	NA	4380	4380	119	164	353	35	353	NA
13b Electric Multiple Unit Passenger RR-6%	10	6	73	10	730	NA	4380	4380	121	166	357	36	357	NA
17 Moffat Tunnel - DUT to Winter Pk. Diesel Loco. hauled Psgr RR	60	1	140	6	840	2	840	840	150	NA	NA	1	6	2
18 Moffat Tunnel - DUT to Glenwood Diesel Loco. hauled Psgr RR	60	1	140	6	840	2	840	840	385	NA	NA	1	6	2
Double-track alterrnatives														
2a Diesel Light Rail Transit-4%	5	12	59	4	236	NA	2640	2832	112	157	338	68	270	NA
2b Diesel Light Rail Transit-6%	5	12	59	4	236	NA	2640	2832	113	158	340	68	272	NA
2c Diesel Light Rail Transit-Hwy	5	12	59	4	236	NA	2640	2832	112	157	338	68	270	NA
4a Electric Light Rail Transit-4%	5	12	55	4	220	NA	2640	2640	109	154	331	66	265	NA
4b Electric Light Rail Transit-6%	5	12	55	4	220	NA	2640	2640	107	152	327	65	261	NA
4c Electric Light Rail Transit-Hwy	5	12	55	4	220	NA	2640	2640	107	152	327	65	261	NA
6a Diesel Heavy Rail Transit-4%	10	6	60	12	720	NA	4200	8640	150	195	419	42	503	NA
6b Diesel Heavy Rail Transit-6%	10	6	60	12	720	NA	4200	8640	156	201	432	43	519	NA
8a Electric Heavy Rail Transit-4%	10	6	50	14	700	NA	4200	8400	116	161	346	35	485	NA
8b Electric Heavy Rail Transit-6%	10	6	50	14	700	NA	4200	8400	116	161	346	35	485	NA
10a Diesel Loco. hauled Passenger RR-4%	stalled													
10b Diesel Loco. hauled Passenger RR-6%	stalled													
12a Electric Loco. hauled Passenger RR-4%	stalled													
12b Electric Loco. hauled Passenger RR-6%	stalled													
14a Electric Multiple Unit Passenger RR-4%	10	6	73	10	730	NA	4380	8760	119	164	353	35	353	NA
14b Electric Multiple Unit Passenger RR-6%	10	6	73	10	730	NA	4380	8760	119	164	353	35	353	NA
15a Electric Monorail AGS-4%	3.75	16	26	10	260	NA	4160	7,800	93	138	297	79	791	NA
15b Electric Monorail AGS-6%	3.75	16	26	10	260	NA	4160	7,800	92	137	295	79	785	NA
15c Electric Monorail AGS-Hwy	3.75	16	26	10	260	NA	4160	7,800	91	136	292	78	780	NA
16 CIFGA Monorail	5.5	11	20	20	400	NA	4400	10,000	79	124	267	48	969	NA

Sorted by Average Speed (including stops)

DP_4%	PRR_Corridor	Single	-	-	
DP_4%	PRR_Corridor	Double	-	-	
EP_4%	PRR_Corridor	Single	-	-	
EP_4%	PRR_Corridor	Double	-	-	
DP_6%	PRR_Corridor	Single	-	-	
DP_6%	PRR_Corridor	Double	-	-	
EP_6%	PRR_Corridor	Single	-	-	
EP_6%	PRR_Corridor	Double	-	-	
EP_HA	CIFGA Monorail	Double		1	65.8
EP_4%	AGS_Conv Mono	Double		2	58.4
EP_HA	AGS_Conv Mono	Unit		2	57.1
EP_6%	AGS_Conv Mono	Unit		2	56
EP_4%	LRT	Single		2	50.2
EP_4%	LRT	Double		2	50.2
DP_4%	LRT	Single		3	48.7
DP_4%	LRT	Double		3	48.7
EP_HA	LRT	Single		3	48.6
EP_HA	LRT	Double		3	48.6
EP_6%	LRT	Single		3	48.4
EP_6%	LRT	Double		3	48.4
EP_4%	HRT	Single		3	47.2
EP_4%	HRT	Double		3	47.2
DP_HA	LRT	Single		3	46.1
DP_HA	LRT	Double		3	46.1
DP_6%	LRT	Single		3	45.8
DP_6%	LRT	Double		3	45.8
EP_4%	MUP	Single		3	45.7
EP_4%	MUP	Double		3	45.7
EP_6%	HRT	Single		3	44.6
EP_6%	HRT	Double		3	44.6
EP_6%	MUP	Single		3	42.8
EP_6%	MUP	Double		3	42.8
DP_4%	HRT	Single		4	36.4
DP_4%	HRT	Double		4	36.4
DP_6%	HRT	Single		4	33.3
DP_6%	HRT	Double		5	33.3
DP_Glenwood	PRR_Moffat			5	28.7
DP_Winter Park	PRR_Moffat			5	23.2

	Alternatives	Number of trains each direction	Number of cars per train	Car trips operated	Seats per car	Round trip miles	seat miles	Annual Fuel cost ($0.10 per kwh or $1.60 per gal)	Cost per seat mile
15a	**Electric Conv. Monorail, double guideway-4%**	40940	10	409400	26	228	2,426,923,200	$ 12,078,338	$ 0.005
15c	**Electric Conv. Monorail AGS, double guideway-Hwy**	40940	10	409400	26	226	2,405,634,400	$ 12,058,836	$ 0.005
15b	**Electric Conv. Monorail AGS, double guideway-6%**	40940	10	409400	26	226	2,405,634,400	$ 12,513,886	$ 0.005
14a	**Electric Multiple Unit Passenger RR, double track-4%**	15755	10	157550	73	228	2,622,262,200	$ 14,758,649	$ 0.006
16	**CIFGA Monorail (Highway only)**	28904.2	20	578084	20	226	2,612,939,680	$ 14,894,897	$ 0.006
4a	**Electric Light Rail Transit, double track-4%**	31510	4	126040	55	228	1,580,541,600	$ 9,121,891	$ 0.006
14b	**Electric Multiple Unit Passenger RR, double track-6%**	15755	10	157550	73	226	2,599,259,900	$ 15,491,703	$ 0.006
8a	**Electric Heavy Rail Transit, double track-4%**	15755	14	220570	50	228	2,514,498,000	$ 15,634,311	$ 0.006
13a	**Electric Multiple Unit Passenger RR, single track-4%**	15755	10	157550	73	228	2,622,262,200	$ 16,324,067	$ 0.006
3a	**Electric Light Rail Transit, single track-4%**	15755	4	63020	55	228	790,270,800	$ 5,044,715	$ 0.006
4c	**Electric Light Rail Transit, double track-Hwy**	31510	4	126040	55	226	1,566,677,200	$ 10,022,571	$ 0.006
4b	**Electric Light Rail Transit, double track-6%**	31510	4	126040	55	226	1,566,677,200	$ 10,147,666	$ 0.006
13b	**Electric Multiple Unit Passenger RR, single track-6%**	15755	10	157550	73	226	2,599,259,900	$ 17,134,874	$ 0.007
8b	**Electric Heavy Rail Transit, double track-6%**	15755	14	220570	50	226	2,492,441,000	$ 17,117,931	$ 0.007
7a	**Electric Heavy Rail Transit, single track-4%**	15755	14	220570	50	228	2,514,498,000	$ 17,292,608	$ 0.007
1a	**Diesel Light Rail Transit, single track-4%**	15755	4	63020	59	228	847,745,040	$ 5,907,840	$ 0.007
2a	**Diesel Light Rail Transit, double track-4%**	31510	4	126040	59	228	1,695,490,080	$ 11,815,680	$ 0.007
3c	**Electric Light Rail Transit, single track-Hwy**	15755	4	63020	55	226	783,338,600	$ 5,542,822	$ 0.007
3b	**Electric Light Rail Transit, single track-6%**	15755	4	63020	55	226	783,338,600	$ 5,612,003	$ 0.007
7b	**Electric Heavy Rail Transit, single track-6%**	15755	14	220570	50	226	2,492,441,000	$ 18,933,593	$ 0.008
1c	**Diesel Light Rail Transit, single track-Hwy**	15755	4	63020	59	226	840,308,680	$ 6,498,624	$ 0.008
2c	**Diesel Light Rail Transit, double track-Hwy**	31510	4	126040	59	226	1,680,617,360	$ 12,997,248	$ 0.008
1b	**Diesel Light Rail Transit, single track-6%**	15755	4	63020	59	226	840,308,680	$ 6,547,856	$ 0.008
2b	**Diesel Light Rail Transit, double track-6%**	31510	4	126040	59	226	1,680,617,360	$ 13,095,712	$ 0.008
5a	**Diesel Heavy Rail Transit, single track-4%**	15755	12	189060	60	228	2,586,340,800	$ 23,188,272	$ 0.009
6a	**Diesel Heavy Rail Transit, double track-4%**	15755	12	189060	60	228	2,586,340,800	$ 23,188,272	$ 0.009
5b	**Diesel Heavy Rail Transit, single track-6%**	15755	12	189060	60	226	2,563,653,600	$ 24,960,624	$ 0.010
6b	**Diesel Heavy Rail Transit, double track-6%**	15755	12	189060	60	226	2,563,653,600	$ 24,960,624	$ 0.010
17	**Moffat Tunnel to Winter Pk. Diesel Loco. hauled Psgr RR**	100	6	600	140	134	11,256,000	$ 320,000	$ 0.028
18	**Moffat Tunnel to Glenwood Diesel Loco. hauled Psgr RR**	100	6	600	140	268	22,512,000	$ 640,000	$ 0.028

8a	Electric Heavy Rail Transit, double track-4%	Normal days (265)	37	14	518	118,104	$ 2.68	NA	NA	NA	6249	5,437	213	3	640	$ 16.00	$ 316,519	NA	$ 40,231	$ 10,242		
		Peak Days (75)	51	14	714	162,792	$ 2.68	NA	NA	NA	6249	4,874	294	3	882	$ 16.00	$ 436,283	NA	$ 49,717	$ 14,117		
		Holiday Peak Days (25)	85	14	1190	271,320	$ 2.68	NA	NA	NA	6249	3,874	490	3	1471	$ 16.00	$ 727,138	NA	$ 65,864	$ 23,528		
		Annual	15755	14	220570	50,289,960	$ 2.68	NA	NA	NA	6249		90854	3	272562	$ 16.00	$ 134,777,093	NA	$ 15,634,311	$ 4,360,984	$ 2,856,000	157,628,387
8b	Electric Heavy Rail Transit, double track-6%	Normal days (265)	37	14	518	117,068	$ 2.68	NA	NA	NA	6842	5,953	213	3	640	$ 16.00	$ 313,742	NA	$ 44,049	$ 10,242		
		Peak Days (75)	51	14	714	161,364	$ 2.68	NA	NA	NA	6842	5,337	294	3	882	$ 16.00	$ 432,456	NA	$ 54,435	$ 14,117		
		Holiday Peak Days (25)	85	14	1190	268,940	$ 2.68	NA	NA	NA	6842	4,242	490	3	1471	$ 16.00	$ 720,759	NA	$ 72,115	$ 23,528		
		Annual	15755	14	220570	49,848,820	$ 2.68	NA	NA	NA	6842		90854	3	272562	$ 16.00	$ 133,594,838	NA	$ 17,117,931	$ 4,360,984	$ 2,856,000	157,929,753
9a	Diesel Loco. hauled Passenger RR,	stalled																				
	single track-4%																					
9b	Diesel Loco. hauled Passenger RR,	stalled																				
	single track-6%																					
10a	Diesel Loco. hauled Passenger RR,	stalled																				
	double track-4%																					
10b	Diesel Loco. hauled Passenger RR,	stalled																				
	double track-6%																					
11a	Electric Loco. hauled Passenger RR,	stalled																				
	single track-4%																					
11b	Electric Loco. hauled Passenger RR,	stalled																				
	single track-6%																					
12a	Electric Loco. hauled Passenger RR,	stalled																				
	double track-4%																					
12b	Electric Loco. hauled Passenger RR,	stalled																				
	double track-6%																					
13a	Electric Multiple Unit Passenger RR,	Normal days (265)	37	10	370	83,620	$ 4.72	NA	NA	NA	5899	5,486	218	3	653	$ 16.00	$ 394,686	NA	$ 40,597	$ 10,449		
	single track-4%	Peak Days (75)	51	10	510	115,260	$ 4.72	NA	NA	NA	5899	5,250	300	3	900	$ 16.00	$ 544,027	NA	$ 53,551	$ 14,402		
		Holiday Peak Days (25)	85	10	850	192,100	$ 4.72	NA	NA	NA	5899	4,601	500	3	1500	$ 16.00	$ 906,712	NA	$ 78,221	$ 24,004		
		Annual	15755	10	157550	35,606,300	$ 4.72	NA	NA	NA	5899		92692	3	278076	$ 16.00	$ 168,061,736	NA	$ 16,324,067	$ 4,449,212	$ 2,856,000	191,691,015
13b	Electric Multiple Unit Passenger RR,	Normal days (265)	37	10	370	83,620	$ 4.72	NA	NA	NA	6192	5,759	220	3	660	$ 16.00	$ 394,686	NA	$ 42,613	$ 10,567		
	single track-6%	Peak Days (75)	51	10	510	115,260	$ 4.72	NA	NA	NA	6192	5,511	303	3	910	$ 16.00	$ 544,027	NA	$ 56,211	$ 14,566		
		Holiday Peak Days (25)	85	10	850	192,100	$ 4.72	NA	NA	NA	6192	4,830	506	3	1517	$ 16.00	$ 906,712	NA	$ 82,106	$ 24,276		
		Annual	15755	10	157550	35,606,300	$ 4.72	NA	NA	NA	6192		93742	3	281227	$ 16.00	$ 168,061,736	NA	$ 17,134,874	$ 4,499,628	$ 2,856,000	192,552,238
14a	Electric Multiple Unit Passenger RR,	Normal days (265)	37	10	370	83,620	$ 4.72	NA	NA	NA	5899	5,132	218	3	653	$ 16.00	$ 394,686	NA	$ 37,978	$ 10,449		
	double track-4%	Peak Days (75)	51	10	510	115,260	$ 4.72	NA	NA	NA	5899	4,601	300	3	900	$ 16.00	$ 544,027	NA	$ 46,932	$ 14,402		
		Holiday Peak Days (25)	85	10	850	192,100	$ 4.72	NA	NA	NA	5899	3,657	500	3	1500	$ 16.00	$ 906,712	NA	$ 62,175	$ 24,004		
		Annual	15755	10	157550	35,606,300	$ 4.72	NA	NA	NA	5899		92692	3	278076	$ 16.00	$ 168,061,736	NA	$ 14,758,649	$ 4,449,212	$ 2,856,000	190,125,597
14b	Electric Multiple Unit Passenger RR,	Normal days (265)	37	10	370	83,620	$ 4.72	NA	NA	NA	6192	5,387	220	3	660	$ 16.00	$ 394,686	NA	$ 39,864	$ 10,567		
	double track-6%	Peak Days (75)	51	10	510	115,260	$ 4.72	NA	NA	NA	6192	4,830	303	3	910	$ 16.00	$ 544,027	NA	$ 49,264	$ 14,566		
		Holiday Peak Days (25)	85	10	850	192,100	$ 4.72	NA	NA	NA	6192	3,839	506	3	1517	$ 16.00	$ 906,712	NA	$ 65,264	$ 24,276		
		Annual	15755	10	157550	35,606,300	$ 4.72	NA	NA	NA	6192		93742	3	281227	$ 16.00	$ 168,061,736	NA	$ 15,491,703	$ 4,499,628	$ 2,856,000	190,909,067
15a	Electric Conv. Monorail, double guideway-4%	Normal days (265)	96	10	960	216,960	$2.00	NA	NA	NA	1858	1,616	269	2	538	$ 16.00	$ 433,920	NA	$ 31,036	$ 8,608		
		Peak Days (75)	133	10	1330	300,580	$2.00	NA	NA	NA	1858	1,449	269	2	538	$ 16.00	$ 601,160	NA	$ 38,550	$ 8,608		
		Holiday Peak Days (25)	221	10	2210	499,460	$2.00	NA	NA	NA	1858	1,152	269	2	538	$ 16.00	$ 998,920	NA	$ 50,917	$ 8,608		
		Annual	40940	10	409400	92,524,400	$2.00	NA	NA	NA	1,858		269	2	538	$ 16.00	$ 185,048,800	NA	$ 12,078,338	$ 8,608	$ 2,856,000	199,991,746
15b	Electric Conv. Monorail AGS, double guideway-6%	Normal days (265)	96	10	960	216,960	$2.00	NA	NA	NA	1925	1,675	269	2	538	$ 16.00	$ 433,920	NA	$ 32,155	$ 8,608		
		Peak Days (75)	133	10	1330	300,580	$2.00	NA	NA	NA	1925	1,502	269	2	538	$ 16.00	$ 601,160	NA	$ 39,940	$ 8,608		
		Holiday Peak Days (25)	221	10	2210	499,460	$2.00	NA	NA	NA	1925	1,194	269	2	538	$ 16.00	$ 998,920	NA	$ 52,753	$ 8,608		
		Annual	40940	10	409400	92,524,400	$2.00	NA	NA	NA	1925		269	2	538	$ 16.00	$ 185,048,800	NA	$ 12,513,886	$ 8,608	$ 2,856,000	200,427,294
15c	Electric Conv. Monorail AGS, double guideway-Hwy	Normal days (265)	96	10	960	216,960	$2.00	NA	NA	NA	1855	1,614	273	2	546	$ 16.00	$ 433,920	NA	$ 30,986	$ 8,736		
		Peak Days (75)	133	10	1330	300,580	$2.00	NA	NA	NA	1855	1,447	273	2	546	$ 16.00	$ 601,160	NA	$ 38,488	$ 8,736		
		Holiday Peak Days (25)	221	10	2210	499,460	$2.00	NA	NA	NA	1855	1,150	273	2	546	$ 16.00	$ 998,920	NA	$ 50,834	$ 8,736		
		Annual	40940	10	409400	92,524,400	$2.00	NA	NA	NA	1855		273	2	546	$ 16.00	$ 185,048,800	NA	$ 12,058,836	$ 8,736	$ 2,856,000	199,972,372
16	CIFGA Monorail (Highway only)	Normal days (265)	68	20	1920	433,920	$2.00	NA	NA	NA	3243	2,821	269	3	807	$ 16.00	$ 867,840	NA	$ 38,416	$ 12,912		
		Peak Days (75)	94	20	2660	601,160	$2.00	NA	NA	NA	3243	2,530	269	3	807	$ 16.00	$ 1,202,320	NA	$ 47,474	$ 12,912		
		Holiday Peak Days (25)	153	20	3060	691,560	$2.00	NA	NA	NA	3243	2,011	269	3	807	$ 16.00	$ 1,383,120	NA	$ 61,526	$ 12,912		
		Annual	28904	20	578084	130,646,984	$2.00	NA	NA	NA	3243		269	3	807	$ 16.00	$ 261,293,968	NA	$ 14,894,897	$ 12,912	$ 2,856,000	279,057,777
17	Moffat Tunnel to Winter Pk.	Normal days (265)	0	0	0	-																
	Diesel Loco. hauled Psgr RR	Peak Days (75)	1	6	6	804	$ 3.00	2	268	$ 7.00	1000	1,000	5	3	15	$ 16.00	$ 2,412	$ 1,876	$ 3,200	$ 240		
	(from DUT)	Holiday Peak Days (25)	1	6	6	804	$ 3.00	2	268	$ 7.00	1000	1,000	5	3	15	$ 16.00	$ 2,412	$ 1,876	$ 3,200	$ 240		
		Annual	100	6	600	80,400	$ 3.00	200	26800	$ 7.00	1000		500	3	1500	$ 16.00	$ 241,200	$ 187,600	$ 320,000	$ 24,000		772,800
18	Moffat Tunnel to Glenwood	Normal days (265)	0	0	0	-																
	Diesel Loco. hauled Psgr RR	Peak Days (75)	1	6	6	1,608	$ 3.00	2	536	$ 7.00	2000	2,000	10	3	30	$ 16.00	$ 4,824	$ 3,752	$ 6,400	$ 480		
	(from DUT)	Holiday Peak Days (25)	1	6	6	1,608	$ 3.00	2	536	$ 7.00	2000	2,000	10	3	30	$ 16.00	$ 4,824	$ 3,752	$ 6,400	$ 480		
		Annual	100	6	600	160,800	$ 3.00	200	53600	$ 7.00	2000		1000	3	3000	$ 16.00	$ 482,400	$ 375,200	$ 640,000	$ 48,000		1,545,600

I-70 PEIS Secondary Screening - FGT operating costs
Operating Costs

	Alternatives		Number of trains each direction	Number of cars per train	Car trips operated	Car miles operated	Cost per car mile (w/o fuel)	Loco. trips operated	Loco. miles operated	Cost per loco mile (w/o fuel)	Fuel (kwh or gal) consumed per trip	Fuel (kwh or gal) consumed per trip adjusted for regen. Braking	Train hours per day/year	Crew size	Crew hours	Cost per crew person hour	Total car mile cost (w/o fuel)	Total loco mile cost (w/o fuel)	Fuel cost ($0.10 per kwh or $1.60 per gal)	Total Crew cost	Other staff (station, fare inspection, dispatch, mgmt)	Total Operating costs
1a	Diesel Light Rail Transit, single track-4%	Per Normal day (265)	37	4	148	33,744	$ 3.00	NA	NA	NA	120	120	208	5	1042	$ 16.00	$ 101,232	NA	$ 14,208	$ 16,675		
		Per Peak Day (75)	51	4	204	46,512	$ 3.00	NA	NA	NA	120	120	287	5	1437	$ 16.00	$ 139,536	NA	$ 19,584	$ 22,984		
		Per Holiday Peak Day (25)	85	4	340	77,520	$ 3.00	NA	NA	NA	120	120	479	5	2394	$ 16.00	$ 232,560	NA	$ 32,640	$ 38,307		
		Annual	15755	4	63020	14,368,560	$ 3.00	NA	NA	NA	120		88753	5	443766	$ 16.00	$ 43,105,680	NA	$ 5,907,840	$ 7,100,253	$ 2,285,000	58,398,773
1b	Diesel Light Rail Transit, single track-6%	Per Normal day (265)	37	4	148	33,448	$ 3.00	NA	NA	NA	133	133	210	5	1048	$ 16.00	$ 100,344	NA	$ 15,747	$ 16,773		
		Per Peak Day (75)	51	4	204	46,104	$ 3.00	NA	NA	NA	133	133	289	5	1445	$ 16.00	$ 138,312	NA	$ 21,706	$ 23,120		
		Per Holiday Peak Day (25)	85	4	340	76,840	$ 3.00	NA	NA	NA	133	133	482	5	2408	$ 16.00	$ 230,520	NA	$ 36,176	$ 38,533		
		Annual	15755	4	63020	14,242,520	$ 3.00	NA	NA	NA	133		89278	5	446392	$ 16.00	$ 42,727,560	NA	$ 6,547,856	$ 7,142,267	$ 2,285,000	58,702,683
1c	Diesel Light Rail Transit, single track-Hwy	Per Normal day (265)	37	4	148	33,448	$ 3.00	NA	NA	NA	132	132	208	5	1042	$ 16.00	$ 100,344	NA	$ 15,629	$ 16,675		
		Per Peak Day (75)	51	4	204	46,104	$ 3.00	NA	NA	NA	132	132	287	5	1437	$ 16.00	$ 138,312	NA	$ 21,542	$ 22,984		
		Per Holiday Peak Day (25)	85	4	340	76,840	$ 3.00	NA	NA	NA	132	132	479	5	2394	$ 16.00	$ 230,520	NA	$ 35,904	$ 38,307		
		Annual	15755	4	63020	14,242,520	$ 3.00	NA	NA	NA	132		88753	5	443766	$ 16.00	$ 42,727,560	NA	$ 6,498,624	$ 7,100,253	$ 2,285,000	58,611,437
2a	Diesel Light Rail Transit, double track-4%	Per Normal day (265)	74	4	296	67,488	$ 3.00	NA	NA	NA	120	120	417	5	2084	$ 16.00	$ 202,464	NA	$ 28,416	$ 33,349		
		Per Peak Day (75)	102	4	408	93,024	$ 3.00	NA	NA	NA	120	120	575	5	2873	$ 16.00	$ 279,072	NA	$ 39,168	$ 45,968		
		Per Holiday Peak Day (25)	170	4	680	155,040	$ 3.00	NA	NA	NA	120	120	958	5	4788	$ 16.00	$ 465,120	NA	$ 65,280	$ 76,613		
		Annual	31510	4	126040	28,737,120	$ 3.00	NA	NA	NA	120		177506	5	887532	$ 16.00	$ 86,211,360	NA	$ 11,815,680	$ 14,200,507	$ 2,285,000	114,512,547
2b	Diesel Light Rail Transit, double track-6%	Per Normal day (265)	74	4	296	66,896	$ 3.00	NA	NA	NA	133	133	419	5	2097	$ 16.00	$ 200,688	NA	$ 31,494	$ 33,547		
		Per Peak Day (75)	102	4	408	92,208	$ 3.00	NA	NA	NA	133	133	578	5	2890	$ 16.00	$ 276,624	NA	$ 43,411	$ 46,240		
		Per Holiday Peak Day (25)	170	4	680	153,680	$ 3.00	NA	NA	NA	133	133	963	5	4817	$ 16.00	$ 461,040	NA	$ 72,352	$ 77,067		
		Annual	31510	4	126040	28,485,040	$ 3.00	NA	NA	NA	133		178557	5	892783	$ 16.00	$ 85,455,120	NA	$ 13,095,712	$ 14,284,533	$ 2,285,000	115,120,365
2c	Diesel Light Rail Transit, double track-Hwy	Per Normal day (265)	74	4	296	66,896	$ 3.00	NA	NA	NA	132	132	417	5	2084	$ 16.00	$ 200,688	NA	$ 31,258	$ 33,349		
		Per Peak Day (75)	102	4	408	92,208	$ 3.00	NA	NA	NA	132	132	575	5	2873	$ 16.00	$ 276,624	NA	$ 43,085	$ 45,968		
		Per Holiday Peak Day (25)	170	4	680	153,680	$ 3.00	NA	NA	NA	132	132	958	5	4788	$ 16.00	$ 461,040	NA	$ 71,808	$ 76,613		
		Annual	31510	4	126040	28,485,040	$ 3.00	NA	NA	NA	132		177506	5	887532	$ 16.00	$ 85,455,120	NA	$ 12,997,248	$ 14,200,507	$ 2,285,000	114,937,875
3a	Electric Light Rail Transit, single track-4%	Per Normal day (265)	37	4	148	33,448	$ 2.68	NA	NA	NA	1823	1,695	204	5	1021	$ 16.00	$ 89,641	NA	$ 12,546	$ 16,329		
		Per Peak Day (75)	51	4	204	46,104	$ 2.68	NA	NA	NA	1823	1,622	281	5	1407	$ 16.00	$ 123,559	NA	$ 16,549	$ 22,508		
		Per Holiday Peak Day (25)	85	4	340	76,840	$ 2.68	NA	NA	NA	1823	1,422	469	5	2345	$ 16.00	$ 205,931	NA	$ 24,173	$ 37,513		
		Annual	15755	4	63020	14,242,520	$ 2.68	NA	NA	NA	1823		86915	5	434575	$ 16.00	$ 38,169,954	NA	$ 5,044,715	$ 6,953,207	$ 2,856,000	53,023,875
3b	Electric Light Rail Transit, single track-6%	Per Normal day (265)	37	4	148	33,448	$ 2.68	NA	NA	NA	2028	1,886	202	5	1008	$ 16.00	$ 89,641	NA	$ 13,957	$ 16,132		
		Per Peak Day (75)	51	4	204	46,104	$ 2.68	NA	NA	NA	2028	1,805	278	5	1390	$ 16.00	$ 123,559	NA	$ 18,410	$ 22,236		
		Per Holiday Peak Day (25)	85	4	340	76,840	$ 2.68	NA	NA	NA	2028	1,582	463	5	2316	$ 16.00	$ 205,931	NA	$ 26,891	$ 37,060		
		Annual	15755	4	63020	14,242,520	$ 2.68	NA	NA	NA	2028		85865	5	429324	$ 16.00	$ 38,169,954	NA	$ 5,612,003	$ 6,869,180	$ 2,856,000	53,507,137
3c	Electric Light Rail Transit, single track-Hwy	Per Normal day (265)	37	4	148	33,448	$ 2.68	NA	NA	NA	2003	1,863	202	5	1008	$ 16.00	$ 89,641	NA	$ 13,785	$ 16,132		
		Per Peak Day (75)	51	4	204	46,104	$ 2.68	NA	NA	NA	2003	1,783	278	5	1390	$ 16.00	$ 123,559	NA	$ 18,183	$ 22,236		
		Per Holiday Peak Day (25)	85	4	340	76,840	$ 2.68	NA	NA	NA	2003	1,562	463	5	2316	$ 16.00	$ 205,931	NA	$ 26,560	$ 37,060		
		Annual	15755	4	63020	14,242,520	$ 2.68	NA	NA	NA	2003		85865	5	429324	$ 16.00	$ 38,169,954	NA	$ 5,542,822	$ 6,869,180	$ 2,856,000	53,437,955
4a	Electric Light Rail Transit, double track-4%	Per Normal day (265)	74	4	296	66,896	$ 2.68	NA	NA	NA	1823	1,586	408	5	2041	$ 16.00	$ 179,281	NA	$ 23,473	$ 32,659		
		Per Peak Day (75)	102	4	408	92,208	$ 2.68	NA	NA	NA	1823	1,422	563	5	2814	$ 16.00	$ 247,117	NA	$ 29,008	$ 45,016		
		Per Holiday Peak Day (25)	170	4	680	153,680	$ 2.68	NA	NA	NA	1823	1,130	938	5	4689	$ 16.00	$ 411,862	NA	$ 38,429	$ 75,027		
		Annual	31510	4	126040	28,485,040	$ 2.68	NA	NA	NA	1823		173830	5	869151	$ 16.00	$ 76,339,907	NA	$ 9,121,891	$ 13,906,413	$ 2,856,000	102,224,211
4b	Electric Light Rail Transit, double track-6%	Per Normal day (265)	74	4	296	66,896	$ 2.68	NA	NA	NA	2028	1,764	403	5	2017	$ 16.00	$ 179,281	NA	$ 26,113	$ 32,264		
		Per Peak Day (75)	102	4	408	92,208	$ 2.68	NA	NA	NA	2028	1,582	556	5	2780	$ 16.00	$ 247,117	NA	$ 32,270	$ 44,472		
		Per Holiday Peak Day (25)	170	4	680	153,680	$ 2.68	NA	NA	NA	2028	1,257	927	5	4633	$ 16.00	$ 411,862	NA	$ 42,750	$ 74,120		
		Annual	31510	4	126040	28,485,040	$ 2.68	NA	NA	NA	2028		171730	5	858648	$ 16.00	$ 76,339,907	NA	$ 10,147,666	$ 13,738,360	$ 2,856,000	103,081,933
4c	Electric Light Rail Transit, double track-Hwy	Per Normal day (265)	74	4	296	66,896	$ 2.68	NA	NA	NA	2003	1,743	403	5	2017	$ 16.00	$ 179,281	NA	$ 25,791	$ 32,264		
		Per Peak Day (75)	102	4	408	92,208	$ 2.68	NA	NA	NA	2003	1,562	556	5	2780	$ 16.00	$ 247,117	NA	$ 31,872	$ 44,472		
		Per Holiday Peak Day (25)	170	4	680	153,680	$ 2.68	NA	NA	NA	2003	1,242	927	5	4633	$ 16.00	$ 411,862	NA	$ 42,223	$ 74,120		
		Annual	31510	4	126040	28,485,040	$ 2.68	NA	NA	NA	2003		171730	5	858648	$ 16.00	$ 76,339,907	NA	$ 10,022,571	$ 13,738,360	$ 2,856,000	102,956,839
5a	Diesel Heavy Rail Transit, single track-4%	Normal days (265)	37	12	444	101,232	$ 4.00	NA	NA	NA	471	471	258	3	775	$ 16.00	$ 404,928	NA	$ 55,766	$ 12,402		
		Peak Days (75)	51	12	612	139,536	$ 4.00	NA	NA	NA	471	471	356	3	1068	$ 16.00	$ 558,144	NA	$ 76,867	$ 17,095		
		Holiday Peak Days (25)	85	12	1020	232,560	$ 4.00	NA	NA	NA	471	471	594	3	1781	$ 16.00	$ 930,240	NA	$ 128,112	$ 28,492		
		Annual	15755	12	189060	43,105,680	$ 4.00	NA	NA	NA	471		110022	3	330067	$ 16.00	$ 172,422,720	NA	$ 23,188,272	$ 5,281,076	$ 2,856,000	203,748,068
5b	Diesel Heavy Rail Transit, single track-6%	Normal days (265)	37	12	444	100,344	$ 4.00	NA	NA	NA	507	507	266	3	799	$ 16.00	$ 401,376	NA	$ 60,029	$ 12,787		
		Peak Days (75)	51	12	612	138,312	$ 4.00	NA	NA	NA	507	507	367	3	1102	$ 16.00	$ 553,248	NA	$ 82,742	$ 17,626		
		Holiday Peak Days (25)	85	12	1020	230,520	$ 4.00	NA	NA	NA	507	507	612	3	1836	$ 16.00	$ 922,080	NA	$ 137,904	$ 29,376		
		Annual	15755	12	189060	42,727,560	$ 4.00	NA	NA	NA	507		113436	3	340308	$ 16.00	$ 170,910,240	NA	$ 24,960,624	$ 5,444,928	$ 2,856,000	204,171,792
6a	Diesel Heavy Rail Transit, double track-4%	Normal days (265)	37	12	444	100,344	$ 4.00	NA	NA	NA	471	471	258	3	775	$ 16.00	$ 401,376	NA	$ 55,766	$ 12,402		
		Peak Days (75)	51	12	612	138,312	$ 4.00	NA	NA	NA	471	471	356	3	1068	$ 16.00	$ 553,248	NA	$ 76,867	$ 17,095		
		Holiday Peak Days (25)	85	12	1020	230,520	$ 4.00	NA	NA	NA	471	471	594	3	1781	$ 16.00	$ 922,080	NA	$ 128,112	$ 28,492		
		Annual	15755	12	189060	42,727,560	$ 4.00	NA	NA	NA	471		110022	3	330067	$ 16.00	$ 170,910,240	NA	$ 23,188,272	$ 5,281,076	$ 2,856,000	202,235,588
6b	Diesel Heavy Rail Transit, double track-6%	Normal days (265)	37	12	444	100,344	$ 4.00	NA	NA	NA	507	507	266	3	799	$ 16.00	$ 401,376	NA	$ 60,029	$ 12,787		
		Peak Days (75)	51	12	612	138,312	$ 4.00	NA	NA	NA	507	507	367	3	1102	$ 16.00	$ 553,248	NA	$ 82,742	$ 17,626		
		Holiday Peak Days (25)	85	12	1020	230,520	$ 4.00	NA	NA	NA	507	507	612	3	1836	$ 16.00	$ 922,080	NA	$ 137,904	$ 29,376		
		Annual	15755	12	189060	42,727,560	$ 4.00	NA	NA	NA	507		113436	3	340308	$ 16.00	$ 170,910,240	NA	$ 24,960,624	$ 5,444,928	$ 2,856,000	204,171,792
7a	Electric Heavy Rail Transit, single track-4%	Normal days (265)	37	14	518	118,104	$ 2.68	NA	NA	NA	6249	5,812	213	3	640	$ 16.00	$ 316,519	NA	$ 43,006	$ 10,242		
		Peak Days (75)	51	14	714	162,792	$ 2.68	NA	NA	NA	6249	5,562	294	3	882	$ 16.00	$ 436,283	NA	$ 56,728	$ 14,117		
		Holiday Peak Days (25)	85	14	1190	271,320	$ 2.68	NA	NA	NA	6249	4,874	490	3	1471	$ 16.00	$ 727,138	NA	$ 82,862	$ 23,528		
		Annual	15755	14	220570	50,289,960	$ 2.68	NA	NA	NA	6249		90854	3	272562	$ 16.00	$ 134,777,093	NA	$ 17,292,608	$ 4,360,984	$ 2,856,000	159,286,685
7b	Electric Heavy Rail Transit, single track-6%	Normal days (265)	37	14	518	117,068	$ 2.68	NA	NA	NA	6842	6,363	213	3	640	$ 16.00	$ 313,742	NA	$ 47,087	$ 10,242		
		Peak Days (75)	51	14	714	161,364	$ 2.68	NA	NA	NA	6842	6,089	294	3	882	$ 16.00	$ 432,456	NA	$ 62,112	$ 14,117		
		Holiday Peak Days (25)	85	14	1190	268,940	$ 2.68	NA	NA	NA	6842	5,337	490	3	1471	$ 16.00	$ 720,759	NA	$ 90,725	$ 23,528		
		Annual	15755	14	220570	49,848,820	$ 2.68	NA	NA	NA	6842		90854	3	272562	$ 16.00	$ 133,594,838	NA	$ 18,933,593	$ 4,360,984	$ 2,856,000	159,745,415

I-70 PEIS Secondary Screening - FGT operating costs

Total Costs

		Annual		50 year total													Total cost	
		Operating cost	Track & Structure maintenance cost	Operating cost	Track & Structure maintenance cost	Number of cars	Cost per car	est. life (years)	Number of Locos	Cost per Loco	est. life (years)	50 year rolling stock cost	Rolling stock maint. Facilities	Track, Structure & Signal Construction cost	Electrification construction cost	Total Capital costs	50 Years	Annualized
1a	Diesel Light Rail Transit, single track-4%	$ 58,398,773	$14,448,510	$ 2,919,938,667	$722,425,500	135	$ 3,000,000	30	NA	NA	NA	$ 675,100,000	$108,016,000	$1,300,000,000	NA	$ 2,083,116,000	$ 5,003,054,667	$ 100,061,093
1b	Diesel Light Rail Transit, single track-6%	$ 58,702,683	$13,743,300	$ 2,935,134,133	$687,165,000	136	$ 3,000,000	30	NA	NA	NA	$ 679,400,000	$108,704,000	$530,000,000	NA	$ 1,318,104,000	$ 4,253,238,133	$ 85,064,763
1c	Diesel Light Rail Transit, single track-Hwy	$ 58,611,437	$13,746,450	$ 2,930,571,867	$687,322,500	135	$ 3,000,000	30	NA	NA	NA	$ 675,100,000	$108,016,000	$470,000,000	NA	$ 1,253,116,000	$ 4,183,687,867	$ 83,673,757
2a	Diesel Light Rail Transit, double track-4%	$ 114,512,547	$24,743,610	$ 5,725,627,333	$1,237,180,500	270	$ 3,000,000	30	NA	NA	NA	$ 1,350,200,000	$216,032,000	$2,340,000,000	NA	$ 3,906,232,000	$ 9,631,859,333	$ 192,637,187
2b	Diesel Light Rail Transit, double track-6%	$ 115,120,365	$26,007,318	$ 5,756,018,267	$1,300,365,900	272	$ 3,000,000	30	NA	NA	NA	$ 1,358,800,000	$217,408,000	$840,000,000	NA	$ 2,416,208,000	$ 8,172,226,267	$ 163,444,525
2c	Diesel Light Rail Transit, double track-Hwy	$ 114,937,875	$24,743,610	$ 5,746,893,733	$1,237,180,500	270	$ 3,000,000	30	NA	NA	NA	$ 1,350,200,000	$216,032,000	$740,000,000	NA	$ 2,306,232,000	$ 8,053,125,733	$ 161,062,515
3a	Electric Light Rail Transit, single track-4%	$ 53,023,875	$19,264,680	$ 2,651,193,762	$963,234,000	132	$ 2,600,000	40	NA	NA	NA	$ 430,430,000	$105,952,000	$1,300,000,000	$ 210,000,000	$ 2,046,382,000	$ 4,697,575,762	$ 93,951,515
3b	Electric Light Rail Transit, single track-6%	$ 53,507,137	$18,324,400	$ 2,675,356,844	$916,220,000	131	$ 2,600,000	40	NA	NA	NA	$ 424,840,000	$104,576,000	$530,000,000	$ 210,000,000	$ 1,269,416,000	$ 3,944,772,844	$ 78,895,457
3c	Electric Light Rail Transit, single track-Hwy	$ 53,437,955	$18,328,600	$ 2,671,897,769	$916,430,000	131	$ 2,600,000	40	NA	NA	NA	$ 424,840,000	$104,576,000	$470,000,000	$ 210,000,000	$ 1,209,416,000	$ 3,881,313,769	$ 77,626,275
4a	Electric Light Rail Transit, double track-4%	$ 102,224,211	$32,991,480	$ 5,111,210,574	$1,649,574,000	265	$ 2,600,000	40	NA	NA	NA	$ 860,860,000	$211,904,000	$2,340,000,000	$ 400,000,000	$ 3,812,764,000	$ 8,923,974,574	$ 178,479,491
4b	Electric Light Rail Transit, double track-6%	$ 103,081,933	$32,983,920	$ 5,154,096,652	$1,649,196,000	261	$ 2,600,000	40	NA	NA	NA	$ 849,680,000	$209,152,000	$840,000,000	$ 400,000,000	$ 2,298,832,000	$ 7,452,928,652	$ 149,058,573
4c	Electric Light Rail Transit, double track-Hwy	$ 102,956,839	$32,991,480	$ 5,147,841,927	$1,649,574,000	261	$ 2,600,000	40	NA	NA	NA	$ 849,680,000	$209,152,000	$740,000,000	$ 400,000,000	$ 2,198,832,000	$ 7,346,673,927	$ 146,933,479
5a	Diesel Heavy Rail Transit, single track-4%	$ 203,748,068	$14,448,510	$ 10,187,403,400	$722,425,500	503	$ 3,000,000	30	NA	NA	NA	$ 2,515,500,000	$402,480,000	$1,300,000,000	NA	$ 4,217,980,000	$ 14,405,383,400	$ 288,107,668
5b	Diesel Heavy Rail Transit, single track-6%	$ 204,171,792	$13,743,300	$ 10,208,589,600	$687,165,000	519	$ 3,000,000	30	NA	NA	NA	$ 2,592,900,000	$414,864,000	$530,000,000	NA	$ 3,537,764,000	$ 13,746,353,600	$ 274,927,072
6a	Diesel Heavy Rail Transit, double track-4%	$ 202,235,588	$26,007,318	$ 10,111,779,400	$1,300,365,900	503	$ 3,000,000	30	NA	NA	NA	$ 2,515,500,000	$402,480,000	$2,340,000,000	NA	$ 5,257,980,000	$ 15,369,759,400	$ 307,395,188
6b	Diesel Heavy Rail Transit, double track-6%	$ 204,171,792	$24,737,940	$ 10,208,589,600	$1,236,897,000	519	$ 3,000,000	30	NA	NA	NA	$ 2,592,900,000	$414,864,000	$840,000,000	NA	$ 3,847,764,000	$ 14,056,353,600	$ 281,127,072
7a	Electric Heavy Rail Transit, single track-4%	$ 159,286,685	$19,264,680	$ 7,964,334,227	$963,234,000	485	$ 2,600,000	40	NA	NA	NA	$ 1,574,982,500	$387,688,000	$1,300,000,000	$ 220,000,000	$ 3,482,670,500	$ 11,447,004,727	$ 228,940,095
7b	Electric Heavy Rail Transit, single track-6%	$ 159,745,415	$18,324,400	$ 7,987,270,726	$916,220,000	485	$ 2,600,000	40	NA	NA	NA	$ 1,574,982,500	$387,688,000	$530,000,000	$ 220,000,000	$ 2,712,670,500	$ 10,699,941,226	$ 213,998,825
8a	Electric Heavy Rail Transit, double track-4%	$ 157,628,387	$32,991,480	$ 7,881,419,371	$1,649,574,000	485	$ 2,600,000	40	NA	NA	NA	$ 1,574,982,500	$387,688,000	$2,340,000,000	$ 410,000,000	$ 4,712,670,500	$ 12,594,089,871	$ 251,881,797
8b	Electric Heavy Rail Transit, double track-6%	$ 157,929,753	$32,983,920	$ 7,896,487,649	$1,649,196,000	485	$ 2,600,000	40	NA	NA	NA	$ 1,574,982,500	$387,688,000	$840,000,000	$ 410,000,000	$ 3,212,670,500	$ 11,109,158,149	$ 222,183,163
9a	Diesel Loco. hauled Passenger RR, single track-4%	stalled																
9b	Diesel Loco. hauled Passenger RR, single track-6%	stalled																
10a	Diesel Loco. hauled Passenger RR, double track-4%	stalled																
10b	Diesel Loco. hauled Passenger RR, double track-6%	stalled																
11a	Electric Loco. hauled Passenger RR, single track-4%	stalled																
11b	Electric Loco. hauled Passenger RR, single track-6%	stalled																
12a	Electric Loco. hauled Passenger RR, double track-4%	stalled																
12b	Electric Loco. hauled Passenger RR, double track-6%	stalled																
13a	Electric Multiple Unit Passenger RR, single track-4%	$ 191,691,015	$19,264,680	$ 9,584,550,737	$963,234,000	353	$ 2,800,000	40	NA	NA	NA	$ 1,234,100,000	$282,080,000	$1,300,000,000	$ 220,000,000	$ 3,036,180,000	$ 12,620,730,737	$ 252,414,615
13b	Electric Multiple Unit Passenger RR, single track-6%	$ 192,552,238	$18,324,400	$ 9,627,611,896	$916,220,000	357	$ 2,800,000	40	NA	NA	NA	$ 1,249,150,000	$285,520,000	$530,000,000	$ 220,000,000	$ 2,284,670,000	$ 11,912,281,896	$ 238,245,638
14a	Electric Multiple Unit Passenger RR, double track-4%	$ 190,125,597	$34,676,424	$ 9,506,279,856	$1,733,821,200	353	$ 2,800,000	40	NA	NA	NA	$ 1,234,100,000	$282,080,000	$2,340,000,000	$ 420,000,000	$ 4,276,180,000	$ 13,782,459,856	$ 275,649,197
14b	Electric Multiple Unit Passenger RR, double track-6%	$ 190,909,067	$32,983,920	$ 9,545,453,344	$1,649,196,000	353	$ 2,800,000	40	NA	NA	NA	$ 1,234,100,000	$282,080,000	$840,000,000	$ 420,000,000	$ 2,776,180,000	$ 12,321,633,344	$ 246,432,667
15a	Electric Conv. Monorail, double guideway-4%	$ 199,991,746	$34,676,424	$ 9,999,587,288	$1,733,821,200	791	$ 1,000,000	25	NA	NA	NA	$ 1,582,400,000	$632,960,000	$1,824,306,818	$ 400,000,000	$ 4,439,666,818	$ 14,439,254,106	$ 288,785,082
15b	Electric Conv. Monorail AGS, double guideway-6%	$ 200,427,294	$32,983,920	$ 10,021,364,700	$1,649,196,000	785	$ 1,000,000	25	NA	NA	NA	$ 1,570,933,333	$628,373,333	$1,735,265,152	$ 400,000,000	$ 4,334,571,818	$ 14,355,936,518	$ 287,118,730
15c	Electric Conv. Monorail AGS, double guideway-Hwy	$ 199,972,372	$32,991,480	$ 9,998,618,580	$1,649,574,000	780	$ 1,000,000	25	NA	NA	NA	$ 1,559,466,667	$623,786,667	$1,735,662,879	$ 400,000,000	$ 4,318,916,212	$ 14,317,534,792	$ 286,350,696
16	CIFGA Monorail (Highway only)	$ 279,057,777	$34,676,424	$ 13,952,888,832	$1,733,821,200	969	$ 1,200,000	25	NA	NA	NA	$ 2,326,690,909	$775,563,636	$1,824,306,818	$ 400,000,000	$ 5,326,561,364	$ 19,279,450,195	$ 385,589,004
17	Moffat Tunnel to Winter Pk. Diesel Loco. hauled Psgr RR	$ 772,800	NA	$ 38,640,000	NA	6	$ 1,800,000	50	2	4100000	50	$ 10,800,100	$4,800,000	NA	NA	$ 15,600,100	$ 54,240,100	$ 1,084,802
18	Moffat Tunnel to Glenwood Diesel Loco. hauled Psgr RR	$ 1,545,600	NA	$ 77,280,000	NA	6	$ 1,800,000	50	2	4100000	50	$ 10,800,100	$4,800,000	NA	NA	$ 15,600,100	$ 92,880,100	$ 1,857,602

Length (in feet)		
Hwy	458215	
4%	481617	
6%	458110	
factor for double	1.8	
Maintenance costs, (per foot)		
Track & Signal	$30	
Track, Sig. & Ele	$40	
R.S. Maint. Facil., (per car)		$800,000
Fare Collection system		$5,000,000

FGT COST SUMMARY - Alignment Dependent costs

Alignment	Single Track w/ passing sidings	Double Track w/ crossovers	AGS
Highway (>6% grac	$470,000,000	$740,000,000	$ 1,735,662,879
Corridor 6% (<6% (	$530,000,000	$840,000,000	$ 1,735,265,152
4% (<4% grades pr	$1,300,000,000	$2,340,000,000	$ 1,824,306,818

AGS costs	
per mile	per foot
$ 20,000,000	$ 3,788

Sort by OM		O&M 50 years	Total Capital	Total Cost 50 years
17	Moffat Tunnel to Winter Pk. Diesel Loco. hauled Psgr R	$ 38,640,000	$ 15,600,100	$ 54,240,100
18	Moffat Tunnel to Glenwood Diesel Loco. hauled Psgr RR	$ 77,280,000	$ 15,600,100	$ 92,880,100
3c	Electric Light Rail Transit, single track-Hwy	$ 3,588,327,769	$ 1,209,416,000	$ 3,881,313,769
3b	Electric Light Rail Transit, single track-6%	$ 3,591,576,844	$ 1,269,416,000	$ 3,944,772,844
3a	Electric Light Rail Transit, single track-4%	$ 3,614,427,762	$ 2,046,382,000	$ 4,697,575,762
1c	Diesel Light Rail Transit, single track-Hwy	$ 3,617,894,367	$ 1,253,116,000	$ 4,183,687,867
1b	Diesel Light Rail Transit, single track-6%	$ 3,622,299,133	$ 1,318,104,000	$ 4,253,238,133
1a	Diesel Light Rail Transit, single track-4%	$ 3,642,364,167	$ 2,083,116,000	$ 5,003,054,667
4a	Electric Light Rail Transit, double track-4%	$ 6,760,784,574	$ 3,812,764,000	$ 8,923,974,574
4c	Electric Light Rail Transit, double track-Hwy	$ 6,797,415,927	$ 2,198,832,000	$ 7,346,673,927
4b	Electric Light Rail Transit, double track-6%	$ 6,803,292,652	$ 2,298,832,000	$ 7,452,928,652
2a	Diesel Light Rail Transit, double track-4%	$ 6,962,807,833	$ 3,906,232,000	$ 9,631,859,333
2c	Diesel Light Rail Transit, double track-Hwy	$ 6,984,074,233	$ 2,306,232,000	$ 8,053,125,733
2b	Diesel Light Rail Transit, double track-6%	$ 7,056,384,167	$ 2,416,208,000	$ 8,172,226,267
7b	Electric Heavy Rail Transit, single track-6%	$ 8,903,490,726	$ 2,722,670,500	$ 10,709,941,226
7a	Electric Heavy Rail Transit, single track-4%	$ 8,927,568,227	$ 3,492,670,500	$ 11,457,004,727
8a	Electric Heavy Rail Transit, double track-4%	$ 9,530,993,371	$ 4,702,670,500	$ 12,584,089,871
8b	Electric Heavy Rail Transit, double track-6%	$ 9,545,683,649	$ 3,202,670,500	$ 11,099,158,149
13b	Electric Multiple Unit Passenger RR, single track-6%	$ 10,543,831,896	$ 2,294,670,000	$ 11,922,281,896
13a	Electric Multiple Unit Passenger RR, single track-4%	$ 10,547,784,737	$ 3,046,180,000	$ 12,630,730,737
5b	Diesel Heavy Rail Transit, single track-6%	$ 10,895,754,600	$ 3,537,764,000	$ 13,746,353,600
5a	Diesel Heavy Rail Transit, single track-4%	$ 10,909,828,900	$ 4,217,980,000	$ 14,405,383,400
14b	Electric Multiple Unit Passenger RR, double track-6%	$ 11,194,649,344	$ 2,761,180,000	$ 12,306,633,344
14a	Electric Multiple Unit Passenger RR, double track-4%	$ 11,240,101,056	$ 4,261,180,000	$ 13,767,459,856
6a	Diesel Heavy Rail Transit, double track-4%	$ 11,412,145,300	$ 5,257,980,000	$ 15,369,759,400
6b	Diesel Heavy Rail Transit, double track-6%	$ 11,445,486,600	$ 3,847,764,000	$ 14,056,353,600
15c	Electric Conv. Monorail AGS, double guideway-Hwy	$ 11,648,192,580	$ 3,734,116,212	$ 13,732,734,792
15b	Electric Conv. Monorail AGS, double guideway-6%	$ 11,670,560,700	$ 3,745,471,818	$ 13,766,836,518
15a	Electric Conv. Monorail, double guideway-4%	$ 11,733,408,488	$ 3,846,266,818	$ 13,845,854,106
16	CIFGA Monorail (Highway only)	$ 15,686,710,032	$ 4,454,052,273	$ 18,406,941,105

Sort by Capital		O&M 50 years	Total Capital	Total Cost 50 years	Capital cost per mile
18	Moffat Tunnel to Glenwood Diesel Loco. hauled Psgr RR	$ 77,280,000	$ 15,600,100	$ 92,880,100	$ 116,419
17	Moffat Tunnel to Winter Pk. Diesel Loco. hauled Psgr R	$ 38,640,000	$ 15,600,100	$ 54,240,100	$ 232,837
3c	Electric Light Rail Transit, single track-Hwy	$ 3,588,327,769	$ 1,209,416,000	$ 3,881,313,769	$ 14,062,977
1c	Diesel Light Rail Transit, single track-Hwy	$ 3,617,894,367	$ 1,253,116,000	$ 4,183,687,867	$ 14,571,116
3b	Electric Light Rail Transit, single track-6%	$ 3,591,576,844	$ 1,269,416,000	$ 3,944,772,844	$ 14,760,651
1b	Diesel Light Rail Transit, single track-6%	$ 3,622,299,133	$ 1,318,104,000	$ 4,253,238,133	$ 15,326,791
3a	Electric Light Rail Transit, single track-4%	$ 3,614,427,762	$ 2,046,382,000	$ 4,697,575,762	$ 23,795,140
1a	Diesel Light Rail Transit, single track-4%	$ 3,642,364,167	$ 2,083,116,000	$ 5,003,054,667	$ 24,222,279
4c	Electric Light Rail Transit, double track-Hwy	$ 6,797,415,927	$ 2,198,832,000	$ 7,346,673,927	$ 25,567,814
13b	Electric Multiple Unit Passenger RR, single track-6%	$ 10,543,831,896	$ 2,294,670,000	$ 11,922,281,896	$ 26,682,209
4b	Electric Light Rail Transit, double track-6%	$ 6,803,292,652	$ 2,298,832,000	$ 7,452,928,652	$ 26,730,605
2c	Diesel Light Rail Transit, double track-Hwy	$ 6,984,074,233	$ 2,306,232,000	$ 8,053,125,733	$ 26,816,651
2b	Diesel Light Rail Transit, double track-6%	$ 7,056,384,167	$ 2,416,208,000	$ 8,172,226,267	$ 28,095,442
7b	Electric Heavy Rail Transit, single track-6%	$ 8,903,490,726	$ 2,722,670,500	$ 10,709,941,226	$ 31,658,959
14b	Electric Multiple Unit Passenger RR, double track-6%	$ 11,194,649,344	$ 2,761,180,000	$ 12,306,633,344	$ 32,106,744
13a	Electric Multiple Unit Passenger RR, single track-4%	$ 10,547,784,737	$ 3,046,180,000	$ 12,630,730,737	$ 35,420,698
8b	Electric Heavy Rail Transit, double track-6%	$ 9,545,683,649	$ 3,202,670,500	$ 11,099,158,149	$ 37,240,355
7a	Electric Heavy Rail Transit, single track-4%	$ 8,927,568,227	$ 3,492,670,500	$ 11,457,004,727	$ 40,612,448
5b	Diesel Heavy Rail Transit, single track-6%	$ 10,895,754,600	$ 3,537,764,000	$ 13,746,353,600	$ 41,136,791
15c	Electric Conv. Monorail AGS, double guideway-Hwy	$ 11,648,192,580	$ 3,734,116,212	$ 13,732,734,792	$ 43,419,956
15b	Electric Conv. Monorail AGS, double guideway-6%	$ 11,670,560,700	$ 3,745,471,818	$ 13,766,836,518	$ 43,551,998
4a	Electric Light Rail Transit, double track-4%	$ 6,760,784,574	$ 3,812,764,000	$ 8,923,974,574	$ 44,334,465
15a	Electric Conv. Monorail, double guideway-4%	$ 11,733,408,488	$ 3,846,266,818	$ 13,845,854,106	$ 44,724,033
6b	Diesel Heavy Rail Transit, double track-6%	$ 11,445,486,600	$ 3,847,764,000	$ 14,056,353,600	$ 44,741,442
2a	Diesel Light Rail Transit, double track-4%	$ 6,962,807,833	$ 3,906,232,000	$ 9,631,859,333	$ 45,421,302
5a	Diesel Heavy Rail Transit, single track-4%	$ 10,909,828,900	$ 4,217,980,000	$ 14,405,383,400	$ 49,046,279
14a	Electric Multiple Unit Passenger RR, double track-4%	$ 11,240,101,056	$ 4,261,180,000	$ 13,767,459,856	$ 49,548,605
16	CIFGA Monorail (Highway only)	$ 15,686,710,032	$ 4,454,052,273	$ 18,406,941,105	$ 51,791,305
8a	Electric Heavy Rail Transit, double track-4%	$ 9,530,993,371	$ 4,702,670,500	$ 12,584,089,871	$ 54,682,215
6a	Diesel Heavy Rail Transit, double track-4%	$ 11,412,145,300	$ 5,257,980,000	$ 15,369,759,400	$ 61,139,302

Sort by 50 year Total		O&M 50 years	Total Capital	Total Cost 50 years
17	Moffat Tunnel to Winter Pk. Diesel Loco. hauled Psgr R	$ 38,640,000	$ 15,600,100	$ 54,240,100
18	Moffat Tunnel to Glenwood Diesel Loco. hauled Psgr RR	$ 77,280,000	$ 15,600,100	$ 92,880,100
3c	Electric Light Rail Transit, single track-Hwy	$ 3,588,327,769	$ 1,209,416,000	$ 3,881,313,769
3b	Electric Light Rail Transit, single track-6%	$ 3,591,576,844	$ 1,269,416,000	$ 3,944,772,844
1c	Diesel Light Rail Transit, single track-Hwy	$ 3,617,894,367	$ 1,253,116,000	$ 4,183,687,867
1b	Diesel Light Rail Transit, single track-6%	$ 3,622,299,133	$ 1,318,104,000	$ 4,253,238,133
3a	Electric Light Rail Transit, single track-4%	$ 3,614,427,762	$ 2,046,382,000	$ 4,697,575,762
1a	Diesel Light Rail Transit, single track-4%	$ 3,642,364,167	$ 2,083,116,000	$ 5,003,054,667
4c	Electric Light Rail Transit, double track-Hwy	$ 6,797,415,927	$ 2,198,832,000	$ 7,346,673,927
4b	Electric Light Rail Transit, double track-6%	$ 6,803,292,652	$ 2,298,832,000	$ 7,452,928,652
2c	Diesel Light Rail Transit, double track-Hwy	$ 6,984,074,233	$ 2,306,232,000	$ 8,053,125,733
2b	Diesel Light Rail Transit, double track-6%	$ 7,056,384,167	$ 2,416,208,000	$ 8,172,226,267
4a	Electric Light Rail Transit, double track-4%	$ 6,760,784,574	$ 3,812,764,000	$ 8,923,974,574
2a	Diesel Light Rail Transit, double track-4%	$ 6,962,807,833	$ 3,906,232,000	$ 9,631,859,333
7b	Electric Heavy Rail Transit, single track-6%	$ 8,903,490,726	$ 2,722,670,500	$ 10,709,941,226
8b	Electric Heavy Rail Transit, double track-6%	$ 9,545,683,649	$ 3,202,670,500	$ 11,099,158,149
7a	Electric Heavy Rail Transit, single track-4%	$ 8,927,568,227	$ 3,492,670,500	$ 11,457,004,727
13b	Electric Multiple Unit Passenger RR, single track-6%	$ 10,543,831,896	$ 2,294,670,000	$ 11,922,281,896
14b	Electric Multiple Unit Passenger RR, double track-6%	$ 11,194,649,344	$ 2,761,180,000	$ 12,306,633,344
8a	Electric Heavy Rail Transit, double track-4%	$ 9,530,993,371	$ 4,702,670,500	$ 12,584,089,871
13a	Electric Multiple Unit Passenger RR, single track-4%	$ 10,547,784,737	$ 3,046,180,000	$ 12,630,730,737
15c	Electric Conv. Monorail AGS, double guideway-Hwy	$ 11,648,192,580	$ 3,734,116,212	$ 13,732,734,792
5b	Diesel Heavy Rail Transit, single track-6%	$ 10,895,754,600	$ 3,537,764,000	$ 13,746,353,600
15b	Electric Conv. Monorail AGS, double guideway-6%	$ 11,670,560,700	$ 3,745,471,818	$ 13,766,836,518
14a	Electric Multiple Unit Passenger RR, double track-4%	$ 11,240,101,056	$ 4,261,180,000	$ 13,767,459,856
15a	Electric Conv. Monorail, double guideway-4%	$ 11,733,408,488	$ 3,846,266,818	$ 13,845,854,106
6b	Diesel Heavy Rail Transit, double track-6%	$ 11,445,486,600	$ 3,847,764,000	$ 14,056,353,600
5a	Diesel Heavy Rail Transit, single track-4%	$ 10,909,828,900	$ 4,217,980,000	$ 14,405,383,400
6a	Diesel Heavy Rail Transit, double track-4%	$ 11,412,145,300	$ 5,257,980,000	$ 15,369,759,400
16	CIFGA Monorail (Highway only)	$ 15,686,710,032	$ 4,454,052,273	$ 18,406,941,105

Table 4

RTT Analysis Results

Alternative		Fuel Consumption Gallons 4.5	KwHr 5	Annnual Cost Diesel 1.60	Electric 0.10	Total	Total Annual Veh Miles	Total Cost/ Vehicle Mile	Total Cost/ Seat Mile
1	Bus and Improved Van in mixed traffic	4,080,000		$ 6,528,000	$ -	$ 6,528,000	18,353,186	$ 0.356	0.008
2	Diesel Bus in marked HOV lane, peak	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
3	Diesel Bus in marked HOV lane, both	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
4	Diesel Bus in separated HOV Lanes, peak	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
5	Diesel Bus in separate transitway, peak	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
6	Diesel Bus in separate transitway, both	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
7	Diesel Bus in guided transitway, peak	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
8	Diesel Bus in guided transitway, both	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
9	Diesel Bus in guided transitway, BRT stations	4,040,000	-	$ 6,464,000	$ -	$ 6,464,000	18,199,065	$ 0.355	0.008
10	Dual Mode Bus in separate transitway, peak	2,530,000	33,900,000	$ 4,048,000	$ 3,390,000	$ 7,438,000	18,166,454	$ 0.409	0.009
11	Dual Mode Bus in separate transitway, both	2,530,000	33,900,000	$ 4,048,000	$ 3,390,000	$ 7,438,000	18,166,454	$ 0.409	0.009
12	Dual Mode Bus in guided transitway, peak	2,530,000	33,900,000	$ 4,048,000	$ 3,390,000	$ 7,438,000	18,166,454	$ 0.409	0.009
13	Dual Mode Bus in guided transitway, both	2,530,000	33,900,000	$ 4,048,000	$ 3,390,000	$ 7,438,000	18,166,454	$ 0.409	0.009
14	Dual Mode Bus in guided transitway, BRT stations	2,530,000	33,900,000	$ 4,048,000	$ 3,390,000	$ 7,438,000	18,166,454	$ 0.409	0.009
15	Electric Bus in separate transitway, both	3,040,000	46,070,000	$ 4,864,000	$ 4,607,000	$ 9,471,000	22,881,172	$ 0.414	0.009
16	Electric Bus in guided transitway, both	3,040,000	46,070,000	$ 4,864,000	$ 4,607,000	$ 9,471,000	22,881,172	$ 0.414	0.009
17	Electric Bus in guided transitway, BRT stations	3,040,000	46,070,000	$ 4,864,000	$ 4,607,000	$ 9,471,000	22,881,172	$ 0.414	0.009

Note: *Electric bus alternatives has diesel due to feeder system*

MAIN LINE OPERATIONS Capital Costs

Alternative	Description	Type	Capital *(main line operations)*: Vehicles *(main line operations)*: Max Vehicles	Total Plus 20%	Unit Price	Total Cost	Right of Way Infrastructure: Total	Electrification	Total	Facilities: Operations	Transit Centers	Total	Total Capital	Annualized: Vehicles 12 4.0%	ROW 25 4.2%	Facilities 25 *Life* 4.2% *Real Interest*	Total Annualized
1	Bus and Improved Van in mixed traffic	Mixed	97	116	$ 350,000	$ 40,600,000	$ -	$ -	$ -	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 101,600,000	$4,300,000	$ -	$4,000,000	$8,300,000
2	Diesel Bus in marked HOV lane, peak	HOV/Transit	97	116	$ 350,000	$ 40,600,000	$ 422,913,920	$ -	$ 422,913,920	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 524,513,920	$4,300,000	$ 27,600,000	$4,000,000	$35,900,000
3	Diesel Bus in marked HOV lane, both	HOV/Transit	97	116	$ 350,000	$ 40,600,000	$ 487,510,880	$ -	$ 487,510,880	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 589,110,880	$4,300,000	$ 31,900,000	$4,000,000	$40,200,000
4	Diesel Bus in separated HOV Lanes, peak	HOV/Transit	97	116	$ 350,000	$ 40,600,000	$ 682,903,280	$ -	$ 682,903,280	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 784,503,280	$4,300,000	$ 44,600,000	$4,000,000	$52,900,000
5	Diesel Bus in separate transitway, peak	HOV/Transit	97	116	$ 350,000	$ 40,600,000	$570,429,360		$ 570,429,360	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 672,029,360	$4,300,000	$ 37,300,000	$4,000,000	$45,600,000
6	Diesel Bus in separate transitway, both	HOV/Transit	97	116	$ 350,000	$ 40,600,000	$682,903,280		$ 682,903,280	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 784,503,280	$4,300,000	$ 44,600,000	$4,000,000	$52,900,000
7	Diesel Bus in guided transitway, peak	Guide	97	116	$ 350,000	$ 40,600,000	$457,384,680		$ 457,384,680	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 558,984,680	$4,300,000	$ 29,900,000	$4,000,000	$38,200,000
8	Diesel Bus in guided transitway, both	Guide	97	116	$ 350,000	$ 40,600,000	$537,560,120		$ 537,560,120	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 639,160,120	$4,300,000	$ 35,100,000	$4,000,000	$43,400,000
9	Diesel Bus in guided transitway, BRT stations	Guide	97	116	$ 350,000	$ 40,600,000	$549,560,120		$ 549,560,120	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 651,160,120	$4,300,000	$ 35,900,000	$4,000,000	$44,200,000
10	Dual Mode Bus in separate transitway, peak	HOV/Transit	97	116	$ 1,000,000	$ 116,000,000	$570,429,360	$ 100,000,000	$ 670,429,360	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 847,429,360	$12,400,000	$ 43,800,000	$4,000,000	$60,200,000
11	Dual Mode Bus in separate transitway, both	HOV/Transit	97	116	$ 1,000,000	$ 116,000,000	$682,903,280	185,000,000	$ 867,903,280	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 1,044,903,280	$12,400,000	$ 56,700,000	$4,000,000	$73,100,000
12	Dual Mode Bus in guided transitway, peak	Guide	97	116	$ 1,000,000	$ 116,000,000	$457,384,680	100,000,000	$ 557,384,680	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 734,384,680	$12,400,000	$ 36,400,000	$4,000,000	$52,800,000
13	Dual Mode Bus in guided transitway, both	Guide	97	116	$ 1,000,000	$ 116,000,000	$537,560,120	185,000,000	$ 722,560,120	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 899,560,120	$12,400,000	$ 47,200,000	$4,000,000	$63,600,000
14	Dual Mode Bus in guided transitway, BRT stations	Guide	97	116	$ 1,000,000	$ 116,000,000	$549,560,120	185,000,000	$ 734,560,120	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 911,560,120	$12,400,000	$ 48,000,000	$4,000,000	$64,400,000
15	Electric Bus in separate transitway, both	HOV/Transit	97	116	$ 700,000	$ 81,200,000	$1,038,160,080	235,000,000	$ 1,273,160,080	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 1,415,360,080	$6,400,000	$ 83,200,000	$4,000,000	$93,600,000
16	Electric Bus in guided transitway, both	Guide	97	116	$ 700,000	$ 81,200,000	$847,057,320	235,000,000	$ 1,082,057,320	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 1,224,257,320	$6,400,000	$ 70,700,000	$4,000,000	$81,100,000
17	Electric Bus in guided transitway, BRT stations	Guide	97	116	$ 700,000	$ 81,200,000	$860,557,320	235,000,000	$ 1,095,557,320	$ 36,000,000	$ 25,000,000	$ 61,000,000	$ 1,237,757,320	$6,400,000	$ 71,600,000	$4,000,000	$82,000,000

FEEDER OPERATIONS

(from feeder.xls/feeder ops)

Capital			Annualized (rounded)
Fixed Route			
Vehicles			
20% Total			
21		128	
Unit		$ 275,000	
Total		$ 35,310,000	$ 3,760,000
Ops Facilities	25 year life		
Vail		$ 7,500,000	
Summit		6,500,000	
Idaho/else		1,250,000	
Total		$ 15,250,000	$997,000
Other	life=10 years		
Electronics		$ 3,191,000	
Equipment		1,276,500	
Total		$ 4,467,500	$556,000
Total Fixed Route		$ 55,027,500	$ 5,313,000
ADA Paratransit			
	Life		
Vehicles	4	$ 3,124,000	$865,000
Equipment	10	$ 3,021,000	$376,000
Facility	25	$ 5,000,000	$327,000
Total ADA		$ 11,145,000	$1,568,000
All Cap		$ 66,172,500	$ 6,881,000
ADD Feeder for Trolley Bus Options Capital			
Vehicles		31,200,000	$3,363,000
Facility and Other		9,500,000	$621,000
Total		40,700,000	$3,984,000
Total for TB Options			$ 10,865,000

Total Cost Summary

Alternative	Description	Type	Main Line Operations: Total Capital	Main Line Operations: Capital Cost per mile	Main Line Operations: Annualized	Main Line Operations: Operating Costs	Main Line Operations: Total Annualized	Feeder Operations: Total Capital	Feeder Operations: Annualized	Feeder Operations: Operations	Totals: Annual Capital	Totals: Annual Operations	Totals: Total Annual
1	Bus and Improved Van in mixed traffic	Mixed	$ 101,600,000	$ 1,181,395	$8,300,000	$ 14,870,000	$23,170,000	$ 66,200,000	$6,881,000	$ 18,050,000	$15,181,000	$ 32,920,000	$48,101,000
2	Diesel Bus in marked HOV lane, peak	HOV/Transit	$ 524,513,920	$ 6,098,999	$35,900,000	$ 12,950,000	$48,850,000	$ 66,200,000	$6,881,000	$ 18,050,000	$42,781,000	$ 31,000,000	$73,781,000
3	Diesel Bus in marked HOV lane, both	HOV/Transit	$ 589,110,880	$ 6,850,127	$40,200,000	$ 12,950,000	$53,150,000	$ 66,200,000	$6,881,000	$ 18,050,000	$47,081,000	$ 31,000,000	$78,081,000
4	Diesel Bus in separated HOV Lanes, peak	HOV/Transit	$ 784,503,280	$ 9,122,131	$52,900,000	$ 12,950,000	$65,850,000	$ 66,200,000	$6,881,000	$ 18,050,000	$59,781,000	$ 31,000,000	$90,781,000
5	Diesel Bus in separate transitway, peak	HOV/Transit	$ 672,029,360	$ 7,814,295	$45,600,000	$ 12,950,000	$58,550,000	$ 66,200,000	$6,881,000	$ 18,050,000	$52,481,000	$ 31,000,000	$83,481,000
6	Diesel Bus in separate transitway, both	HOV/Transit	$ 784,503,280	$ 9,122,131	$52,900,000	$ 12,950,000	$65,850,000	$ 66,200,000	$6,881,000	$ 18,050,000	$59,781,000	$ 31,000,000	$90,781,000
7	Diesel Bus in guided transitway, peak	Guide	$ 558,984,680	$ 6,499,822	$38,200,000	$ 12,950,000	$51,150,000	$ 66,200,000	$6,881,000	$ 18,050,000	$45,081,000	$ 31,000,000	$76,081,000
8	Diesel Bus in guided transitway, both	Guide	$ 639,160,120	$ 7,432,094	$43,400,000	$ 12,950,000	$56,350,000	$ 66,200,000	$6,881,000	$ 18,050,000	$50,281,000	$ 31,000,000	$81,281,000
9	Diesel Bus in guided transitway, BRT stations	Guide	$ 651,160,120	$ 7,571,629	$44,200,000	$ 12,950,000	$57,150,000	$ 66,200,000	$6,881,000	$ 18,050,000	$51,081,000	$ 31,000,000	$82,081,000
10	Dual Mode Bus in separate transitway, peak	HOV/Transit	$ 847,429,360	$ 9,853,830	$60,200,000	$ 12,190,000	$72,390,000	$ 66,200,000	$6,881,000	$ 18,050,000	$67,081,000	$ 30,240,000	$97,321,000
11	Dual Mode Bus in separate transitway, both	HOV/Transit	$ 1,044,903,280	$ 12,150,038	$73,100,000	$ 12,190,000	$85,290,000	$ 66,200,000	$6,881,000	$ 18,050,000	$79,981,000	$ 30,240,000	$110,221,000
12	Dual Mode Bus in guided transitway, peak	Guide	$ 734,384,680	$ 8,539,357	$52,800,000	$ 12,190,000	$64,990,000	$ 66,200,000	$6,881,000	$ 18,050,000	$59,681,000	$ 30,240,000	$89,921,000
13	Dual Mode Bus in guided transitway, both	Guide	$ 899,560,120	$ 10,460,001	$63,600,000	$ 12,190,000	$75,790,000	$ 66,200,000	$6,881,000	$ 18,050,000	$70,481,000	$ 30,240,000	$100,721,000
14	Dual Mode Bus in guided transitway, BRT stations	Guide	$ 911,560,120	$ 10,599,536	$64,400,000	$ 12,190,000	$76,590,000	$ 66,200,000	$6,881,000	$ 18,050,000	$71,281,000	$ 30,240,000	$101,521,000
15	Electric Bus in separate transitway, both	HOV/Transit	$ 1,415,360,080	$ 16,457,675	$93,600,000	$ 8,660,000	$102,260,000	$ 106,872,500	$10,865,000	$ 31,050,000	$104,465,000	$ 39,710,000	$144,175,000
16	Electric Bus in guided transitway, both	Guide	$ 1,224,257,320	$ 14,235,550	$81,100,000	$ 8,660,000	$89,760,000	$ 106,872,500	$10,865,000	$ 31,050,000	$91,965,000	$ 39,710,000	$131,675,000
17	Electric Bus in guided transitway, BRT stations	Guide	$ 1,237,757,320	$ 14,392,527	$82,000,000	$ 8,660,000	$90,660,000	$ 106,872,500	$10,865,000	$ 31,050,000	$92,865,000	$ 39,710,000	$132,575,000

Sorted by Capital Costs per mile

			Total Capital	Capital Cost per mile
1	Bus and Improved Van in mixed traffic	Mixed	$101,600,000	$1,181,395
2	Diesel Bus in marked HOV lane, peak	HOV/Transit	$524,513,920	$6,098,999
7	Diesel Bus in guided transitway, peak	Guide	$558,984,680	$6,499,822
3	Diesel Bus in marked HOV lane, both	HOV/Transit	$589,110,880	$6,850,127
8	Diesel Bus in guided transitway, both	Guide	$639,160,120	$7,432,094
9	Diesel Bus in guided transitway, BRT stations	Guide	$651,160,120	$7,571,629
5	Diesel Bus in separate transitway, peak	HOV/Transit	$672,029,360	$7,814,295
12	Dual Mode Bus in guided transitway, peak	Guide	$734,384,680	$8,539,357
4	Diesel Bus in separated HOV Lanes, peak	HOV/Transit	$784,503,280	$9,122,131
6	Diesel Bus in separate transitway, both	HOV/Transit	$784,503,280	$9,122,131
10	Dual Mode Bus in separate transitway, peak	HOV/Transit	$847,429,360	$9,853,830
13	Dual Mode Bus in guided transitway, both	Guide	$899,560,120	$10,460,001
14	Dual Mode Bus in guided transitway, BRT stations	Guide	$911,560,120	$10,599,536
11	Dual Mode Bus in separate transitway, both	HOV/Transit	$1,044,903,280	$12,150,038
16	Electric Bus in guided transitway, both	Guide	$1,224,257,320	$14,235,550
17	Electric Bus in guided transitway, BRT stations	Guide	$1,237,757,320	$14,392,527
15	Electric Bus in separate transitway, both	HOV/Transit	$1,415,360,080	$16,457,675

ALT	Alternative Description	Added width	Width Cost/ mile	Slip Ramps @ $300,000ea.	BRT @ $1,500,000ea	Dedicated Interchange 2 Ramps @ $4,500,000ea	Dedicated Interchange 4 Ramps @ $6,590,000ea	Twin Tunnel Bore @ $8,000,000	Eisenhower Tunnel Bore @ $150,000,000	Total of Unit Costs	Width Cost @ 70.83 or 93.13	TOTAL
1	1 Bus and Improved Van in mixed traffic	0	$ -	0	0	0	0	0	0	$0	$0	$0
2	2 Diesel Bus in marked HOV lane (Reversible) (Contra Flow), peak	16	$ 5,824,000	8	0	0	0	1	0	$10,400,000	$412,513,920	$422,913,920
3	3 Diesel Bus in marked HOV lane, both	24	$ 6,736,000	8	0	0	0	1	0	$10,400,000	$477,110,880	$487,510,880
4	4 Diesel Bus in separated HOV Lanes (reversible), peak	44	$ 9,016,000	1	0	0	8	1	0	$44,300,000	$638,603,280	$682,903,280
5	5 Diesel Bus in separate transitway (reversible), peak	28	$ 7,192,000	1	0	8	0	1	0	$61,020,000	$509,409,360	$570,429,360
6	6 Diesel Bus in separate transitway (twoway traffic), both	44	$ 9,016,000	1	0	0	8	1	0	$44,300,000	$638,603,280	$682,903,280
7	7 Diesel Bus in guided transitway (reversible), peak	14	$ 5,596,000	1	0	8	0	1	0	$61,020,000	$396,364,680	$457,384,680
8	8 Diesel Bus in guided transitway, both	26	$ 6,964,000	1	0	0	8	1	0	$44,300,000	$493,260,120	$537,560,120
9	9 Diesel Bus in guided transitway, both directions, w/ BRT stations	26	$ 6,964,000	1	8	0	8	1	0	$56,300,000	$493,260,120	$549,560,120
10	10 Dual Mode Bus in separate transitway (reversible), peak	28	$ 7,192,000	1	0	8	0	1	0	$61,020,000	$509,409,360	$570,429,360
11	11 Dual Mode Bus in separate transitway, both	44	$ 9,016,000	1	0	0	8	1	0	$44,300,000	$638,603,280	$682,903,280
12	12 Dual Mode Bus in guided transitway (reversible), peak	14	$ 5,596,000	1	0	8	0	1	0	$61,020,000	$396,364,680	$457,384,680
13	13 Dual Mode Bus in guided transitway, both	26	$ 6,964,000	1	0	0	8	1	0	$44,300,000	$493,260,120	$537,560,120
14	14 Dual Mode Bus in guided transitway, both directions, w/ BRT stations	26	$ 6,964,000	1	8	0	8	1	0	$56,300,000	$493,260,120	$549,560,120
15	15 Electric Bus in separate transitway, both	44	$ 9,016,000	0	0	0	9	1	1	$198,500,000	$839,660,080	$1,038,160,080
16	16 Electric Bus in guided transitway, both	26	$ 6,964,000	0	0	0	9	1	1	$198,500,000	$648,557,320	$847,057,320
17	17 Electric Bus in guided transitway, both directions, w/ BRT stations	26	$ 6,964,000	0	9	0	9	1	1	$212,000,000	$648,557,320	$860,557,320

Notes:

Type	Cost Est
Slip Ramp	$300,000
BRT	$1,500,000
Ded Int 2 R	$4,500,000
Ded Int 4R	$6,590,000
T TUNNEL	$8,000,000
E TUNNEL	$150,000,000

Width cost based on estimates at floyd hill

Ad Width	Cost est
4	$ 4,726,544.00
16	$ 5,881,835.51
40	$ 8,787,956.69

RTT Operations Plan

Origin	Days/Year	Pattern	Revenue Miles O-W	Revenue Miles RT	RT Running Times (Hours) Mixed	HOV	Guide	Equide	Ave Frequency Max	Base	Vehicles in Service Max	Base	Max/Base (Freq)	Max Vehs for Frequency Mixed	HOV	Guide	Equide	Annual Revenue Hours Mixed	HOV	Guide	Equide
	Approx Speed			(O-W X 2)	45	51	54	60													
DIA																					
Holiday Peak	25																				
		1	74	148	3.3	2.9	2.7	1.5	20	30	3	2	67%	9	8	8	4	3,000	2,667	2,667	1,333
		2	92	184	4.1	3.6	3.4	2.1	20	30	10	6	67%	12	10	10	6	4,000	3,333	3,333	2,000
		3	90	180	4.0	3.5	3.3	2.0	20	30	5	3	67%	12	10	10	6	4,000	3,333	3,333	2,000
		4	118	236	5.2	4.6	4.4	2.9	20	30	35	23	67%	15	13	13	8	5,000	4,333	4,333	2,667
											53			48	41	41	24	16,000	13,667	13,667	8,000
Peak	75																				
		1	62	124	2.8	2.4	2.3	1.1	30	60	1	1	50%	5	4	4	2	4,125	3,300	3,300	1,650
		2	92	184	4.1	3.6	3.4	2.1	30	60	8	4	50%	8	7	6	4	6,600	5,775	4,950	3,300
		3	90	180	4.0	3.5	3.3	2.0	30	60	3	1	50%	8	7	6	4	6,600	5,775	4,950	3,300
		4	118	236	5.2	4.6	4.4	2.9	30	60	23	11	50%	10	9	8	5	8,250	7,425	6,600	4,125
											35			31	27	24	15	25,575	22,275	19,800	12,375
Normal	265																				
		1	62	124	2.8	2.4	2.3	1.1	60	60	1	1	100%	2	2	2	1	9,540	9,540	9,540	4,770
		2	90	180	4.0	3.5	3.3	2.0	60	60	1	1	100%	4	3	3	2	19,080	14,310	14,310	9,540
		3	92	184	4.1	3.6	3.4	2.1	60	60	3	3	100%	4	3	3	2	19,080	14,310	14,310	9,540
		4	118	236	5.2	4.6	4.4	2.9	60	60	11	11	100%	5	4	4	2	23,850	19,080	19,080	9,540
											16			15	12	12	7	71,550	57,240	57,240	33,390
DIA Totals	365										53							113,125	93,182	90,707	53,765
C-470																					
Holiday Peak	25																				
		1	62	124	2.8	2.4	2.3	2.1	20	30	5	3	67%	8	7	6	6	2,667	2,333	2,000	2,000
		2	60	120	2.7	2.4	2.2	2.0	20	30	3	2	67%	8	7	6	6	2,667	2,333	2,000	2,000
		3	88	176	3.9	3.5	3.3	2.9	20	30	19	12	67%	11	10	9	8	3,667	3,333	3,000	2,667
											27			27	24	21	20	9,000	8,000	7,000	6,667
Peak	75																				
		1	62	124	2.8	2.4	2.3	2.1	30	60	3	1	50%	5	4	4	4	4,125	3,300	3,300	3,300
		2	60	120	2.7	2.4	2.2	2.0	30	60	2	1	50%	5	4	4	4	4,125	3,300	3,300	3,300
		3	88	176	3.9	3.5	3.3	2.9	30	60	12	6	50%	7	6	6	5	5,775	4,950	4,950	4,125
											17			17	14	14	13	14,025	11,550	11,550	10,725
Normal	265																				
		1	60	120	2.7	2.4	2.2	2.0	60	60	1	1	100%	2	2	2	2	9,540	9,540	9,540	9,540
		2	88	176	3.9	3.5	3.3	2.9	60	60	7	7	100%	3	3	3	2	14,310	14,310	14,310	9,540
											8			5	5	5	4	23,850	23,850	23,850	19,080
C-470 Totals											27							46,875	43,400	42,400	36,472
Central Denver																					
Holiday Peak	25																				
		1	35	70	1.6	1.4	1.3	0.7	30	60	3	1	50%	3	2	2	1	825	550	550	275
		2	59	118	2.6	2.3	2.2	1.5	30	60	1	1	50%	5	4	4	2	1,375	1,100	1,100	550
		3	75	150	3.3	2.9	2.8	2.0	30	60	2	1	50%	6	5	5	4	1,650	1,375	1,375	1,100
		4	103	206	4.6	4.0	3.8	2.9	60	60	11	11	100%	4	4	3	2	1,800	1,800	1,350	900
											17			18	15	14	9	5,650	4,825	4,375	2,825
Peak	75																				
		1	35	70	1.6	1.4	1.3	0.7	60	60	2	2	100%	1	1	1	1	1,350	1,350	1,350	1,350
		2	59	118	2.6	2.3	2.2	1.5	60	60	1	1	100%	2	2	2	1	2,700	2,700	2,700	1,350
		3	75	150	3.3	2.9	2.8	2.0	60	60	1	1	100%	3	2	2	2	4,050	2,700	2,700	2,700
		4	103	206	4.6	4.0	3.8	2.9	60	60	7	7	100%	4	4	3	2	5,400	5,400	4,050	2,700
											11			10	9	8	6	13,500	12,150	10,800	8,100
Normal	265																				
		1	59	118	2.6	2.3	2.2	1.5	120	120	1	1	100%	1	1	1	1	4,770	4,770	4,770	4,770
		2	75	150	3.3	2.9	2.8	2.0	120	120	1	1	100%	1	1	1	1	4,770	4,770	4,770	4,770
		3	103	206	4.6	4.0	3.8	2.9	120	120	3	3	100%	2	2	1	1	9,540	9,540	4,770	4,770
											5			4	4	3	3	19,080	19,080	14,310	14,310
Central Denver Totals											17							38,230	36,055	29,485	25,235
Grand Totals																		198,230	172,637	162,592	115,472

Named Cells

Item	code	days/yr	Hours	
Holiday Peak	hol	25	Max	4
Peak	peak	75	Base	14
Normal	norm	265	Total	18
Speeds	losf	36		
	mixed	45		
	hov	51		
	guide	54		
	equide	60		
original values	losf	30		
	mixed	45		
	hov	55		
	guide	60		

reflected in these speeds

Speed Impact if Buses in Mixed Traffic at Eisenhower Tunnel

Origin	Distance (miles) To Loveland	Loveland/ Vail*	Total
DIA	74	34	108
%	69%	31%	100%
C470	44	34	78
%	56%	44%	100%
Cent Denver	59	34	93
%	63%	37%	100%

Average Corridor Speeds

	Mixed	HOV/TW	Guide
DIA	45	52	55
C470	45	51	53
Cent Denver	45	51	55

54 MPH

51 MPH

45 MPH

*mixed traffic west of Eisenhower (east portal)

2020 LOS

Segment	LOS	Distance	Distance E/F	C/D
Evergreen/C470	E/F	9.0	9.0	
Floyd Hill/Evergreen	D	4.5		4.5
Eisenhower to F.Hill	E/F	33.5	33.5	
Frisco to Eisenhower	E/F	8.0	8.0	
Vail to Frisco	C/D	26.0		26.0
Totals		81.0	50.5	30.50
			62%	38%

Scenario	PH Speed
Mixed	36

Fuel Consumption

Mileage

Application		Rev Hrs	Mainline Veh Hrs 33%	Speed	Miles	Revenue Hrs I-70	Trolley	Feeder Total	Veh Hrs 20%	Speed	Miles	Total Miles
Diesel	Mixed	198,230	263,646	45	11,864,066	270,380		270,380	324,456	20	6,489,120	18,353,186
	HOV/TW	172,637	229,607	51	11,709,945	270,380		270,380	324,456	20	6,489,120	18,199,065
	Guide	172,637	229,607	51	11,709,945	270,380		270,380	324,456	20	6,489,120	18,199,065
Dual	HOV/TW	162,592	216,247	54	11,677,334	270,380		270,380	324,456	20	6,489,120	18,166,454
	Guide	162,592	216,247	54	11,677,334	270,380		270,380	324,456	20	6,489,120	18,166,454
Electric	HOV/TW	115,472	153,577	60	9,214,639	270,380	132,915	403,295	483,954	28	13,666,533	22,881,172
	Guide	115,472	153,577	60	9,214,639	270,380	132,915	403,295	483,954	28	13,666,533	22,881,172

Application		Miles Mainline Diesel	Mainline Electric	Feeder Diesel	Total Diesel	Total Electric	Fuel Gallons 4.5	KwHr 5
Diesel	Mixed	11,864,066		6,489,120	18,353,186	-	4,080,000	-
	HOV/TW	11,709,945		6,489,120	18,199,065	-	4,040,000	-
	Guide	11,709,945		6,489,120	18,199,065	-	4,040,000	-
Dual	HOV/TW	4,897,591	6,779,743	6,489,120	11,386,711	6,779,743	2,530,000	33,900,000
	Guide	4,897,591	6,779,743	6,489,120	11,386,711	6,779,743	2,530,000	33,900,000
Electric	HOV/TW	-	9,214,639	13,666,533	13,666,533	9,214,639	3,040,000	46,070,000
	Guide	-	9,214,639	13,666,533	13,666,533	9,214,639	3,040,000	46,070,000

Dual Allocation of electric/diesel

	Segment	DIA	Cen Denver	c470	Wtd	%	
Diesel	to C470	30	15	0	19	15%	42%
Electric	c470 to Eisenhower	74	74	74	74	58%	
Diesel	Eisenhower Vail	34	34	34	34	27%	
		138	123	108	127	100%	
		56%	18%	26%			

	Rev Hrs	%
DIA	90,707	56%
Cen Den	29,485	18%
C470	42,400	26%
	162,592	100%

RTT Travel Patterns

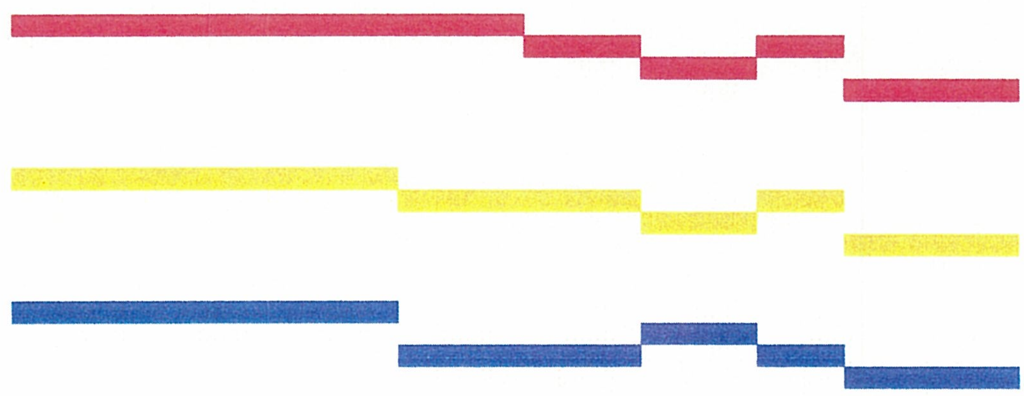
Model Destination

Origin/Level/Pattern	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/Dillon)	Frisco	Copper	Vail
Distance Between Stations		9	11	12	12	6	10	2	7	19
Cumulative Distance (via I-70)		9	20	32	44	50	60	52	59	78
DIA	30	39	50	62	74	80	90	82	89	108

Holiday Peak
1
2
3
4

Peak
1
2
3
4

Normal
1
2
3
4

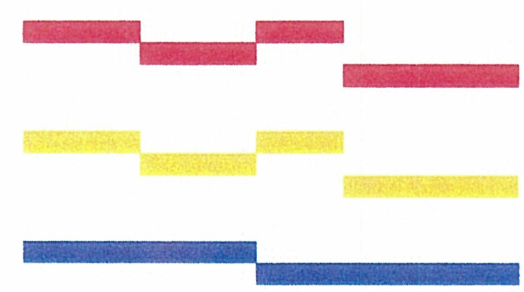


Origin/Level/Pattern	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/Dillon)	Frisco	Copper	Vail
Distance Between Stations		9	11	12	12	6	10	2	7	19
Cumulative Distance (via I-70)		9	20	32	44	50	60	62	69	88
C-470	0	9	20	32	44	50	60	62	69	88

Holiday Peak
1
2
3

Peak
1
2
3

Normal
1
2

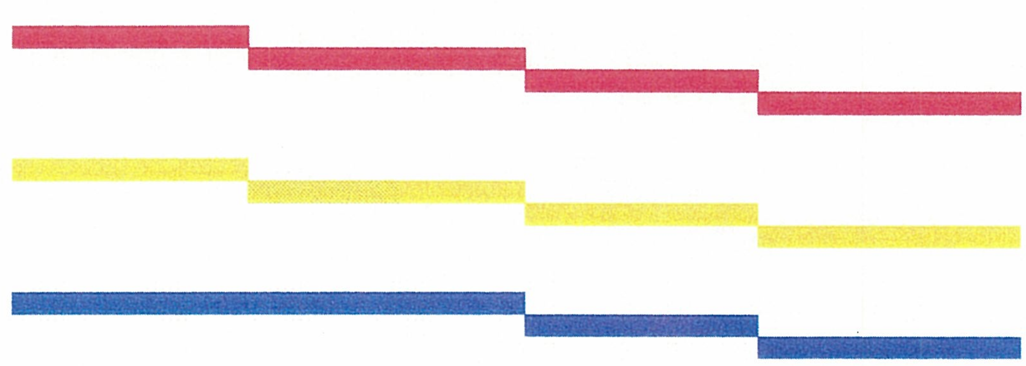


Origin/Level/Pattern	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/Dillon)	Frisco	Copper	Vail
Distance Between Stations		9	11	12	12	6	10	2	7	19
Cumulative Distance		9	20	32	44	50	60	62	69	88
Central Denver	15	24	35	47	59	65	75	77	84	103

Holiday Peak
1
2
3
4

Peak
1
2
3
4

Normal
1
2
3



Legend:

Solid = stop served in near and intermediate term

Stop served on a Demand Response basis

Basic Factors

Service	Level	Days/Year	Average Overall Frequency Max 4 hrs	Average Overall Frequency Balance (14hrs)	Number of Pattern Stops	Days/Week	Span of Operation	Special Features
DIA	Overall					7	5 am to 11 pm	*checked through luggage*
	Holiday Peak	25	20	30				
	Peak	75	30	60				
	Normal	265	60	60				
C-470 Park & Ride	Overall					7	5 am to 11 pm	"sky cap" at stops storage at stops
	Holiday Peak	25	20	30				
	Peak	75	30	60				
	Normal	265	60	60				
Central Denver	Overall					7	5 am to 11 pm	"sky cap" at stops storage at stops
	Holiday Peak	25	30	60				
	Peak	75	60	60				
	Normal	265	120	120				

Theoretical capacity of RTT modes

			rounded	
Peak period number of vehicles observed on I-70, per lane		1075		Per 4/16/01 email from Scott Burger, J F Sato
Percent achievable with all buses, per lane		50%		
Peak hour number of buses in dedicated lane		537.5		
Number of seats:	diesel buses (@45seats)	24187.5	24,000	Assumes that it is not feasible to put enough power in articulated diesel buses to reliably maintain speeds on I-70 grades with full loads
	dual mode or electric buses (@ 60 seats)	32250	32,000	Assumes 60 foot articulated buses.

Basic Source: David Phillips, TSC-Chicago
file: rail line 5.xls

2020 Rail Line Flows (peak day)

Link	FROM_MP	TO_MP	FLOW	WB Flow	Net on Board: WB flow, peak hour	EB Flow
DIA to Gateway	0.00	10.19	475	300	90	175
Gateway to Stapleton	10.19	18.26	1697	1,050	315	647
Stapleton to Downing	18.26	21.96	4048	2,236	671	1,812
Downing to DUT	21.96	23.89	4842	2,728	818	2,114
DUT to Wadsworth / I-76	23.89	32.31	24509	12,603	3,781	11,906
Wadsworth to Golden	32.31	40.57	25550	13,216	3,965	12,334
Golden to Evergreen	40.57	49.98	27231	13,926	4,178	13,305
Evergreen to US 6 / I-70	49.98	56.54	27170	13,896	4,169	13,274
US 6 to Idaho Springs	56.54	61.69	27187	13,905	4,171	13,282
Idaho Springs to Empire	61.69	69.66	26723	13,675	4,103	13,047
Empire to Loveland	69.66	85.80	26601	13,612	4,084	12,989
Loveland to Keystone	85.80	95.43	25899	13,261	3,978	12,638
Keystone to Silverthorne	95.43	102.94	23523	11,905	3,571	11,618
Silverthorne to Frisco	102.94	105.99	22278	11,276	3,383	11,003
Frisco to Copper Mountain	105.99	113.28	18532	9,531	2,859	9,001
Copper Mountain to Vail	113.28	132.48	15963	8,193	2,458	7,770

Boardings and Alightings

Rieck changes:

	Westbound Rail Line		PH Offs	On-Board	Peak Hr	Peak Hr (PH)	PH Cumm	PH Offs Ridership By Origin**			Other Peak Hour Load		Eastbound Rail Line		Total	
								DIA	Central Den	C470	Average	Divided by 3				
STOP	ON	OFF	30%	cumm	30%	cumm (ons)	Ons	55%	15%	30%	20%	60%	ON	OFF	ON	OFF
DIA	300	-		300	90	90	90				60	60	0	175	300	175
Gateway	752	3		1,050	315	315	405				210	210	4	476	756	479
Stapleton	1,192	6		2,236	671	671	1,076				447	447	8	1174	1201	1180
Downing	538	45		2,728	818	818	1,894				546	546	42	344	580	389
DUT	10,521	646		12,603	3,781	3,781	5,675				2,521	2,521	497	10289	11018	10935
Wadsworth	1,509	896	269	13,216	3,965	3,965	9,640		121		2,643	2,643	927	1355	2436	2251
Golden	1,013	304	91	13,926	4,178	4,178	13,818		91		**2,785**	2,785	262	1232	1275	1536
Evergreen*	118	147	44	13,896	4,169	4,169	17,986	24	20		2,779	2,779	147	116	265	264
US 6*	10	2	1	13,905	4,171	4,171	22,158	0	0		2,781	2,781	2	11	13	12
Idaho Springs	51	280	84	13,675	4,103	4,103	26,260	46	38		2,735	2,735	282	47	333	328
Empire*	18	81	24	13,612	4,084	4,084	30,344	13	11		2,722	2,722	79	21	97	102
Loveland	121	472	142	13,261	3,978	3,978	34,322	78	64		2,652	2,652	471	120	592	592
Keystone	260	1,616	485	11,905	3,571	3,571	37,894	267	73	145	2,381	2,381	1334	315	1594	1931
Silverthorne	127	756	227	11,276	3,383	3,383	41,277	125	34	68	2,255	2,255	737	122	864	878
Frisco	320	2,065	620	9,531	2,859	2,859	44,136	341	93	186	1,906	1,906	2218	217	2538	2282
Copper Mountain	109	1,446	434	8,193	2,458	2,458	46,594	239	65	130	1,639	1,639	1339	108	1448	1554
Vail	-	8,193	2,458	(0)	(0)	(0)	46,593	1,352	369	737	(0)	(0)	7770	0	7770	8193
								2,485	**857**	**1,267**						
*connectivity problem with bus service?																
Totals	**16,959**	**16,959**	4,609	>>total through Golden												

***See below left for proportions; no C-470 before Silverthorne*
C470 distribution added to Cen Denver

4,609 >>>check

62

Per Bob Friis, Sato, Year 1 is 80-90% of this; therefore we can assume the same ridership for the whole 50 years. 2020 might be considered the midrange.
Per Friis, While some of the data for stops within the Denver area is low, the overall number west of Golden is about right.
Peak hour flow is based on 30% of all day ridership

Offs
Golden to
West 15,363

Bob Friis original work	Origination of Demand: Winter	%	Summer	%	Total	%	Use
DIA/Out of State	20,706	65%	14,789	63%	35,495	64%	55%
Front Range							
Resorts/Daily	6,650		606		7,256		
Urban Areas/5 counties	4,390		7,950		12,340		
	11,040	35%	8,556	37%	19,596	36%	45%
Grand Totals	31,746	100%	23,345	100%	55,091	100%	100%

Split: C470	Denver	Total
30.0%	15.0%	45.0%
66.7%	33.3%	100.0%

"OFFS"			
Capacity for Other Peak hours			
Total Peak Day	15,363		
PH (highest)	4,609		
Balance	10,754		
		PH (highest)	Total Peak
% for remaining 3 Peak Hrs	60%	30%	90%
Riders	6,452		
Per Hour	2,151		
Vehicles	47		

RTT Travel Patterns

This Ridership Not Used in Summary

Seating Capacity Seats 45

Model Destination

Origin/Level/Pattern		Percent of PH Riders	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	check	Peak Vehicles		Daily Riders	Annual
PH 2020 Offs (Westbound)				24	46	13	78	125	267	341	239	1,352	2,484	2,485			PH Share	50%
DIA																		
Holiday Peak		100%		24	46	13	78	125	267	341	239	1,352	2,484					
	1			24	46	13	78						162		3			
	2							125		341			466		10			
	3								267				267	2,484	5	53	4,969	124,000
	4										239	1,352	1,590		35			
Peak		67%		16	31	9	52	84	179	228	160	906	1,665					
	1			16	31	9							56		1			
	2						52	84		228			364		8			
	3								179				179	1,665	3	35	3,329	250,000
	4										160	906	1,066		23			
Normal		33%		8	15	4	26	41	88	112	79	446	820					
	1			8	15	4							28		1			
	2								88				88		1			
	3						26	41		112			179	820	3	16	1,640	435,000
	4										79	446	525		11			
																		809,000

Origin/Level/Pattern		Percent of PH Riders	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/Dillon)	Frisco	Copper	Vail	Totals	check	Peak Vehicles		Daily Riders	Annual
PH 2020 Offs (Westbound)								68	145	186	130	737	1,267	1,267				
C-470																		
Holiday Peak		100%						68	145	186	130	737	1,267					
	1							68		186			254		5			
	2								145				145	1,267	3	27	2,534	63,000
	3										130	737	868		19			
Peak		67%						46	97	125	87	494	849					
	1							46		125			170		3			
	2								97				97	849	2	17	1,698	127,000
	3										87	494	581		12			
Normal		33%						22	48	61	43	243	418					
	1							22	48				70		1			
	2									61	43	243	348	418	7	8	836	222,000
																		412,000

Origin/Level/Pattern		Percent of PH Riders	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	check	Peak Vehicles		Daily Riders	Annual
PH 2020 Offs (Westbound)			91	20	38	11	64	34	73	93	65	369	857	857				
Downtown Denver																		
Holiday Peak		100%	91	20	38	11	64	34	73	93	65	369	857					
	1		91	20	38								149		3			
	2					11	64						75		1	17		
	3							34	73				107	857	2		1,714	43,000
	4									93	65	369	527		11			
Peak		67%	61	13	25	7	43	23	49	62	44	247	574					
	1		61	13	25								100		2			
	2					7	43						50		1			
	3							23	49				72		1	11		
	4									62	44	247	353	574	7		1,148	86,000
Normal		33%	30	7	12	4	21	11	24	31	21	122	283					
	1		30	7	12	4	21						74		1			
	2							11	24				35		1	5		
	3									31	21	122	174	283	3		566	150,000
																		279,000

Total RTT Riders 1,500,000

Legend:

Solid = stop served in near and intermediate term

Stop served on a Demand Response basis

Item			Assumptions	Operating	Maintenance	Ops + Maint	Capital		Comments
							Rolling Stock	Infrastructure	
OTR Coaches							$ 350,000		
Useful Life							12		
Stand Transit Coach							$ 275,000		
life							12		
Dual Powered OTR Coach							$ 1,000,000		
life							12		
Trolleybuses *(electric)*							$ 700,000		
Useful Life							18		
Operations and Maintenance Facility								$12,000,000	Enclosed structure, 30 to 40 vehicles
Useful Life								30	
Bus Passenger Waiting Facilities *(all climate controlled)*									
	Major							7,500,000	*Large Fully Staffed; fare media sales; 8-10 bays*
	Average							4,000,000	*Medium Fully Staffed; fare media sales 5-6 bays*
	Minor							2,500,000	*Minimally staffed building 3-4 bays*
Diesel Buses									
	Driver		$ 16.00						
		Taxes	$ 1.54						
		Ann OT	5%	$ 18.42					
		Yrly Benefits	$ 6,000						
		Per Hour		2.88					
	Fuel		$ 1.60						
		MPG	4.5						
		MPH	35						
		Galls/Hour	7.8						
		Fuel/hr		12.44					
	Insurance/mile		$ 0.05						
		Per Hour		1.75					
	Dispatch		$ 18.00						
		Taxes	$ 1.74						
		Ann OT	5%						
		Yrly Benefits	$ 6,000						
		Per Hour		0.12					
	Other Support			0.35					
	Mechanic		$ 19.00						
		Taxes	$ 1.83						
		Ann OT	10%						
		Yrly Benefits	$ 6,400						
		Annual Miles/Veh	60,000						
		Vehs/Mech	4						
		Per Mile	$ 0.032						
		Per Hour			1.12				
	Cleaners/Fuelers		$ 10.00						
		Taxes	$ 0.97						
		Ann OT	10%						
		Yrly Benefits	$ 6,400						
		Annual Miles/Veh	60,000						
		Vehs/Cleaner	20						
		Per Mile	$ 0.006						
		Per Hour			0.22				
	Parts/Mile		$ 0.35						
		Per Hour			12.25				
	Tires/Mile		$ 0.033						
		Per Hour			1.16				
	Deadhead/Non productive time		33%	$ 12.01	$ 4.93				
	Contingency		9%	5.00	2.50				
Totals				$ 52.98	$ 22.18	$ 75.16			

Appendix A

Criteria and Assumptions for FGT/RTT Second Level Screening Process

	Criteria	Assumptions	Highest	Highest to Intermediate	Intermediate	Intermediate to Lowest	Lowest
NEED	**System Capacity**	System capacity is based on conceptual ridership plans. The range is from an inability to provide seats for all passengers in peak direction during peak hours in opening year to an ability to provide seats for all peak hour passengers in peak direction forecast for year 20.	Significantly exceeds year 2020 demand	Somewhat exceeds year 2020 demand	Accommodates year 2020 demand.	Provides seats for opening year demand but not year 2020 demand.	Does not provide seats for all passengers in peak direction during peak hours in opening year demand.
	System Attractiveness	The relative attributes of the system technology to attract ridership based on the amenities and ride quality, including curvature, noise, food service, baggage handling, and susceptibility to weather conditions.	Vehicles in a guideway have higher ride quality, due to lower curvature, and quiet electric motors. Vehicles with food service, not as susceptible to weather conditions and full baggage handling.				Low ride quality is based on vehicles on the roadway in mixed traffic, greater curvature in the route, and high interior noise from power type and operations. Low amenities include vehicles with no food service, trip highly susceptible to weather and no baggage handling.
	Average Speed	Average Speed in mph including stops/dwell for 10 stops - time based on Vail to C-470 or Golden trip times.	> 60 mph	50 to 60 mph	40 to 50 mph	36 to 40 mph	<35 mph
	Connectivity	Connectivity in number of transfers required between modes. The "ideal" is origin to destination with no transfer between transit vehicles at either of the Mountain Corridor journey.	Vehicles can operate through to destination at both ends of corridor, including wide variety of origins/destinations (I.e. sites in Metro Denver, Winter Park, Breckinridge, etc.)	Vehicles can interoperate on systems planned at either end of corridor. No transfer required at either end.	Vehicles can interoperate on systems planned at Denver end of corridor. No transfer required at I-470.	Vehicles can interoperate on planned Vail-Eagle system. No transfer required at Vail.	Vehicles cannot interoperate on systems planned at either end of corridor.Transfers required at both ends
	Feeder/Distributor Requirements	Feeder/Distributor Requirements in percent change in vehicle miles from that presently used for local transit services in the Corridor.	Feeder systems in existence or no feeder system needed. Minimal change in local transit services required in the corridor. Utilizes these existing feeder systems as their network.		Feeder systems in existence. Moderate change in local transit services required in the corridor.		New feeder systems required. Significant change in local transit services required in the corridor.
SAFETY	**Safety System**	System Safety - Measures relative safety of the transit alternative considering the relative potential for crashes.	Heavyweight (FRA compliant) rail vehicles on new alignment	Middleweight rail vehicles on new alignment	Use of buses with professional drivers only on guided transitway. Lightest weight rail vehicles on new alignment.	Use of buses with professional drivers only on transitway.	Mixed traffic, including vans (with lightweight construction).
IMPLEMENTATION	**Infrastructure Cost**	Including associated highway improvements over a 50 year period.	<$10M/mile	$10-20M/mile	$20-30M/mile	$30-40M/mile	>$40M/mile
	Technology Availability	Criteria range from technologies that are currently available to operate within the corridor to technologies that are currently in the developmental or research stage. The range in between covers any modifications required to existing technologies for operation in the corridor. An additional factor relates to the percent grade that given technologies are capable of operating within.	System is able to operate in the corridor without modifications.	Minor modifications required	Technology exists but requires significant modifications.	Extensive modifications required	System is in the research and development stage.
	Fuel Availability	Identifies whether linehaul mode uses petroleum-based fuel (with its currently available supply and established production and distribution system), or has a heavy use of electricity, (which is presently dependent on relatively limited production and generation capabilities and the potential difficulty/expense in providing needed additional capacity.)	Uses existing facilities	Uses existing facilities with some modifications	Uses some existing facilities and some new infrastructure	Uses mostly new infrastructure	Uses all new infrastructure.
	Fuel Limitations	Federal Policy dictates that transit systems minimize the use of non-renewable fuel sources. This criteria measure whether the proposed system is capable of using non-renewable fuels.	Uses multiple, renewable fuel resources	Uses renewable fuel resources,	Uses a combination of non-renewable and renewable fuel resources	Uses mostly non-renewable fuel resources,	Uses only non-renewable fuel resources (fossil fuels).
	Energy Consumption	Relative rating based on system power requirements. Diesel fuel is assumed at $1.60/gal. Electrical energy is assumed at $0.10/kWH.	<$0.006/seat-mile	$0.006/seat-mile	$0.007seat-mile	$0.008/seat-mile	>$0.009/seat-mile

FGT Assumptions

With the exception of the AGS alternatives, only systems with actual working examples that are in regular service for one year, or more, are being evaluated (see FGT Examples).
Standard railroad gauge (4'8.5"/1435cm) examples were used, but other gauges could be utilized.
All systems assumed to be specified with air conditioning, reclining seats (and intercity seat pitch), rest rooms and, if desired, food service (except where noted).
All systems assumed to scheduled for no greater than seated loads (no standees).
All are assumed to be self-propelled (with multiple unit operation) except those identified as Locomotive hauled.
All electrically-powered trains are expected to be operated on either low voltage DC or high voltage AC systems.
All new FGT alignments, except light rail, will have no highway grade crossings except, possibly, in low speed areas.

		Typ. max. grades	Street legal	Limited train length	End doors	FRA compliant	Tilt avail.	Double-deck avail
1	Diesel Light Rail Transit, single track	6%	yes	yes (3 cars/294')	no	no	no	no
2	Diesel Light Rail Transit, double track	6%	yes	yes (3 cars/294')	no	no	no	no
3	Electric Light Rail Transit, single track	8%	yes	yes (3 cars/294')	no	no	no	no
4	Electric Light Rail Transit, double track	8%	yes	yes (3 cars/294')	no	no	no	no
5	Diesel Heavy Rail Transit, single track	6%	no	no	yes	no	yes	no
6	Diesel Heavy Rail Transit, double track	6%	no	no	yes	no	yes	no
7	Electric Heavy Rail Transit, single track	7%	no	no	yes	no	yes	yes
8	Electric Heavy Rail Transit, double track	7%	no	no	yes	no	yes	yes
9	Diesel Loco. hauled Passenger RR, single track	4%	no	no	yes	yes	yes	yes
10	Diesel Loco. hauled Passenger RR, double track	4%	no	no	yes	yes	yes	yes
11	Electric Loco. hauled Passenger RR, single track	4%	no	no	yes	yes	yes	yes
12	Electric Loco. hauled Passenger RR, double track	4%	no	no	yes	yes	yes	yes
13	Electric Multiple Unit Passenger RR, single track	6%	no	no	yes	yes	yes	yes
14	Electric Multiple Unit Passenger RR, double track	6%	no	no	yes	yes	no	yes
15	AGS, Conventional Monorail, double guideway	10%	no	no	yes	yes	no	yes
16	Electric CIFGA Monorail, double guideway	10%	no	no	yes	no	NA	no
18	Moffat Tunnel to Winter Pk. Diesel Loco. hauled Psg	2%	no	no	yes	no	NA	no
19	Moffat Tunnel to Glenwood Diesel Loco. hauled Psg	2%	no	no	yes	yes	yes	yes

Typ. max. grades	These are not the steepest grades that can be climbed by a given technology but, rather, the steepest that are used fairly routinely.
Street legal	Light rail trains can not only cross streets at grade but, where appropriate, run on streets intermixed with vehicle traffic.
Limited train length	Light rail train length is limited by the need to keep passenger stops within the length of a city block to avoid blocking intersections while stopped.
End doors	Doors between cars of a train are feature of all rail modes except light rail. These allow passengers to readily move to cars with available seats. They are required for systems with on-board fare collection (unless each car has a collector). They also facilitate food service, allowing a single dining car to serve patrons on an entire train.
FRA compliant	Identifies modes which are built to the Federal Railroad Administration's standards for buff strength ,etc. FRA standards must be met for operation on the national rail system. Because of their high buff strength characteristics, FRA-compliant equipment cannot normally be operated on light rail lines.
Tilt avail.	Identifies modes for which trains with tilting body capability (which allows faster operation through curves) has been built.
Double-deck avail	Identifies modes for which trains with double-deck bodies have been built.

FGT Examples

	Mode	Examples	Adaptations assumed for tested example
1, 2	Diesel Light Rail Transit	NJ Transit (Camden-Trenton), OC Transpo (Ottawa), several in Europe	Intercity seating, rest rooms, no food service
3, 4	Electric Light Rail Transit	RTD and multiple other U.S. systems. Karlsruhe (Germany) pioneered multi-voltage LRT and has food service for its longer	Intercity seating, rest rooms, no food service
5, 6	Diesel Heavy Rail Transit	Non-FRA compliant Diesel Multiple Unit (DMU) trains in various countries (including British, French, German and Australian). (Tilting DMUs have been built for German Federal Railways, Virgin Rail, Britain and Norwegian Railways)	All tested examples have tilting capability. Magnetic track brakes assumed for 6% grade alignment
7, 8	Electric Heavy Rail Transit	Non-FRA compliant Electric Multiple Unit (EMU) trains. EMUs built for railways throughout the world by multiple suppliers, including those built for mountain railroads, fall into this category. (Tilting EMU trains are operated in Italy Switzerland and Finland. Double Deck EMU trains are operated, including in France and Australia.)	All tested examples either have tilting capability or are double deck (combination is not available). Magnetic track brakes assumed for 6% grade alignment
9, 10	Diesel Loco. hauled Passenger RR	FRA-compliant trains such as Amtrak Amfleet, Horizon and NY State Turbotrains, as well as some commuter rail operations. (Double deck examples include Amtrak Superliners California cars and Pacific Surfliners as well as numerous commuter systems. Tilting examples include Amtrak Cascade Talgo trains.)	All tested examples either have tilting capability or are double deck (combination is not available). Locomotives on both ends for added power & dynamic braking.
11, 12	Electric Loco. hauled Passenger RR	FRA-compliant trains such as Amtrak Acela and Amfleet, as well as SEPTA and Maryland DOT commuter rail operations. (Double-deck examples include Maryland DOT and Long Island RR.)	All tested examples either have tilting capability or are double deck (combination is not available). Locomotives on both ends for added power & regenerative braking, magnetic track brakes assumed for 6% grade alignment
13, 14	Electric Multiple Unit Passenger RR	FRA-compliant EMU trains, as used by SEPTA, NJ Transit, Long Island RR, Metro North and South Shore. (Only FRA-compliant double deck example is Metra Electric-Chicago suburban.)	Both single and double deck examples are tested. Tilting capability not available. Magnetic track brakes assumed for 6% grade alignment
15	AGS, Conventional Monorail	The most common type of AGS is the supported monorail; they are operated in transit service (non-amusement park) in a variety of locations around the world. Suspended monorails are operating in Japan (Shonan and Chiba City)and Germany (Wuppertal and Dortmund University). No side-hanging systems have been built, although a major effort, including construction of a test track, is underway in South Carolina.	Intercity seating, rest rooms, no food service
16	Electric CIFGA Monorail	No systems have been built, to date; concept planning only.	Intercity seating
17	Moffat Tunnel to Winter Pk. Diesel Loco. hauled Psgr RR	see 9	Same as 9
18	Moffat Tunnel to Glenwood Diesel Loco. hauled Psgr RR	see 9	Same as 9

Suppliers

There has been a continuing, worldwide consolidation of suppliers in the railcar manufacturing industry. With this consolidation, some provide products over the complete range. Others specialize in only one or two areas.

AGS technologies are generally proprietary, with patented guideway technology. Guideway and all trains must be purchased from the same manufacturer.

RTT Assumptions

	All systems assumed to be specified with air conditioning, reclining seats and rest rooms.	
	All systems assumed to scheduled for no greater than seated loads (no standees).	
	All systems assumed to be limited to vehicles of carriers specifically certified for this operation; all drivers are professional drivers with Commercial Drivers License (CDL).	
	Use of Transitways will be limited to vehicles of carriers specifically certified for this operation; all drivers are professional drivers with Commercial Drivers License (CDL).	
	Peak direction-only alternatives utilize normal I-70 lanes for reverse-peak movements, which are assumed to be uncongested.	
	All RTT systems will be tested on existing I-70 alignment.	
1	Bus and Improved Van in mixed traffic	None
2	Diesel Bus in marked HOV lane, peak	An HOV lane (with shoulders) would be built, as a widening of each side of I-70. It would be operated as an HOV lane in the peak direction only. Access would be limited to buses, vans and automobiles with 3 or more riders.
3	Diesel Bus in marked HOV lane, both	An HOV lane (with shoulders) would be built, as a widening of each side of I-70. Access would be limited to buses, vans and automobiles with 3 or more riders.
4	Diesel Bus in separated HOV Lanes, peak	A double HOV lane (with shoulders) would be built as a separate roadway, either integrated with I-70 or parallel. It would be operated as a one direction two lane roadway, operated in the peak direction only, with reverse-flow operation in one direction. Entrance and exit ramps would be built at all "station" sites. Access would be limited to buses, vans and automobiles with 3 or more riders.
5	Diesel Bus in separate transitway, peak	A single lane (with shoulders) would be built as a separate roadway, either integrated with I-70 or parallel. It would be operated as a one direction roadway, operated in the peak direction only, with reverse-flow operation in regular I-70 lanes. Entrance and exit ramps would be built at all "station" sites. Access would be limited to buses and pre-authorized vans (driven by CDL holders).
6	Diesel Bus in separate transitway, both	A double lane (with shoulders) would be built as a separate roadway, either integrated with I-70 or parallel. It would be operated as a bi-directional roadway. No passing would be permitted. Entrance and exit ramps would be built at all "station" sites. Access would be limited to buses and pre-authorized vans (driven by CDL holders).
7	Diesel Bus in guided transitway, peak	A single lane would be built as a separate roadway equipped with guided bus technology (reducing lane width requirements) either integrated with I-70 or parallel. It would be operated as a one direction roadway, operated in the peak direction only, with reverse-flow operation in regular I-70 lanes. Dedicated entrance and exit ramps would be built at all "station" sites. Access would be limited to buses equipped for the guideway
8	Diesel Bus in guided transitway, both	Two guideway lanes would be built as a separate roadway equipped, either integrated with I-70 or parallel. They would be operated bi-directionally. Dedicated entrance and exit ramps would be built at all "station" sites. Access would be limited to buses equipped for the guideway technology.
9	Diesel Bus in guided transitway, BRT stations	Two guideway lanes would be built as a separate roadway equipped, either integrated with I-70 or parallel. They would be operated bi-directionally. On-line stations would be built at all "stations". Passing is permitted only at stations. Dedicated entrance and exit ramps would also be built at major "station" sites. Access would be limited to buses equipped for the guideway technology.
10	Dual Mode Bus in separate transitway, peak	Same as 5, except transitway and ramps would be equipped with overhead power supply for buses. Buses could operated as normal buses off wire.
11	Dual Mode Bus in separate transitway, both	Same as 6, except transitway and ramps would be equipped with overhead power supply for buses. Buses could operated as normal buses off wire. Buses could operated as normal buses off wire.
12	Dual Mode Bus in guided transitway, peak	Same as 7, except transitway and ramps would be equipped with power rails for buses. Buses could operate normally off guideway.
13	Dual Mode Bus in guided transitway, both	Same as 8, except transitway and ramps would be equipped with power rails for buses. Buses could operate normally off guideway.
14	Dual Mode Bus in guided transitway, BRT stations	Same as 9, except transitway and ramps would be equipped power rails for buses. Buses could operate normally off guideway.
15	Electric Bus in separate transitway, both	Same as 6, except transitway and ramps would be equipped with power rails for buses. Buses cannot operate off guideway.
16	Electric Bus in guided transitway, both	Same as 8, except transitway and ramps would be equipped with power rails for buses. Buses cannot operate off guideway.
17	Electric Bus in guided transitway, BRT stations	Same as 9, except transitway and ramps would be equipped with power rails for buses. Buses cannot operate off guideway. Buses cannot operate off guideway.

5/29/07

RTT Examples

	Mode	Examples	Adaptations assumed for tested example
1	Bus and Improved Van in mixed traffic	Marin Co., CA, Los Angeles, Seattle have BRT stations on freeways	None
2	Diesel Bus in marked HOV lane, peak	I-25, U.S. 36 (Boulder Tpke), New Jersey (XBL)	no BRT stations
3	Diesel Bus in marked HOV lane, both	Los Angeles (I-605-Harbor Freeway, includes BRT stations)	no BRT stations
4	Diesel Bus in separated HOV Lanes, peak	Washington D.C. (Shirley Highway)	
5	Diesel Bus in separate transitway, peak	Houston	
6	Diesel Bus in separate transitway, both	Pittsburgh, Ottawa, Curitiba (Brazil), (all have BRT stations)	no BRT stations
7	Diesel Bus in guided transitway, peak	none	
8	Diesel Bus in guided transitway, both	Adelaide, Australia	
9	Diesel Bus in guided transitway, BRT stations	Las Vegas (proposed)(slow speed)	Technology used in Las Vegas apparently limited to 70kph (42mph); Adelaide technology assumed
10	Dual Mode Bus in separate transitway, peak	none	
11	Dual Mode Bus in separate transitway, both	Seattle, Silver line, Boston (under construction)(both include downtown tunnels with BRT stations)	no BRT stations
12	Dual Mode Bus in guided transitway, peak	none	
13	Dual Mode Bus in guided transitway, both	none	
14	Dual Mode Bus in guided transitway, BRT stations	Caen, Lyon, Grenoble, Rouen (all in France, slow speed)	Technology used in France apparently limited to 70kph (42mph); Adelaide technology assumed
15	Electric Bus in separate transitway, both	Euclid Blvd., Cleveland (system in design, slow speed system, includes BRT stations)	high speed electric buses not proven; assumes they are feasible
16	Electric Bus in guided transitway, both	none	
17	Electric Bus in guided transitway, BRT stations	Essen, Germany (slow speed, discontinued)	

Appendix B

Types of FGT Equipment Tested

I-70 PEIS

Rail Equipment Analysis

Diesel LRT

Cars tested (from Railsim 7® Rolling Stock library)

Type	Length	Wt Lbs	Wt Tons	Axles	Continuous Power	Aux power from engine	Aux kW	Max Speed	Max Accel.	Max Decel.	Capacity	Max Train Length	Floor level	Comments
AEG RegioLiner DMU (LTG 260)	134	102,734	51.4	6	737HP	Y	40kW	74MPH	2.17MPH/s	3.07MPH/s	117	4	LL	
Siemens-Duewag 628.4 Light Diesel	151.8	154,880	77.4	8	650HP	N		75MPH	2.5MPH/s	3.0MPH/s	148	4	LL	
NJT 2000-2001 SNJ Concept Art	95	107,000	53.5	6	600HP	Y	40KW	60MPH	2.5MPH/s	6.0MPH/s	80	4	LL	
Siemens Regio Sprinter VT4N	**81.5**	**66,138**	**33.1**	**4**	**530HP**	**Y**	**40KW**	**60MPH**	**2.96MPH/s**	**6.5MPH/s**	**74**	**4**	**LL**	

Trains tested

		Modifications assumed					Test results I-470 - Vail								
							Highway alignment			6% alignment			4% alignment		
Type	No. of cars	Train Length (ft.)	Car Capac.	Train Capac.	Other	Comments	Avg. Speed	Elapsed Time	Gallons fuel used	Avg. Speed	Elapsed Time	Gallons fuel used	Avg. Speed	Elapsed Time	Gallons fuel used
AEG RegioLiner DMU (LTG 260)	4	536	93	372				stalled			stalled		insufficient braking		
Siemens-Duewag 628.4 Light Diesel	4	607	118	472			36.6	2:22	224		stalled		40.1	2:16	212
NJT 2000-2001 SNJ Concept Art	4	380	64	256			41.7	2:04	178	41.5	2:05	180	44.8	2:02	160
Siemens Regio Sprinter VT4N	**4**	**326**	**59**	**236**			**46.1**	**1:52**	**131.6**	**45.8**	**1:53**	**133**	**48.7**	**1:52**	**120.2**

I-70 PEIS

Rail Equipment Analysis

Electric LRT

Cars tested (from Railsim 7® Rolling Stock library)

Type	Length	Wt Lbs	Wt Tons	Axles	Continuous Power	Aux kW	Max Speed	Max Accel	Max Decel	Capacity	Max Train Length	Current	Floor level	Comments
Denver RTD 1998-99 Siemens-Duewag	79.7	88,660	44.3	6	813	40	55	3.0MPH/s	3.5MPH/s	64	4	750Vdc	LL	
Boston MBTA 1998-2001 Breda #8 LRV	74	86,000	43	6	520	40	55	2.8MPH/s	6.0MPH/s	46	3	620Vdc	LL	
Buffalo NFTA 1984-85 Tokyu Car LRV	66.8	66,000	33	4	540	40	55	3.0MPH/s	3.5MPH/s	51	4		HL	Non-Articulated
Dallas DART 2000-01 Kinki-Sharyo/Itochu	92.6	107,000	53.5	6	750	40	65	3.5MPH/s	3.5MPH/s	76	4	750Vdc	LL	
NJ Transit Newark/HBLRT Kinki-Sharyo/Alstom	89.6	99,337	49.7	6	643	40	55	3.5MPH/s	4.5MPH/s	72	4	750Vdc	LL	
Portland Tri-Met 1997-9 Type 2/SD Low Floor	91.9	109,000	54.5	6	752	40	55	3.5MPH/s	6.0MPH/s	72	4	650Vdc	LL	
Sacramento SRTD 2001-03 High Floor LRV	79.7	77,162	38.6	6	507	40	55	2.9MPH/s	6.5MPH/s	64	4	750Vdc	HL	
San Jose Santa Clara VTA 200 Low Floor LR	**88.6**	**100,000**	**50**	**6**	**1050**	**40**	**55**	**3.5MPH/s**	**5.0MPH/s**	**68**	**3**	**750Vdc**	**LL**	
Karlsruhe VBK 1994-95 GT8-100C/S2	123	129,189	61.5	8	657	40	62	2.5MPH/s	4.1MPH/s	101	4	15000ac	HL	dual voltage(also 15000Vdc)

Trains tested

Type	No. of cars	Train Length (ft.)	Car Capac.	Train Capac.	Other	Highway alignment Avg. Speed	Highway alignment Elapsed Time	Highway alignment kwh used	Test results I-470 - Vail 6% alignment Avg. Speed	6% alignment Elapsed Time	6% alignment kwh used	4% alignment Avg. Speed	4% alignment Elapsed Time (min)	4% alignment kwh used
Denver RTD 1998-99 Siemens-Duewag	4	319	51	204		47.5	1:49	2379	47.3	1:49	2414	49.3	1:50	2173
Boston MBTA 1998-2001 Breda #8 LRV	3	222	37	111		42.7	2:01	1695	42.5	2:02	1708	45.1	2:01	1536
Buffalo NFTA 1984-85 Tokyu Car LRV	4	268	41	164		46.1	1:52		45.9	1:53		48	1:53	
Dallas DART 2000-01 Kinki-Sharyo/Itochu	4	370	61	244		47.2	1:50	2877	46.9	1:51	2910	50.2	1:49	2636
NJ Transit Newark/HBLRT Kinki-Sharyo/Alstom	4	358	58	232		43.6	1:59	2528	9:36	2:00	2557	47.7	1:54	2250
Portland Tri-Met 1997-9 Type 2/SD Low Floor	4	368	58	232		44.7	1:56	2742	44.5	1:57	2774	46.9	1:56	2479
Sacramento SRTD 2001-03 High Floor LRV	4	319	51	204		40.7	2:08	2058	40.3	2:09	2083	42.3	2:09	1873
San Jose Santa Clara VTA 200 Low Floor LR	**3**	**266**	**55**	**165**		**48.6**	**1:47**	**2003**	**48.4**	**1:47**	**2028**	**49.9**	**1:49**	**1823**
Karlsruhe VBK 1994-95 GT8-100C/S2	4	492	98	392		40.8	2:07	3283	40.6	2:08	3303	44.2	2:03	2970

Modifications assumed

I-70 PEIS

Rail Equipment Analysis

Diesel Heavy Rail Transit (HRT)

Cars tested (from Railsim 7® Rolling Stock library)

Type	Length	Wt Lbs	Wt Tons	Axles	Continuous Power	Aux power from engine	Aux kW	Max Speed	Max Accel	Max Decel	Capacity	Max Train Length	Floor Level	Comments
Melbourne Metropolitan Transit Comeng MU	78.8	97,827	48.9	4	432HP	N		71.8MPH	2.74MPH/s	2.74MPH/s	97	12	HL	
RENFE Spanish 1999 Talgo 1668 DMU-12	49	53,278	26.5	1.25	335HP/u			136MPH	1.45MPH/s		396	12		
BR British 1992 ABB 166TT DMU-3 Turbo	73.2	86,532	43.3	4	349HP/u			89.5MPH	2.2MPH/s l	.89MPH/s jr	274	12		
ABB Explorer/Endeavour DMU-3	**79.6**	**128,590**	**64.3**	**4**	**473HP**			**90.6MPH**	**2.5MPH/s l**	**1.79MPH/s sr**	**162**	**12**		
Hong Cong MTRC 1981-95 Alstom RT	80	97386	48.7	4	1273HP	N	40	84MPH	2.74MPH/s	2.96MPH/s	60	12		

Trains tested

Type	No. of cars	Train Length (ft.)	Modifications assumed: Car Capac.	Train Capac.	Other	Comments	Test results I-470 - Vail: Highway alignment: Avg. Speed	Elapsed Time (min)	Gallons fuel used	6% alignment: Avg. Speed	Elapsed Time (min)	Gallons fuel used	4% alignment: Avg. Speed	Elapsed Time (min)	Gallons fuel used
Melbourne Metropolitan Transit Comeng MU	12	945.6	77	924				not tested			not tested		FAILED	Insufficient Brakes	
RENFE Spanish 1999 Talgo 1668 DMU-12	12	588	33	396				not tested			not tested		FAILED	Stalled on grade	
		0		0											
		0		0											
BR British 1992 ABB 166TT DMU-3 Turbo	12	878.4	219 (3)	876				not tested			not tested		33.2	2:44	424
ABB Explorer/Endeavour DMU-3	**12**	**955.2**	**130 (3)**	**520**		**With FS Cap is 497**		**not tested**					**36.4**	**2:30**	471
Hong Cong MTRC 1981-95 Alstom RT	12	960	48	576				not tested			not tested		FAILED	Stalled on grade	

I-70 PEIS

Rail Equipment Analysis

Electric Heavy Rail Transit (HRT)

Cars tested (from Railsim 7® Rolling Stock library)

Type	Length	Wt Lbs	Wt Tons	Axles	Continuous Power	Aux kW	Max Speed	Max Accel.	Max Decel.	Cars in set	Car Capacity	Set Capacity	Current	Floor level	Tilt	DD	Comments
Heathrow Exp Class 332 EMU	67.2	75,178	37.6	4	402/u		99MPH	2.24MPH/s	1.0MPH/s	4	62	248		HL			
DB AG German 1999 Class 426 EMU	55.4	59,525	29.8	4	250/u	50	62MPH	2.23MPH/s l	1.0MPH/s sr	2	50	100	1500Vdc				
Paris RER 1996 Alstom/ANF MI 2N BiLevel EMU-5	73.5	126,985	63.5	4	965	66	86.9MPH	2.96MPH/s	2.96MPH/s	5	80	400	25000Vac	HL		Y	
Paris SNCF Z20500 BiLevel EMU-4																	
Modified Pendolino EMU																	
Example EMU r2																	

Trains tested

Type	No. of cars	Train Length (ft.)	Car Capac.	Train Capac.	Other	Comments	Highway alignment: Avg. Speed	Highway alignment: Elapsed Time	Highway alignment: kwh used	6% alignment: Avg. Speed	6% alignment: Elapsed Time	6% alignment: kwh used	4% alignment: Avg. Speed	4% alignment: Elapsed Time	4% alignment: kwh used
Heathrow Exp Class 332 EMU	12	806	57	684				not tested		FAILED	Insuf Brakes		FAILED	Insuf Brakes	
DB AG German 1999 Class 426 EMU	12	665	40	480				not tested		FAILED	Stalled on grade		34.4	2:38	5378
Paris RER 1996 Alstom/ANF MI 2N BiLevel EMU-5	10	735		0				not tested			Not Tested		FAILED	Stalled on grade	
Paris SNCF Z20500 BiLevel EMU-4	8			0				not tested			Not Tested		FAILED	Stalled on grade	
Modified Pendolino EMU	6							not tested			Not Tested		FAILED	Stalled on grade	
Example EMU r2								not tested		44.5	1:56	6842	47.1	1:56	6249

Test results I-470 - Vail

I-70 PEIS

Rail Equipment Analysis

Electric Multiple Unit Passenger RR

Cars tested (from Railsim 7® Rolling Stock library)

Type	Length	Wt Lbs	Wt Tons	Axles	Continuous Power	Aux kW	Max Speed	Max Accel.	Max Decel.	Capacity	Max Train Length	Current	Floor Level	Comments
Amtrak 1999 Bombardier/Alstom Acela 6 Cars	83	122,571	61.3	4	857.9		160	2.5MPH/s	2.75MPH/s	259	8	25000Vac	HL & LL	
NICTD Indiana South Shore 2000-1 EMU-1	85	119,000	59.5	4	600		79	1.95MPH/s	2.5MPH/s	110	8	1500Vdc	HL & LL	
Montreal AMT 1994-95 Class MR90	**85.3**	**113,000**	**56.5**	**4**	**760**	**62.5**	**68**	**2.0MPH/s**	**3.0MPH/s**	**88**	**8**	**25000Vac**	**HL & LL**	
NJT 1977-78 Jersey Arrow III	85	138,280	69.1	4	1340	80	100	2.3MPH/s	2.5MPH/s	119	14	25000Vac	HL & LL	

Trains tested

		Modifications assumed					Test results I-470 - Vail								
							Highway alignment			6% alignment			4% alignment		
Type	No. of cars	Train Length (ft.)	Car Capac.	Train Capac.	Other	Comments	Avg. Speed	Elapsed Time (min)	kwh used	Avg. Speed	Elapsed Time (min)	kwh used	Avg. Speed	Elapsed Time (min)	kwh used
Amtrak Acela	6	638	43	258				not tested	FAILED Stalled on grade			FAILED Stalled on grade			
NICTD EMU-1	8	680	88	704				not tested		42.8	2:01	6192	Insufficient Brakes		
Montreal AMT MR90	**8**	**682**	**70**	**560**				**not tested**		**42.8**	**2:01**	**6192**	**45.7**	**1:59**	**6899**
NJT 1977078 Jersey Arrow III	14	1190	95	1330				not tested	FAILED Insufficient Brakes			FAILED Stalled on grade			

I-70 PEIS

Rail Equipment Analysis

Passenger RR, locomotives & cars

Locomotives tested (from Railsim 7® Rolling Stock library)

Type	Length	Wt Lbs	Wt Tons	Axles	Max Ad	Continuous Power	Aux Power from Engine	Aux kW	Max Speed	Max Accel	Max Decel	Electric Current	Comments
Diesel locomotives													
Amtrak Genesis P42 Diesel	66.3	264,000	132	4	25.00%	4250HP	Y	29	103MPH	2.0MPH/s	2.0MPH/s		
Bombardier/US FRA/Allied Signal 2000 TE40 Diesel Turbine (Flywheel Equipped)	75	200,000	100	4	25.00%	4000HP		29	150MPH	2.0MPH/s	2.0MPH/s		
DE30AC EMD Low Profile Diesel Locomotive	75	300,000	150	4	31.00%	3000HP		29	100MPH	2.5MPH/s	2.7MPH/s		
F40PHM-2 Metra Diesel	56.2	265,500	133	4	25.00%	3200HP	Y	29	80MPH	2.0MPH/s	2.0MPH/s		
Amtrak and Metro North P32AC-DM (AMD 110 Diesel)	69	274,400	137.2	4	22.80%	3300HP	Y	29	110MPH	2.0MPH/s	2.0MPH/s		
F59PHI Amtrak California and Cascade Diesel	58.2	265,500	133	4	25.00%	3200HP	N	29	110MPH	2.0MPH/s	2.0MPH/s		
User Defined DE70AC EMD Low Profile Diesel	75	300,000	150	4	33%	4000HP	N	29	100MPH	2.7MPH/s	2.7MPH/s		
User Defined P42AC Diesel	70	300,000	140	4	33%	4250HP	N	29	100MPH	2.7MPH/s	2.7MPH/s		
Electric locomotives													
Amtrak AEM7 25KV Electric	51.1	201,750	101	4	20.70%	5790HP	N	123	135MPH	2.5MPH/s	2.5MPH/s	25000Vac	High Horsepow

Cars tested (from Railsim 7® Rolling Stock library)

Type	Length	Wt Lbs	Wt Tons	Axles	Capacity	Prop Cap	Max Speed	Svc Brk Rate	Platform	Comments
Amtrak WSDOT 1997 Talgo Train Set	509	357,005	178.5	13	251	251	79	2.89MPH/s	LL	Extremely Lightweight, Low Capacity,
Amtrak WSDOT 1997 Talgo Train Set - Two Consists	1,018	714,010	357	26	502	502	79	2.89MPH/s	LL	Quiet and Comfortable
NICTD South Shore TMU-1 Nippon Sharyo Trailer	85	119,000	59.5	4	130	104	79	1.0MPH/s	HL & LL	Would need extensive interior modifications
Caltrans 1993 MK Bi-Level California Car	85	120,000	60	4	90	90	125	1.5MPH/s	LL	Some design modifications - ski storage
GO Transit Single Level Coach	85	67,600	33.8	4	94	74	83	1.0MPH/s	HL & LL	Verify Denver Ski Train modifications
MARC 1985-87 Sumitomo Single Level Coach	85	93,920	46.9	4	121	96	110	1.0MPH/s	HL & LL	Would need extensive interior modifications
MARC Mitsui/Kawasaki Bi-Level Coach	85	130,000	65	4	148	118	110	1.0MPH/s	HL & LL	Would need extensive interior modifications
Amtrak Heritage Baggage Car	73.6	150,000	75	4			110	1.0MPH/s		
Amtrak Superliner Bi-Level Coach Baggage	85	165,600	82.8	4	72	72	110	1.0MPH/s	LL	Has ski storage capacity
Amtrak Superliner II Bi-Level Diner	85	158,000	79	4	72	72	110	1.0MPH/s	LL	
Amtrak Superliner II Bi-Level Lounge	85	151,000	75.5	4	68	68	110	1.0MPH/s	LL	
Amtrak Superliner II Bi-Level Sleeper	85	160,000	80	4	44	44	110	1.0MPH/s	LL	
Caltrain 1985-87 Nippon Sharyo Bi-Level Commuter Co	85	113,000	56.5	4	148	118	100	1.0MPH/s	LL	Would need extensive interior modifications
LIRR 1990 C-1 ABB/Tokyu Bi-Level Commuter Coach	85	127,600	63.8	4	190	152	80	1.0MPH/s	HL	Low profile, Large windows, 2 mid car side doors
Altamont 1997 Bombardier Bi-Level Commuter Coach	85	117,500	58.8	4	139	111	84	2.0MPH/s	LL	Would need extensive interior modifications
MBTA 1991 Kawasaki BTC Bi-Level Commuter Coach	85.3	120,600	60.3	4	185	148	80	1.0MPH/s	HL & LL	Would need extensive interior modifications

Diesel Trains tested

Type	No. of cars	No. of locos	Train Length (ft.)	Modifications assumed: Avg. Car Capac.	Train Capac.	Other	Comments	Highway alignment: Avg. Speed	Elapsed Time (min)	Gallons fuel used	Test results I-470 - Vail 6% alignment: Avg. Speed	Elapsed Time (min)	Gallons fuel used	4% alignment: Avg. Speed	Elapsed Time (min)	Gallons fuel used
2 AMTK P42 & 6 Altamont Bombardier Commuter Ch	6	2	643.6	125	687				not tested			not tested		FAILED - Insufficient Brakes		
			0		0				not tested							
			0		0				not tested							
			0		0				not tested							
			0		0				not tested							
									not tested							
			0		0											
			0		0											

Electric Trains tested

Type	No. of cars	No. of locos	Train Length (ft.)	Modifications assumed: Car Capac.	Train Capac.	Other	Comments	Highway alignment: Avg. Speed	Elapsed Time (min)	kwh used	Test results I-470 - Vail 6% alignment: Avg. Speed	Elapsed Time (min)	kwh used	4% alignment: Avg. Speed	Elapsed Time (min)	kwh used
2 ALP44 & 6 Altamont Bombardier Commuter Ch	6	2	0	125	687				not tested			not tested			STALLED	
			#VALUE!		0				not tested							
			0		0				not tested							
			0		0				not tested							
			0		0				not tested							
			0		0				not tested							
			0		0											

Appendix C

FGT and RTT Electrification Costs

Alternatives

FGT	3	Electric Light Rail Transit, single track	See Tab LRT-Single	$	210,000,000
	4	Electric Light Rail Transit, double track	See Tab LRT-Double	$	400,000,000
	7	Electric Heavy Rail Transit, single track	See Tab HRT-Single	$	230,000,000
	8	Electric Heavy Rail Transit, double track	See Tab HRT-Double	$	400,000,000
	13	Electric Multiple Unit Passenger RR, single track	See Tab RR EMU-Single	$	230,000,000
	14	Electric Multiple Unit Passenger RR, double track	See Tab RR EMU-Double	$	405,000,000
	15	Electric Supported Monorail, double guideway	See Tab AGS	$	185,000,000
RTT	11	Dual Mode Bus in separate transitway, peak	See Tab DMB Peak	$	100,000,000
	12	Dual Mode Bus in separate transitway, both	See Tab DMB Both	$	185,000,000
	13	Dual Mode Bus in guided transitway, peak	See Tab DMB Peak	$	100,000,000
	14	Dual Mode Bus in guided transitway, both	See Tab DMB Both	$	185,000,000
	15	Dual Mode Bus in guided transitway, BRT stations	See Tab DMB Both	$	185,000,000
	16	Electric Bus in separate transitway, both	See Tab Electric Bus	$	235,000,000
	17	Electric Bus in guided transitway, both	See Tab Electric Bus	$	235,000,000
	18	Electric Bus in guided transitway, BRT stations	See Tab Electric Bus	$	235,000,000

Electric Light Rail Transit
Single Track

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	261	$ 18,480	$ 4,823,280	$ 2,893,968	$ 7,717,248
12 KV INSULATORS	EA.	6873	$ 45	$ 309,285	$ 185,571	$ 494,856
12 KV SPACERS	EA.	6873	$ 15	$ 103,095	$ 61,857	$ 164,952
3000 KVA SUBSTATION	EA.	11	$ 105,000	$ 1,155,000	$ 693,000	$ 1,848,000
AUTOMATIC TIE SWITCH	EA.	10	$ 5,000	$ 50,000	$ 30,000	$ 80,000
CATENARY POLES	EA.	2291	$ 3,000	$ 6,873,000	$ 4,123,800	$ 10,996,800
CATENARY POLES XO	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY POLES PASSING	EA.	216	$ 3,000	$ 648,000	$ 388,800	$ 1,036,800
CATENARY SYSTEM MAIN LINE	FT.	458220	$ 200	$ 91,644,000	$ 54,986,400	$ 146,630,400
CATENARY SYSTEM XO	FT.	0	$ 200	$ -	$ -	$ -
CATENARY SYSTEM PASSING	FT.	4400	$ 200	$ 880,000	$ 528,000	$ 1,408,000
SCADA	EA.	11	$ 10,000	$ 110,000	$ 66,000	$ 176,000
CIRCUIT BRK. AUTO RELCLOSE	EA.	44	$ 40,000	$ 1,760,000	$ 1,056,000	$ 2,816,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 173,369,056
					20% CONT	$ 34,673,811
						$ 208,042,867
		Cost/Mile	$ 2,397,360		Cost Rounded to	$ 210,000,000

System Voltage =25,000 v a.c.
System Length=86.8 miles
A.) Base Consist= 4 cars
B.) Base Energy required in KWH =2004 KWh
C.) Energy required in KVA=B.x1.38=2766KVA
D.) Number of consists required=6
E.) Energy required one direction=CxD=16,594KVA
F.) Energy required for both directions=2xE=33,187KVA
G.) Substations required(one/ stop+2)=11
H.) Substation KVA=F/G=3016KVA
I.) One track with passing siding spaced 4 miles apart

Electric Light Rail Transit
Double track

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	261	$ 18,480	$ 4,823,280	$ 2,893,968	$ 7,717,248
12 KV INSULATORS	EA.	6873	$ 45	$ 309,285	$ 185,571	$ 494,856
12 KV SPACERS	EA.	6873	$ 15	$ 103,095	$ 61,857	$ 164,952
3000 KVA SUBSTATION	EA.	11	$ 105,000	$ 1,155,000	$ 693,000	$ 1,848,000
AUTOMATIC TIE SWITCH	EA.	20	$ 5,000	$ 100,000	$ 60,000	$ 160,000
CATENARY POLES	EA.	4583	$ 3,000	$ 13,749,000	$ 8,249,400	$ 21,998,400
CATENARY POLES XO	EA.	55	$ 3,000	$ 165,000	$ 99,000	$ 264,000
CATENARY POLES PASSING	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY SYSTEM MAIN LINE	FT.	916438	$ 200	$ 183,287,600	$ 109,972,560	$ 293,260,160
CATENARY SYSTEM XO	FT.	5424	$ 200	$ 1,084,800	$ 650,880	$ 1,735,680
CATENARY SYSTEM PASSING	FT.	0	$ 200	$ -	$ -	$ -
SCADA	EA.	11	$ 10,000	$ 110,000	$ 66,000	$ 176,000
CIRCUIT BRK. AUTO RELCLOSE	EA.	66	$ 40,000	$ 2,640,000	$ 1,584,000	$ 4,224,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 332,043,296
					20% CONT	$ 66,408,659
						$ 398,451,955
		Cost/Mile	$ 4,591,518		Cost Rounded to	$ 400,000,000

System Voltage =25,000 v a.c.
System Length=86.8 miles
A.) Base Consist= 4 cars
B.) Base Energy required in KWH =2004 KWh
C.) Energy required in KVA=B.x1.38=2766KVA
D.) Number of consists required=6
E.) Energy required one direction=CxD=16,594KVA
F.) Energy required for both directions=2xE=33,187KVA
G.) Substations required(one/ stop+2)=11
H.) Substation KVA=F/G=3016KVA
I.) Two track with crossover(XO) spaced 8 miles.

Electric Heavy Rail Transit
Single Track

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	260	$ 18,480	$ 4,804,800	$ 2,882,880	$ 7,687,680
12 KV INSULATORS	EA.	6,856	$ 45	$ 308,520	$ 185,112	$ 493,632
12 KV SPACERS	EA.	6,856	$ 15	$ 102,840	$ 61,704	$ 164,544
10000 KVA SUBSTATION	EA.	12	$ 350,000	$ 4,200,000	$ 2,520,000	$ 6,720,000
AUTOMATIC TIE SWITCH	EA.	10	$ 5,000	$ 50,000	$ 30,000	$ 80,000
CATENARY POLES	EA.	2,286	$ 3,000	$ 6,858,000	$ 4,114,800	$ 10,972,800
CATENARY POLES XO	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY POLES PASSING	EA.	216	$ 3,000	$ 648,000	$ 388,800	$ 1,036,800
CATENARY SYSTEM MAIN LINE	FT.	457,055	$ 200	$ 91,411,000	$ 54,846,600	$ 146,257,600
CATENARY SYSTEM XO	FT.	0	$ 200	$ -	$ -	$ -
CATENARY SYSTEM PASSING	FT.	44,000	$ 200	$ 8,800,000	$ 5,280,000	$ 14,080,000
SCADA	EA.	48	$ 10,000	$ 480,000	$ 288,000	$ 768,000
CIRCUIT BRK. AUTO RELCLOSE	EA.	10	$ 40,000	$ 400,000	$ 240,000	$ 640,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 188,901,056
					20% CONT	$ 37,780,211
						$ 226,681,267
		Cost/Mile			Cost Rounded to	$ 230,000,000

System Voltage = 25,000 v.a.c
System Length = 86.6
A.) Base Consist = 14 cars/consist
B.) Base Energy required in KWH = 6,843 KWH
C.) Energy required in KVA = B.x1.38 = 9,443 KWH
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 56,660 KVA
F.) Energy required for both directions = 2xE = 113,320 KVA
G.) Substations required(one/ stop+2) = 12
H.) Substation KVA = F/G = 9443 KVA
I.) One Track with Passing Siding Spaced 4 Miles Apart

Electric Heavy Rail Transit
Double Track

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	260	$ 18,480	$ 4,804,800	$ 2,882,880	$ 7,687,680
12 KV INSULATORS	EA.	6,856	$ 45	$ 308,520	$ 185,112	$ 493,632
12 KV SPACERS	EA.	6,856	$ 15	$ 102,840	$ 61,704	$ 164,544
10000 KVA SUBSTATION	EA.	12	$ 350,000	$ 4,200,000	$ 2,520,000	$ 6,720,000
AUTOMATIC TIE SWITCH	EA.	22	$ 5,000	$ 110,000	$ 66,000	$ 176,000
CATENARY POLES	EA.	4,570	$ 3,000	$ 13,710,000	$ 8,226,000	$ 21,936,000
CATENARY POLES XO	EA.	55	$ 3,000	$ 165,000	$ 99,000	$ 264,000
CATENARY POLES PASSING	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY SYSTEM MAIN LINE	FT.	914,110	$ 200	$ 182,822,000	$ 109,693,200	$ 292,515,200
CATENARY SYSTEM XO	FT.	5,410	$ 200	$ 1,082,000	$ 649,200	$ 1,731,200
CATENARY SYSTEM PASSING	FT.	0	$ 200	$ -	$ -	$ -
SCADA	EA.	72	$ 10,000	$ 720,000	$ 432,000	$ 1,152,000
CIRCUIT BRK. AUTO RELCLOSE	EA.	12	$ 40,000	$ 480,000	$ 288,000	$ 768,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 333,608,256
					20% CONT	$ 66,721,651
						$ 400,329,907
		Cost/Mile			Cost Rounded to	$ 400,000,000

System Voltage = 25,000 v.a.c
System Length = 86.6 miles
A.) Base Consist = 14 cars/consist
B.) Base Energy required in KWH = 6,843 KWH
C.) Energy required in KVA = B.x1.38 = 9,443 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 56,660 KVA
F.) Energy required for both directions = 2xE = 113,320 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 9,443 KVA
I.) Two Tracks with Crossover (XO) Spaced 8 Miles Apart

Electric Multiple Unit Passenger RR
Single Track

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	260	$ 18,480	$ 4,804,800	$ 2,882,880	$ 7,687,680
12 KV INSULATORS	EA.	6,856	$ 45	$ 308,520	$ 185,112	$ 493,632
12 KV SPACERS	EA.	6,856	$ 15	$ 102,840	$ 61,704	$ 164,544
9000 KVA SUBSTATION	EA.	12	$ 315,000	$ 3,780,000	$ 2,268,000	$ 6,048,000
AUTOMATIC TIE SWITCH	EA.	10	$ 5,000	$ 50,000	$ 30,000	$ 80,000
CATENARY POLES	EA.	2,286	$ 3,000	$ 6,858,000	$ 4,114,800	$ 10,972,800
CATENARY POLES XO	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY POLES PASSING	EA.	216	$ 3,000	$ 648,000	$ 388,800	$ 1,036,800
CATENARY SYSTEM MAIN LINE	FT.	457,095	$ 200	$ 91,419,000	$ 54,851,400	$ 146,270,400
CATENARY SYSTEM XO	FT.	0	$ 200	$ -	$ -	$ -
CATENARY SYSTEM PASSING	FT.	44,000	$ 200	$ 8,800,000	$ 5,280,000	$ 14,080,000
SCADA	EA.	12	$ 10,000	$ 120,000	$ 72,000	$ 192,000
CIRCUIT BRK. AUTO RELCLOSE	EA.	72	$ 40,000	$ 2,880,000	$ 1,728,000	$ 4,608,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 191,633,856
					20% CONT	$ 38,326,771
						$ 229,960,627
		Cost/Mile			Cost Rounded to	$ 230,000,000

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) One track with passing siding spaced 4 miles apart

Electric Multiple Unit Passenger RR
Double Track

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	260	$ 18,480	$ 4,804,800	$ 2,882,880	$ 7,687,680
12 KV INSULATORS	EA.	6,856	$ 45	$ 308,520	$ 185,112	$ 493,632
12 KV SPACERS	EA.	6,856	$ 15	$ 102,840	$ 61,704	$ 164,544
9000 KVA SUBSTATION	EA.	12	$ 315,000	$ 3,780,000	$ 2,268,000	$ 6,048,000
AUTOMATIC TIE SWITCH	EA.	10	$ 5,000	$ 50,000	$ 30,000	$ 80,000
CATENARY POLES	EA.	4,570	$ 3,000	$ 13,710,000	$ 8,226,000	$ 21,936,000
CATENARY POLES XO	EA.	55	$ 3,000	$ 165,000	$ 99,000	$ 264,000
CATENARY POLES PASSING	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY SYSTEM MAIN LINE	FT.	914,110	$ 200	$ 182,822,000	$ 109,693,200	$ 292,515,200
CATENARY SYSTEM XO	FT.	5,410	$ 200	$ 1,082,000	$ 649,200	$ 1,731,200
CATENARY SYSTEM PASSING	FT.	0	$ 200	$ -	$ -	$ -
SCADA	EA.	12	$ 10,000	$ 120,000	$ 72,000	$ 192,000
CIRCUIT BRK. AUTO RELCLOSE	EA.	72	$ 40,000	$ 2,880,000	$ 1,728,000	$ 4,608,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 335,720,256
					20% CONT	$ 67,144,051
						$ 402,864,307
		Cost/Mile			Cost Rounded to	$ 405,000,000

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/trains
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 51,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 12
H.) Substation KVA = F/G = 8,544
I.) Two Track with Crossover (XO) Spaced 8 Miles Apart

Electric AGS
Double Guideway

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	260	$ 18,480	$ 4,804,800	$ 2,882,880	$ 7,687,680
12 KV INSULATORS	EA.	6856	$ 45	$ 308,520	$ 185,112	$ 493,632
12 KV SPACERS	EA.	6856	$ 15	$ 102,840	$ 61,704	$ 164,544
2500 KVA SUBSTATION	EA.	44	$ 130,000	$ 5,720,000	$ 3,432,000	$ 9,152,000
AUTOMATIC TIE SWITCH	EA.	42	$ 5,000	$ 210,000	$ 126,000	$ 336,000
POSITIVE CONTACT RAIL	FT.	914110	$ 35	$ 31,993,850	$ 19,196,310	$ 51,190,160
NEGATIVE CONTACT RAIL	FT.	914110	$ 35	$ 31,993,850	$ 19,196,310	$ 51,190,160
CONTACT RAIL SUPPORTS*	EA.	304703	$ 30	$ 9,141,090	$ 5,484,654	$ 14,625,744
POSITIVE CONTACT RAIL (XO)	FT.	2164	$ 35	$ 75,740	$ 45,444	$ 121,184
NEGATIVE CONTACT RAIL (XO)	FT.	2164	$ 35	$ 75,740	$ 45,444	$ 121,184
CONTACT RAIL SUPPORTS (XO)*	EA.	722	$ 30	$ 21,660	$ 12,996	$ 34,656
SCADA	EA.	44	$ 10,000	$ 440,000	$ 264,000	$ 704,000
CIRCUIT BRK. AUTO RECLOSE (a.c.-1/sub.)	EA.	44	$ 40,000	$ 1,760,000	$ 1,056,000	$ 2,816,000
CIRCUIT BRK. AUTO RECLOSE (d.c.-4/sub.)	EA.	176	$ 50,000	$ 8,800,000	$ 5,280,000	$ 14,080,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 152,716,944
					20% CONT	$ 30,543,389
						$ 183,260,333
		Cost/Mile			Cost Rounded to	$ 185,000,000
* Total length contact rail @ 6' spacing						
	Based on Vancouver Skytrain (LIM)					
	System Voltage = 750V d.c.					
	System Length = 86.6 mile					
	A.) Base Consist = 6 cars/consist					
	B.) Base Energy required in KWH = 6842 KWH					
	C.) Energy required in KVA=B.x1.38= 9442 KVA					
	D,) Number of consists required= 6					
	E.) Energy required one direction=CxD= 56,652 KVA					
	F.) Energy required for both directions=2xE= 113,304 KVA					
	G.) Substations required (one every 2 miles)=44					
	H.) Substation KVA=F/G=2575 KVA					
	I.) Two track with crossover (XO) spaced 8 miles apart					

Dual Mode Bus
Peak Direction Only

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	194	$ 18,480	$ 3,585,120	$ 2,151,072	$ 5,736,192
12 KV INSULATORS	EA.	13619	$ 45	$ 612,855	$ 367,713	$ 980,568
12 KV SPACERS	EA.	13619	$ 15	$ 204,285	$ 122,571	$ 326,856
1000 KVA SUBSTATION W/RECT	EA.	32	$ 50,000	$ 1,600,000	$ 960,000	$ 2,560,000
AUTOMATIC TIE SWITCH	EA.	30	$ 5,000	$ 150,000	$ 90,000	$ 240,000
CATENARY POLES	EA.	4550	$ 3,000	$ 13,650,000	$ 8,190,000	$ 21,840,000
CATENARY SYSTEM MAIN LINE	FT.	340462	$ 75	$ 25,534,650	$ 15,320,790	$ 40,855,440
SCADA	EA.	32	$ 10,000	$ 320,000	$ 192,000	$ 512,000
CIRCUIT BRK. AUTO A.C.	EA.	32	$ 40,000	$ 1,280,000	$ 768,000	$ 2,048,000
CIRCUIT BRK. AUTO D.C.	EA.	96	$ 50,000	$ 4,800,000	$ 2,880,000	$ 7,680,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 82,779,056
					20% CONT	$ 16,555,811
						$ 99,334,867
		Cost/Mile	$ 1,540,553		Cost Rounded to	$ 100,000,000

System Voltage = 750v d.c.
System Length = 64.48
A.) Base Consist = One Bus
B.) Base Energy required in KWH = 328 KWH
C.) Energy required in KVA = B.x1.38 = 453 KVA
D.) Number of consists required = 84/Hour
E.) Energy required one direction = CxD = 38,052 KVA
F.) Energy required for both directions = 2xE = N/A
G.) Substations required = System Length x 1 Substation per 2 Miles = 32
H.) Substation KVA = F/G = 865 KVA

Dual Mode Bus
Both Directions

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	193	$ 18,480	$ 3,566,640	$ 2,139,984	$ 5,706,624
12 KV INSULATORS	EA.	13618	$ 45	$ 612,810	$ 367,686	$ 980,496
12 KV SPACERS	EA.	13618	$ 15	$ 204,270	$ 122,562	$ 326,832
1200 KVA SUBSTATION W/RECT.	EA.	32	$ 60,000	$ 1,920,000	$ 1,152,000	$ 3,072,000
AUTOMATIC TIE SWITCH	EA.	30	$ 5,000	$ 150,000	$ 90,000	$ 240,000
CATENARY POLES	EA.	9079	$ 3,000	$ 27,237,000	$ 16,342,200	$ 43,579,200
CATENARY SYSTEM MAIN LINE	FT.	680924	$ 75	$ 51,069,300	$ 30,641,580	$ 81,710,880
SCADA	EA.	32	$ 10,000	$ 320,000	$ 192,000	$ 512,000
CIRCUIT BRK. AUTO A.C.	EA.	32	$ 40,000	$ 1,280,000	$ 768,000	$ 2,048,000
CIRCUIT BRK. AUTO D.C.	EA.	160	$ 50,000	$ 8,000,000	$ 4,800,000	$ 12,800,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 150,976,032
					20% CONT	$ 30,195,206
						$ 181,171,238
		Cost/Mile	$ 2,809,728		Cost Rounded to	$ 185,000,000

System Voltage = 750v d.c.
System Length = 64.48 miles
A.) Base Consist = One Bus
B.) Base Energy required in KWH = 328 KWH
C.) Energy required in KVA = B.x1.38 = 453 KVA
D.) Number of consists required = 168/hour
E.) Energy required for both directions = CxD = 76,104 KVA
F.) Substations required = System length x 1substation per 2 miles = 32
G.) Substation KVA = E/F = 1189 KVA

Electric Bus
Both Directions

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	261	$ 18,480	$ 4,823,280	$ 2,893,968	$ 7,717,248
12 KV INSULATORS	EA.	18329	$ 45	$ 824,805	$ 494,883	$ 1,319,688
12 KV SPACERS	EA.	18329	$ 15	$ 274,935	$ 164,961	$ 439,896
1200 KVA SUBSTATION	EA.	32	$ 60,000	$ 1,920,000	$ 1,152,000	$ 3,072,000
AUTOMATIC TIE SWITCH	EA.	88	$ 5,000	$ 440,000	$ 264,000	$ 704,000
CATENARY POLES	EA.	12220	$ 3,000	$ 36,660,000	$ 21,996,000	$ 58,656,000
CATENARY POLES XO	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY POLES PASSING	EA.	0	$ 3,000	$ -	$ -	$ -
CATENARY SYSTEM MAIN LINE	FT.	916438	$ 75	$ 68,732,850	$ 41,239,710	$ 109,972,560
CATENARY SYSTEM XO	FT.	0	$ 75	$ -	$ -	$ -
CATENARY SYSTEM PASSING	FT.	0	$ 75	$ -	$ -	$ -
SCADA	EA.	32	$ 10,000	$ 320,000	$ 192,000	$ 512,000
CIRCUIT BRK. AUTO A.C.	EA.	32	$ 40,000	$ 1,280,000	$ 768,000	$ 2,048,000
CIRCUIT BRK. AUTO D.C.	EA.	128	$ 50,000	$ 6,400,000	$ 3,840,000	$ 10,240,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 194,681,392
					20% CONT	$ 38,936,278
						$ 233,617,670
		Cost/Mile	$ 2,692,068		Cost Rounded to	$ 235,000,000

System Voltage = 750 v d.c.
System Length = 64.48 miles
A.) Base Consist = one bus
B.) Base Energy required in KWH = 328 KWH
C.) Energy required in KVA = B.x1.38 = 453 KVA
D.) Number of consists required = 168/hour
E.) Energy required for both directions = DxE = 76,104 KVA
F.) Substations required=System length x 1substation per 2 miles = 32
G.) Substation KVA=E/F = 1189KVA

List of simplying assumptions for sheets 2 to 11.

a Primary feed is a continuous 3 phase, 3 wire 12KV feed from start of line to end of line.
b Three 12KV insulators used per catenary pole for the primary feed.
c Three 12 KV spacers are used between each catenary pole to keep the 12KV wires separated on the primary feed.
d All Kw requirements are converted to Kva to account for power factor(0.85) and system effenices(0.85).
e Catenary Poles are spaced approximately 200 feet apart.
f Catenary Poles are also used to support the 12KV primary system.
g Catenary system consists of main messenger,auxiliary wire and contact wire.
h Automatic tie switch provided outside of each substation to tie power sections together in an emergency.
I Four automatic reclose breakers provided, two to isolate the transformer, two for section breakers.
j Other assumptions are shown as shown on each sheet.

COSTS

1 conductor 12 KV wire (4/O@$3.50/ft.)
25KV Substation cost = $35/KVA
750v dc Substation/rectifier, cost = $52/Kw
1 SCADA/substation

Appendix D

Feeder Bus Operations Summary

Summary of Feeder Operations

Operating Costs

Item	Annual Operating Days	C-470 Area	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (*via Silverthorne/ Dillon*)	Frisco	Copper	Vail	Total
Bus Requirement *(Peak Hour)*												
Holiday	25	3	1	2	1	4	6	11	14	10	55	107
Peak	75	2	1	2	1	3	4	8	10	7	37	
Norm	265	1	1	1	1	2	2	4	5	4	19	
Annual Revenue Hours												
Holiday	25	825	275	550	275	1,100	1,650	3,025	3,850	2,750	15,125	29,425
Peak	75	1,650	825	1,650	825	2,475	3,300	6,600	8,250	5,775	30,525	61,875
Norm	265	2,915	2,915	2,915	2,915	5,830	5,830	11,660	14,575	11,660	55,385	116,600
Totals	365	5,390	4,015	5,115	4,015	9,405	10,780	21,285	26,675	20,185	101,035	207,900
Operator		RTD	RTD	New	New	New	Summit	Summit	Summit	Summit	Vail	
Estimated Cost/Hour	$	98	98	70	70	70	70	70	70	70	38	
Annual Operating Cost	$	527,482	$ 392,921	$ 358,050	$ 281,050	$ 658,350	$ 751,814	$ 1,484,449	$ 1,860,356	$ 1,407,734	$ 3,864,122	$ 11,586,328
ADA Paratransit												3,124,002
Sub-total C-470 to Vail Feeder Operations												$ 14,710,330
Feeder from DIA/Central Denver to C-470 *(Trolleybus Options)*												13,000,000
Total Feeder Operations												$ 27,710,330

Capital Costs

Item	Corridor Operations: Fixed Route	Corridor Operations: ADA	Corridor Operations: Total	Metro Ops DIA/C470	Totals
Vehicles	$ 35,310,000	$ 4,000,000	$ 39,310,000	$ 31,200,000	$ 70,510,000
Operating Facilities	15,250,000	5,000,000	20,250,000	7,500,000	27,750,000
Other	4,467,500	3,021,000	7,488,500	2,000,000	9,488,500
Totals	$ 55,027,500	$ 12,021,000	$ 67,048,500	$ 40,700,000	$ 107,748,500

I-70 Feeder Bus Services

Node/Stop	Current Operator	Cost/Hr (1998)	Description
Origin to C-470	RTD		Comprehensive services incl LRT
Evergreen/US 6	RTD	$ 87.00	P&R services; RTD $87/hour
Idaho Springs	No		
Empire	No		
Loveland	No		
Silverthorne	Summit Stage	$ 62.00	Comprehensive; 6am to 11pm (to 1215am in Winter)
Keystone *(via Silverthorne/Dillon)*	Resort System		6am to 12mid
Frisco	Summit Stage	$ 62.00	Comprehensive; 6am to 11pm (to 1215am in Winter)
Copper	Summit Stage	$ 62.00	Comprehensive; 6am to 11pm (to 1215am in Winter)
Vail	Vail Transit	$ 34.00	Varied services; 6am to 11pm/12mid

LINKED TO RTToperations.xls

Estimated Ridership FEEDER OPERATIONS -- see right for feeder from DIA/Cen Denver to C-470 for electric TB

Service Level	Annual Operating Days	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	% of Holiday Peak
2020 Peak Hour Ridership													
Holiday Peak	25	91	44	84	24	142	227	485	620	434	2,458	4,608	100%
Peak	75	61	30	56	16	95	152	325	415	291	1,647	3,088	67%
Normal	265	30	15	28	8	47	75	160	204	143	811	1,521	33%
Weighted Totals	365	41	20	38	11	63	101	216	276	193	1,096	2,054	45%
Average Daily	30%	135	0	258	0	1,498	0	3,201	0	2,242	0	7,334	
Ave Holiday Peak Day		304	147	280	81	472	756	1,616	2,065	1,446	8,193	15,361	
Ave Peak Day		203	99	188	54	316	507	1,083	1,384	969	5,489	10,292	
Ave Norm Day		100	49	93	27	156	250	533	681	477	2,704	5,069	
Bus Requirement (PH)													
Holiday		3	1	2	1	4	6	11	14	10	55		
Peak		2	1	2	1	3	4	8	10	7	37		
Norm		1	1	1	1	2	2	4	5	4	19		
Average		1	1	1	1	2	3	5	7	5	25		
Daily Peak Revenue Hours (4)													
Holiday		12	4	8	4	16	24	44	56	40	220		
Peak		8	4	8	4	12	16	32	40	28	148		
Norm		4	4	4	4	8	8	16	20	16	76		
Off Peak Hours (14); 50% peak													
Holiday		21	7	14	7	28	42	77	98	70	385		
Peak		14	7	14	7	21	28	56	70	49	259		
Norm		7	7	7	7	14	14	28	35	28	133		
Annualized													
Holiday		825	275	550	275	1,100	1,650	3,025	3,850	2,750	15,125	29,425	
Peak		1,650	825	1,650	825	2,475	3,300	6,600	8,250	5,775	30,525	61,875	
Norm		2,915	2,915	2,915	2,915	5,830	5,830	11,660	14,575	11,660	55,385	116,600	
Totals		5,390	4,015	5,115	4,015	9,405	10,780	21,285	26,675	20,185	101,035	207,900	
Operator		RTD	RTD	New	New	New	Summit	Summit	Summit	Summit	Vail		
Ops Rate (1998 +4%)	4%	$ 98	$ 98	$ 70	$ 70	$ 70	$ 70	$ 70	$ 70	$ 70	$ 38	$ 56	
Total Ops Cost		$ 527,482	$ 392,921	$ 358,050	$ 281,050	$ 658,350	$ 751,814	$ 1,484,449	$ 1,860,356	$ 1,407,734	$ 3,864,122	$ 11,586,328	

Vehicles			
Total	20%	Total	
107	21	128	
Unit		$ 275,000	
Total		$ 35,310,000	

Ops Facilities		Fixed Route Vehs	per Veh
Vail	7,500,000	68	110,865
Summit	6,500,000	51	126,829
Idaho/else	1,250,000	9	142,857
Total	15,250,000	128	

Other	
Electronics	3,191,000
Equipment	1,276,500
Total	4,467,500
All Cap	55,027,500

Total Paratransit	
Ops	$3,124,002
Capital	12,021,000

ADA Paratransit
5% of FR

	Fixed	ADA	Annual
Norm	5,069	253	67,165
Peak	10,292	515	38,594
Holiday	15,361	768	19,201
Total			124,960
Hours			62,480
Cost/Hr		$	50.00
Annual		$	3,124,002
Vehs			60
Spares			12
Total			72
Cost			55,000
round			4,000,000
Equipment			
AVL/MDT			1,800,000
Swipe			721,000
Other			500,000
			3,021,000
Facility			5,000,000

DIA/Central Denver to C-470
(Supports Trolleybus options only)

Time		DIA	Cen Den	Total
PH Ridership				
Holiday Peak	100%	2,485	857	3,342
Peak	67%	1,665	574	2,239
Norm	33%	820	283	1,103
Bus Requirement				
Holiday Peak		55	19	74
Peak		37	13	50
Norm		18	6	25
Hours				
Peak RH (4 hrs/day)	days			
Holiday Peak	25	5,522	1,904	7,427
Peak	75	11,100	3,828	14,928
Norm	265	19,317	6,662	25,978
Off Peak (14 hrs/day)--50% peak	days			
Holiday Peak	25	9,664	3,333	12,997
Peak	75	19,424	6,699	26,123
Norm	265	33,804	11,658	45,462
Total				
Holiday Peak		15,186	5,237	20,423
Peak		30,524	10,527	41,051
Norm		53,121	18,320	71,441
Grand Totals		98,831	34,084	132,915
Miles	45			5,981,177

Costs				
Operating	Per Hour (RTD)			$ 98
	Annual			$ 13,000,000
Capital	Vehicles Base		74	
	Spares		15	
		$ 350,000	89	$ 31,200,000
	Facility			$ 7,500,000
	Else			2,000,000
total capital				$ 40,700,000

RTT Travel Patterns

Model Destination

This Ridership Not Used in Summary

Origin/Level/Pattern	Percent of PH Riders	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	check	Peak Vehicles		Daily Riders	Annual
PH 2020 Offs (Westbound)		24	46	13	78	125	267	341	239	1,352		2,484	2,485			PH Share	50%
DIA (Seating Capacity Seats 45)																	
Holiday Peak	100%	24	46	13	78	125	267	341	239	1,352		2,484					
1												162		3			
2												468		10			
3												267	2,484	5	53	4,969	124,000
4												1,590		35			
Peak	67%	16	31	9	52	84	179	228	180	906		1,665					
1												56		1			
2												364	1,665	8	35	3,329	250,000
3												179		3			
4												1,066		23			
Normal	33%	8	15	4	26	41	88	112	79	446		820					
1												28		1			
2												88		1			
3												179	820	3	16	1,640	435,000
4												525		11			
																	809,000

Origin/Level/Pattern	Percent of PH Riders	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	check	Peak Vehicles		Daily Riders	Annual
PH 2020 Offs (Westbound)							68	145	186	130	737	1,267	1,267				
C-470																	
Holiday Peak	100%						68	145	186	130	737	1,267					
1												254		5			
2												145	1,267	3	27	2,534	63,000
3												868		19			
Peak	67%						46	97	125	87	494	849					
1												170		3			
2												97	849	2	17	1,698	127,000
3												581		12			
Normal	33%						22	48	61	43	243	418					
1												70	418	1	8	836	222,000
2												348		7			
																	412,000

Origin/Level/Pattern	Percent of PH Riders	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	check	Peak Vehicles		Daily Riders	Annual
PH 2020 Offs (Westbound)		91	20	38	11	64	34	73	93	65	369	857	857				
Downtown Denver																	
Holiday Peak	100%	91	20	38	11	64	34	73	93	65	369	857					
1												149		3			
2												75	857	1	17	1,714	43,000
3												107		2			
4												527		11			
Peak	67%	61	13	25	7	43	23	49	62	44	247	574					
1												100		2			
2												50		1			
3												72		1	11	1,148	86,000
4												353	574	7			
Normal	33%	30	7	12	4	21	11	24	31	21	122	283					
1												74		1			
2												35		1			
3												174	283	3	5	566	150,000
																	279,000

Total RTT Riders 1,500,000

Legend:
Solid = stop served in near and intermediate term
Stop served on a Demand Response basis

Stations

Service Level	Annual Operating Days	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	% of Holiday Peak
2020 Peak Hour Ridership													
Holiday Peak	25	91	44	84	24	142	227	485	620	434	2,458	4,608	100%
Peak	75	61	30	56	16	95	152	325	415	291	1,647	3,088	67%
Normal	265	30	15	28	8	47	75	160	204	143	811	1,521	33%
Weighted Totals	365	41	20	38	11	63	101	216	276	193	1,096	2,054	45%
Average Daily	30%	135	0	258	0	1,498	0	3,201	0	2,242	0	7,334	
Ave Holiday Peak Day		304	147	280	81	472	756	1,616	2,065	1,446	8,193	15,361	
Ave Peak Day		203	99	188	54	316	507	1,083	1,384	989	5,489	10,292	
Ave Norm Day		100	49	93	27	156	250	533	681	477	2,704	5,069	

Stations (incl baggage handlers)

Bus Requirement (PH)		Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone	Frisco	Copper	Vail	Totals
Holiday		3	1	2	1	4	6	11	14	10	55	
Peak		2	1	2	1	3	4	8	10	7	37	
Norm		1	1	1	1	2	2	4	5	4	19	
Average		1	1	1	1	2	3	5	7	5	25	
Station Type		2,000,000 Minor	2,000,000 Minor	2,000,000 Minor	2,000,000 Minor	2,000,000 Minor	3,000,000 Intermediate	3,000,000 Intermediate	2,000,000 *expansion Intermediate	3,000,000 Intermediate	4,000,000 Major	25,000,000

Vehicles

Total	20%
107	21
Unit	
Total	

Does not incl 2000 space parking garage

Station Type	Cap Cost (no land)	Ops Cost Non personnel)		Daily Boardings
Major	4,000,000	200,000	*Climate controled Large Fully Staffed; fare media sales; 8-10 bays*	>=2000
Intermediate	3,000,000	150,000	*Climate controled Medium Fully Staffed; fare media sales 5-6 bays*	501 to 2000
Minor	2,000,000	100,000	*Climate controled Minimally staffed building 3-4 bays*	<500

(Frisco Intermodal-- $1.3 MM 6.2 acres, 177 parking spaces, 300,000 annual boardings--1997)

300,000 frisco boardings
150,000 50% weekend
>>daily ??? 4,286 35 peak weekends

Staffing	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone	Frisco	Copper	Vail	Totals
Baggage Handling (FTE)						3	5	3	5	8	
Unit Cost						30,000	30,000	30,000	30,000	30,000	
Total Cost (Annual)						92,000	138,000	92,000	138,000	229,000	689,000
Other						6	9	6	9	13	
						30,000	30,000	30,000	30,000	30,000	
						190,000	284,000	190,000	284,000	379,000	1,327,000
Other Ops Costs	100,000	100,000	100,000	100,000	100,000	150,000	150,000	100,000	150,000	200,000	1,250,000
Grand Total									rounded		3,300,000

Compare Added Services with Current Services

Service Level	Annual Operating Days	Origin to C-470	Evergreen/US 6	Idaho Springs	Empire	Loveland	Silverthorne	Keystone (via Silverthorne/ Dillon)	Frisco	Copper	Vail	Totals	% of Holiday Peak
2020 Peak Hour Ridership													
Holiday Peak	25	91	44	84	24	142	227	485	620	434	2,458	4,608	100%
Peak	75	61	30	56	16	95	152	325	415	291	1,647	3,088	67%
Normal	265	30	15	28	8	47	75	160	204	143	811	1,521	33%
Weighted Totals	365	41	20	38	11	63	101	216	276	193	1,096	2,054	45%
Average Daily	30%	135	0	258	0	1,498	0	3,201	0	2,242	0	7,334	
Ave Holiday Peak Day		304	147	280	81	472	756	1,616	2,065	1,446	8,193	15,361	
Ave Peak Day		203	99	188	54	316	507	1,083	1,384	969	5,489	10,292	
Ave Norm Day		100	49	93	27	156	250	533	681	477	2,704	5,069	
Bus Requirement (PH)													
Holiday		3	1	2	1	4	6	11	14	10	55		
Peak		2	1	2	1	3	4	8	10	7	37		
Norm		1	1	1	1	2	2	4	5	4	19		
Average		1	1	1	1	2	3	5	7	5	25		
Daily Peak Revenue Hours (4)													
Holiday		12	4	8	4	16	24	44	56	40	220		
Peak		8	4	8	4	12	16	32	40	28	148		
Norm		4	4	4	4	8	8	16	20	16	76		
Off Peak Hours (14); 50% peak													
Holiday		21	7	14	7	28	42	77	98	70	385		
Peak		14	7	14	7	21	28	56	70	49	259		
Norm		7	7	7	7	14	14	28	35	28	133		
Annualized													
Holiday		825	275	550	275	1,100	1,650	3,025	3,850	2,750	15,125		
Peak		1,650	825	1,650	825	2,475	3,300	6,600	8,250	5,775	30,525		
Norm		2,915	2,915	2,915	2,915	5,830	5,830	11,660	14,575	11,660	55,385		
Totals		5,390	4,015	5,115	4,015	9,405	10,780	21,285	26,675	20,185	101,035		
Operator		RTD	RTD	New	New	New	Summit	Summit	Summit	Summit	Vail		
Ops Rate (1998 +4%)	0.04 $	98 $	98 $	70 $	70 $	70 $	70 $	70 $	70 $	70 $	38 $	56	
Total Ops Cost	$	527,482 $	392,921 $	358,050 $	281,050 $	658,350 $	751,814 $	1,484,449 $	1,860,356 $	1,407,734 $	3,864,122 $	11,586,328	

Summary

Operator	Feeder Annual Revenue Hours	Feeder Annual Revenue Miles 18	Current Annual Revenue Miles	% Change	Miles Feeder for Trolleybus	W/TB Total New	% Change
RTD	9,405	169,290	32,432,954	0.5%	5,981,177	6,150,467	19%
New	18,535	333,630	-			333,630	
Summit	78,925	1,420,650	1,161,149	122.3%		1,420,650	122%
Vail	101,035	1,818,630	530,000	343.1%		1,818,630	343%
Totals	207,900	3,742,200	34,124,103	11.0%		9,723,377	28%

Systems	Ann Riders		Budget	Ann Hours		Budget/Hour	Riders/Hour
RTD	68,602,955	$	161,582,594	1,864,292	$	87	36.8
Summit Stage	1,362,985	$	3,066,048	49,138	$	62	27.7
Eagle County	686,309	$	2,374,569	45,283	$	52	15.2
Vail Transit	3,200,000	$	2,100,000	62,000	$	34	51.6
Avon Beaver Creek	762,659	$	2,165,312	39,262	$	55	19.4
Roaring Fork	2,519,125	$	10,074,359	202,890	$	50	12.4
Snowmass Village	542,538	$	1,494,000	30,359	$	49	17.9
Steamboat Springs	926,529	$	1,600,000	36,582	$	44	25.3
Totals	78,603,100		184,456,882	2,329,806	$	79	33.7

Source: I-70 Mountain Corridor Transit Inventory *July, 2000*

Appendix D
TranSystems
Maximum Gradients for Fixed Guideway Transit Systems (Except Monorail) Proposed for the I-70 Mountain Corridor
January 2001

This page intentionally left blank.

DRAFT 6

Maximum Gradients for Fixed Guideway Transit Systems (Except Monorail) Proposed for the I-70 Mountain Corridor

Prepared for the
Colorado Department of Transportation
and the
Mountain Corridor Advisory Committee

Prepared by
Mark C. Walbrun, PE
& Gary R. Johnson, PE

TranSystems Corporation

January 5, 2001

INTRODUCTION

The portion of Interstate 70 that traverses the Rocky Mountains in Colorado passes through a very challenging environment in which to construct any type of ground based transportation system. This segment of I-70 which begins in Denver near highway C-470 and proceeds west to Eagle is known as the I-70 Mountain Corridor. It is currently being studied as part of a Programmatic Environmental Impact Statement (PEIS) that among other things will evaluate the potential of alternate transportation modes to alleviate the severe congestion on the existing highway.

A number of Fixed Guideway Transit (FGT)[a] systems have been proposed to mitigate the existing and future congestion along the Mountain Corridor. Each of these technologies differs in a number of technical aspects related to their operating performance on steep grades. While it has been generally acknowledged that Advanced Guideway Systems such as Maglev and Monorails will have little trouble operating on grades up to 10%[1], questions have been posed as to the capabilities of conventional rail systems in this environment. Since these rail systems would be expected to operate within or alongside the existing I-70 corridor, they would need to traverse gradients similar to the existing highway grades that vary from level to a maximum of 6.7% for a short distance near the Eisenhower Tunnel.[2]

The purpose of this report is to document current design practice and criteria used for the construction of various FGT technologies, and particularly how they relate to the I-70 Mountain Corridor. The definitions of Advanced Guideway Systems (Maglev and Monorail), Passenger Railroads, and Rail Transit (Light Rail Transit (LRT) and Heavy Rail Transit (HRT)) are taken from the "I-70 Mountain Corridor PEIS - Identification of Transit Alternatives (Draft Final Report)" by TranSystems, dated July 26, 2000. Only rail based systems will be evaluated in this report. Assumptions underlying the applicability of Advanced Guideway Systems to the corridor will be verified during compilation of the Draft Environmental Impact Statement.

DISCUSSION

The generally accepted maximum grade[b] for any passenger carrying steel wheel on steel rail system is about 10% (this is called the adhesion limit[3]). Beyond that limit, the vertical force vectors of the vehicle moving along the grade are able to overcome the friction between the two steel surfaces that propel or retard a train wheels. Any rail system built in excess of the adhesion limit requires supplemental traction and braking

---

[a] Fixed Guideway Transit or FGT is a term used to refer to a group of transit technologies that function in a fixed guideway which includes Advanced Guideway Systems (Maglev and Monorails), Passenger Railroads, and Rail Transit (Light and Heavy rail transit).

[b] Grades (gradients) are expressed in terms of a percentage of vertical change over a given horizontal distance. A 1% grade represents a vertical change of 1 foot over 100 feet of horizontal distance.

assistance such as redundant rubber tired wheels, a rack, or a cable line (called a *funicular*). Maximum design grades (which are well under the adhesion limit) for railroads and rail transit systems are based on a number of factors including available traction power, braking characteristics, wheel/rail adhesion, vehicle weight, and economics.

The typical "general purpose" railroads that crisscross the US are normally constructed using a maximum gradient of 2% or less.[4] This is not, however, the upper limit of their effective design grades, but represents a compromise between **right-of-way** costs, **construction** costs, and freight train **operating** expenses. When difficult topography dictates other approaches, grades can be much steeper as evidenced by the numerous freight lines throughout in Colorado that routinely operate on grades of over 4%.[5] Rail Transit systems, such as the Denver RTD Light Rail lines, are often built with maximum gradients of up to 6% when transitioning to aerial structures.[6]

The 127 mile I-70 Mountain Corridor has the following generalized grade characteristics:

- 78 miles (61% of the route) on grades less than 3.0%
- 37 miles (29% of the route) on grades between 3.0% and 6.0%
- 12 miles (10% of the route) on grades over 6.0% [the maximum highway grade of 6.7% (which is posted as 7%) occurs near the Eisenhower Tunnel]

127
61
66

Alignments on grades at or less than a 3% would present no unusual operating problems for any rail based system. Grades between 3% and 6% are nearing the upper limit of standard Passenger Railroad construction, but well within parameters for Rail Transit (LRT and HRT) technologies.[c]

Grades of 6% to 7% would require a carefully designed alignment and special performance vehicles, but are still within acceptable limits for Rail Transit (LRT and HRT) technologies.

CURRENT PRACTICE

In North America, new general purpose railroad lines are usually designed for a maximum of 1% grade, with some exceptions up to 2%. For Passenger Railroads, Amtrak (operator of most of the passenger railroads in the US) limits grades to a maximum of 2.5% unless special approval has been granted by their Chief Engineer.[7] The TGV, a high speed passenger railroad in France, was constructed with maximum grades of 3.5% to save tunneling costs and allow co-location with highways – a fact that

[c] Optional higher performance motors and braking systems may be required on transit vehicles operating on long grades of greater that 3%.

was highlighted in their prospectus for proposed North American operations.[8] Rail Transit (LRT and HRT) systems are usually designed to operate within 4% gradients, using higher grades for short transition segments.[9]

The effects of gradient on operating speed are closely tied to the curves within any given segment of a rail system. Speed restrictions for gradients are generally based on curvature, not the grade itself. Downgrades often have speed restrictions to avoid building too much momentum prior to encountering restrictive curves, although operations on even steep downgrades can be routinely found at 40 mph. The PATCO HRT system in Philadelphia operates over a long 6% grade to and from the Ben Franklin Bridge at 50 mph. The French TGV Passenger Railroad operates at 185 mph on its 3.5% grades.

REFERENCES

The American Railway Engineering and Maintenance of Way Association (AREMA) sets the recommended practices for the construction and maintenance of railways in North America. Chapter 12 of its Manual for Recommended Practices deals with passenger railways and contains the following excerpt under Part 2 Section 6.3.5 – "Grades":

> "*Commuter rail* [Passenger Rail][d]*, while using existing roadbeds in most cases, should utilize desirable grades of under 2% for mainline operations. Desirable maximum grades for heavy rail* [HRT][d] *construction are approximately 3%. Light rail* [LRT][d] *vehicles usually possess the ability to climb steeper grades than heavy rail equipment. New construction should reference existing operating properties to establish desirable grades. Care must be taken in considering propulsion methods and weather considerations in planning for gradients. A major criterion is vehicle braking performance on descending grades; systems utilizing automatic controls usually require that grades within 1,000 feet of stations be limited to 3% or less. See Table 2-2 for examples of existing systems."*

Table 2-2. Typical Maximum Gradient Examples

Category	Mainline	Exceptions
Commuter Rail	3%	—
Heavy Rail	6%	7%
Light Rail	5-6%	7%
People Mover	6%	8%

[d] "Passenger Rail", "LRT" and "HRT" is added by the author for the clarification of terms only.

The Transportation Research Board (TRB), a division of the National Research Board of the National Academy of Sciences, published a seminal report entitled "Track Design Handbook for Light Rail Transit[10] (Report 57) as part of its Transit Cooperative Research Program. Section 2.4.4 dealing with Maximum Vertical Grades for vehicles states that:

> *"The maximum allowable route grade is limited by the possibility that the LRV (Light Rail Vehicle) could stall or the traction motors overheat. This is the steepest grade that the LRV can negotiate. A short grade that the LRV enters at speed should not be a problem up to about 6%. Above that the operational requirements should be reviewed. Grades of up to 10% are possible. At grades between 6% and 10%, wheel-to-rail slippage may occur in poor conditions, such as when ice or wet leaves are on the rail. This may result in wheel flats during breaking or rail burns during acceleration."*

Section 3.3.3 dealing with Vertical Grades in track states that:

> *"Maximum grades in track are controlled by vehicle braking and tractive efforts. ...As a guideline, the following profile grade limitations are recommended for general use in LRT design:*
>
> *Main Line Tracks:*
> *Maximum Sustained Grade, Unlimited Length – 4.0%*
> *Maximum Sustained Grade, Up to 2500' Between PVIs – 6.0%*
> *Maximum Short Sustained Grade, Up to 500' Between PVIs – 7.0%"*

The distances between PVIs (Points of Vertical Intersection) cited above are for vehicles equipped with standard motors and brakes. High performance motors and brakes are available that will allow virtually continuous operation at those grades.

A frequently used textbook for railroad engineering, Elements of Railroad Engineering,[11] contains the following excerpt:

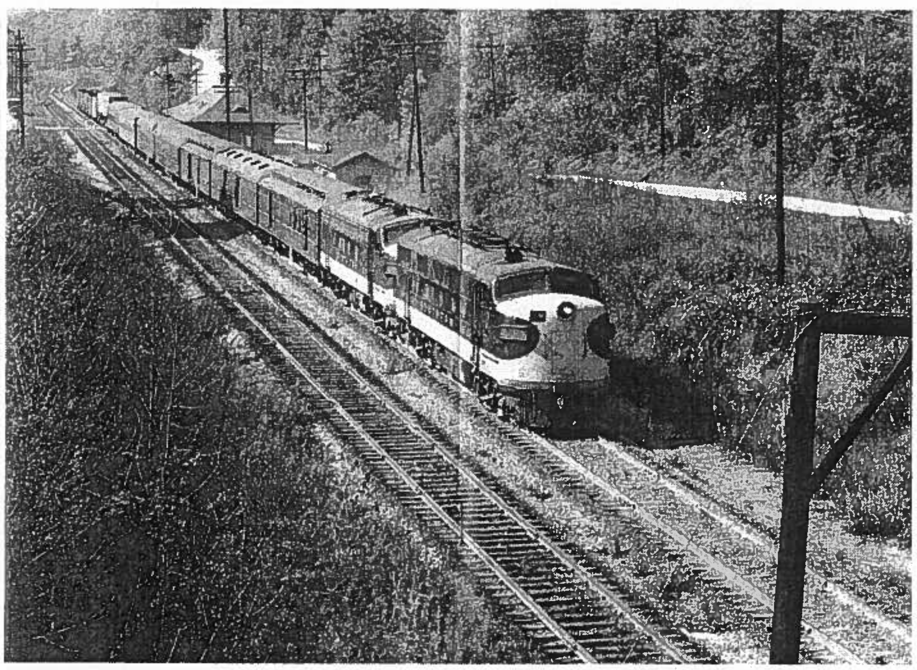
> *"Eastern trunk lines seek grades of 0.3 per cent or under against their heavier traffic, while grades of 4 per cent are frequent in the Rocky Mountains...but heavier grades, approximating 6 per cent, exist and are operated on some mountain, mine, and logging roads. ...A locomotive having only driving wheels and no tender could theoretically just maintain itself at a uniform slow velocity on a grade of about 24.75 per cent. The steepest trolley road grades are about 15 per cent."*

Although the locomotive cited above is presumably a steam unit, current diesel locomotives have similar capabilities.

Two key railway design manuals do not address maximum grade issues. The frequently used textbook "Railroad Engineering"[12] by William W. Hay, Professor Emeritus of Railway Civil Engineering, University of Illinois contains no comment on maximum grades achievable by railroads. The widely used "Transportation Planning Handbook"[13] published by the Institute of Transportation Engineers similarly contains no reference to maximum railway gradients.

EXAMPLES

The steepest grade being currently operated on a railroad branch line in the United States is the Boeing Branch of the BNSF at Mukilteo, Washington serving the aircraft plant at Everett with grades approaching 6.0%.[14] The highest grade being currently operated on a mainline railroad in the United States is the 4.7% grade on Saluda Hill in North Carolina on the Norfolk Southern.[15] This line is in active use for freight service and once operated numerous passenger trains. The photo below by H. W. Bundy Jr. taken in 1963 shows Southern Railway train 28, the Carolina Special, preparing to descend the famous grade on its journey from Knoxville to Columbia.



SR 28 on 4.7% Saluda Hill Grade 1963

In a tract entitled "SMARTrans - Sensible Mountain Area Railway Transport"[16] by Edward Stewart Wright the author extols the virtues of rack assisted railway service. He acknowledges a 9% adhesion limit (page 38) for regular railway operations but goes on to examine the use of rack assists, common in Europe, to handle gradients up to 30% (he suggests the use of 17% grades for short distances in the Mountain Corridor). He also describes a conventional narrow-gauge railway that once operated near Georgetown, Colorado that used 7% grades with steam locomotives and the Uintah Railroad which operated with 7.5% grades. He also notes that a key Union Pacific (ex D&RGW) line over Tennessee Pass was operated for over a century on 4% grades for both freight and passenger trains. In addition, he notes that many tourist railroads in the region, including the Cumbres & Toltec Scenic, Leadville, and Georgetown railways routinely operate over 3% to 4% grades with vintage equipment. The author also notes that the Denver RTD Light Rail line operates over 6% grades on the newly-opened extension to Littleton.

CONCLUSIONS

The I-70 Mountain Corridor alignment presents challenges to any rail system designer, but not beyond what any complex project would entail.

It is important to note that operating restrictions on grades are caused by numerous factors. As long as the grade is below the adhesion limit, the next most important factor is traction power and braking characteristics of the vehicle. These are essentially mechanical limitations and can be overcome with special vehicle designs. Railway equipment that was specially designed for mountain use was common in the United States before the 1950s. Standardization of locomotive design has eliminated the use of specialized units in high grade areas in favor of using multiple units operating together. In most cases, typical Passenger Railroad and Rail Transit equipment can be modified to handle long grades through the use of special duty traction motors and multi-stage regenerative braking systems.

A more important limitation on grades is the economic factors. Operating railroads on higher gradients exacts a significant cost in diesel fuel (or electric power). When many railways were originally constructed in the 1800s, the fuel cost was very high and constructing a longer, gentler gradient resulted in more efficient use of the available energy. This led to the basic design standards still in use today. Importantly, <u>current</u> economic forces would now favor use of a higher gradient to stay within existing transportation corridors, rather than the incur high costs of permitting, right-of-way acquisition, and construction.

Over 78 miles of the corridor (sections at less than 3% grade) could be built using Passenger Railroad or Rail Transit system technology with no special restrictions and operated at speeds up to 79mph (or even higher – up to 110mph - with special signal modifications). The other sections of the I-70 Mountain Corridor (those having grades in excess of 3%) would require a combination of both vehicle and alignment enhancements to support such rail systems.

The 37 miles of moderate grade on the I-70 corridor (3% to 6%) can easily accommodate Rail Transit (LRT and HRT) systems, such as the Denver RTD Light Rail system, at speeds in the 55 mph to 65 mph range. Some propulsion/braking system modifications may be necessary to accommodate long grades (depending upon the type of vehicle chosen). It could also be operated as a Passenger Railroad with slightly lower speeds on curves due to differences in braking profiles between Passenger Railroads and Rail Transit equipment. It could also be utilized as a freight railroad bypass corridor with speeds in the 30-45 mph range.

The remaining 12 miles at high grades (greater than 6%), if not mitigated, would require somewhat slower operating speeds depending upon the track curvature The segments of greater than 6% grade are a small portion of the overall line and not a major contributor to the end-to-end trip times. Mitigation of the greater than 6% grades could be achieved by employing the following techniques:

- Build a lesser grade bypass around the Eisenhower tunnel. One such alternative which has been suggested in via Keystone. Use of the existing but never used pilot bore tunnel should be investigated for feasibility.

- Build a new rail tunnel under the Continental Divide entering and leaving at a lower elevation than the Eisenhower. It is easier (and less expensive) to build long rail tunnels than highway tunnels due to their relative size and lower ventilation requirements.

- Build a direct rack assisted rail line for rail transit operation over a higher grade route using a straighter alignment to save time (unlikely to be fast enough to justify the rack expense and maintenance).

The I-70 Mountain Corridor presents many challenges to rail system designers. The grades along the existing corridor are to be respected but do not present an unsolvable obstacle to implementation of a rail based transportation system. Rail systems currently operate within corridors with equivalent grades and over similar terrain. The final determinate as to the potential performance of any rail based system involving long, steep grades can be calculated based on supplied vehicle braking and acceleration curves applied over a proposed grade profile and curve alignment (called a Train Performance Calculator). This program, once all of the parameters have been identified, can provide end-to-end transit times, aggregate fuel use, and carrying (tonnage) potential of any rail based system under consideration.

The potential of a rail transportation system to provide significant congestion mitigation along the I-70 Mountain Corridor is high and needs to be carefully evaluated and the results considered as part of the PEIS.

[1] Correspondence with Robert Dorer, Volpe Transportation Institute (United States Department of Transportation). December 14, 2000.

[2] Mountain Corridor Profile, TranSystems Corporation 1999

[3] "Railroad Engineering" by William W. Hay, Mgt. E., M. S. John Wiley & Sons, Inc. Page 87. 1953

[4] "Manual of Recommended Practices" by the American Railway Engineering and Maintenance-of-way Association (Chapter 12, Part 2, Section 6.3.5). 2000

[5] [add UPRR track chart reference here]

[6] [add RTD track chart reference here]

[7] "Amtrak Safety Limits and Specifications for Maintenance and Construction of Track – MW1000" by the National Railroad Passenger Corporation. January 1, 1992

[8] op cit. Dorer. TGV actually proposed a maximum grade of 5% in their Texas Triangle proposal.

[9] "Track Design Handbook for Light Rail Transit" published by the Transportation Research Board as part of the Transit Cooperative Research Program (Report 57). 2000

[10] Ibid.

[11] "Elements of Railroad Engineering" by William G. Raymond, Dean of the College of Applied Science – State University of Iowa; Henry E. Riggs, Professor Emeritus of Civil Engineering – University of Michigan; Walter C. Sadler, Professor of Civil Engineering – University of Michigan. John Wiley & Sons, Inc. 1947

[12] op cit. Hay.

[13] "Transportation Planning Handbook" by the Institute of Transportation Engineers. [add current publisher and date]

[14] [add BNSF track chart reference here]

[15] [add NS track chart reference here]

[16] SMARTrans Sensible Mountain Area Railway Transport" by Edward Stewart Wright. bookpublishers intercontinental ltd. 2000

Appendix E
TranSystems
I-70 Programmatic Environmental Impact Statement
Transit Summary Document
January 2003

This page intentionally left blank.

I-70 Programmatic Environmental Impact Statement

Transit Summary Document

TranSystems Corporation

January 21, 2003

for

Colorado Department of Transportation

TABLE OF CONTENTS

INTRODUCTION

A number of transit alternatives to highway expansion are available to handle the growth in traffic along the I-70 Mountain Corridor. These alternatives consist of various forms of rubber tired, rail based, and promising new technologies for ground transportation. Each of these alternatives has a large number of variations due to options in guideway technology, line configuration, propulsion source, and design capacity. These differences affect the initial capital costs to construct the proposed system, the unit cost of the vehicles, the number of vehicles required to meet proposed ridership demand and schedules, and the costs to operate and maintain the system. These option choices significantly affect the ultimate capacity of the proposed system, the overall running time between end points, the energy consumption per passenger, and the environmental impacts of the system.

SUMMARY OF TRANSIT MODES TESTED

The modes that survived Level 2 Screening for the Denver (Jefferson Station, at I-70/US 6/C-470) to Vail segment included:

- Diesel Bus, running either on a Transitway or a Guideway
- Dual-Mode Bus in Guideway
- Diesel Light Rail Transit
- Electric Light Rail Transit
- Heavy Rail Transit
- Passenger Railroad Electric Multiple Unit
- Conventional Monorail
- Advanced Guideway System (Magnetic Levitation)

Redefining/Refining of Modal Alternatives

Some consolidation of these modal alternatives was made at the beginning of the current round of analysis. Further details regarding specific characteristics of each mode tested in this phase may be found in the Train Performance Calculator section.

RTT Alternatives

There have been no changes in the bus technologies utilized in this phase of the study. The I-70 Mountain Corridor is fairly unique. To reduce congestion riders will need to be attracted out of their cars, the buses would need to have high levels of amenities. Because of the distances/travel time involved, typical city bus seating would not be appropriate. Intercity buses have more comfortable seating (although legroom is frequently set too tight) but the single door and steps lead to slow loading/unloading. The typical exterior ski racks installed on resort area shuttles would not be appropriate for long trips at high speed. Rest rooms are required. However, food/beverage service probably cannot be considered because this requires an attendant, which cannot be justified by the relatively small number of passengers served. The buses tested were based on typical, currently-available intercity/suburban buses, with conventional, high floors, but it is assumed that an additional door would be provided, probably at floor height, to speed passenger movement and shorten stop times (this would require corresponding high level platforms at stations). Interior ski racks, perhaps under the floor, would be provided.

Diesel Bus, Transitway or Guideway

These buses were assumed to have a seated capacity of 52, length of 45 feet and weigh 38,000 lbs. The Diesel buses were assumed to have a maximum speed of 70 mph. The Diesel buses were assumed to have a 450 HP engine (400 HP buses are currently typical for intercity use) for climbing the steep grades. This is the largest engine size that it is considered feasible to install in a bus. The "Guideway" refers to a travel way that is somewhat like a rail line in that the buses are equipped with single guidewheels at the front corners of each side, which ride against the low side barriers of the guideway. The low-cost addition of the guidewheels (and a few other small modifications for guideway operation) does not interfere with the ability of the buses to continue off the guideway, allowing through operation on normal highways.

Dual Mode Bus on Guideway

The dual mode bus was modeled as an articulated (bending) bus 60 feet long with seating capacity for 68 passengers and weighed 53,000 lbs. In its electric mode, the dual mode bus runs off power rails integrated into the guideway with a nominal line voltage of 750 DC. Traction motors with a continuous rating of 700 HP were assumed. It was assumed that these buses would also be equipped with a 450 HP diesel engine for use off the guideway and for backup in case of electric power failure. The dual mode bus had a maximum speed of 75 mph. Dual mode buses are not common. The only fleet currently in service in the U.S. is utilized by King County Metro (Seattle). These 60 foot long articulated buses were built in 1982 by Breda (Italy) and are utilized for express bus runs which generally operate in diesel mode in the outlying areas including extensive operation on expressways and enter downtown using electric power obtained from overhead trolley wire in the Downtown Bus Tunnel. A small fleet of dual mode buses with similar characteristics, for use in a similar service, is currently under construction in Germany for Boston. The practical maximum speed for overhead trolley wire is about 45 mph, there are no known examples of electric bus operation faster than this. For the higher speeds required along the I-70 Mountain Corridor, it would be necessary to either utilize overhead catenary wire, as used by electric LRT, for high speed segments, and electric railroads, or power rails integrated with the guideway, very similar to the power collection utilized by people movers, monorails, etc. The latter technology has been assumed.

Rail Transit

The four rail modes were consolidated into one called Rail Transit (see discussion on page 7). This allowed the dropping of consideration of the 6% alignment. This alignment would have involved leaving the existing I-70 alignment for considerable lengths along the route, including extensive tunneling requirements. A special Train Performance Calculator run confirmed that the "heavy rail transit" train developed for Level 2 Screening could handle the occasional short segments of 7% grades of the highway alignment (in the same way as the electric light rail trains)

with minor degradation of performance. The Diesel Light Rail trains could operate on these grades, but had the disadvantages of relatively slow operation and higher noise levels. The short trains provided by light rail, either diesel or electric, are not capable of handling the number of passengers identified in the ridership estimation. The Rail Transit Equipment considered in this phase will be able to be operated in trains, tentatively up to 10 cars in length. These would have end doors (allowing passengers to walk through the train looking for seats and to reach a food/beverage service car and crews to inspect tickets) yet would still be able to operate onto RTD LRT lines (except those with on-street operations). Thus, it was necessary to drop light rail options. It was also concluded that, since a rail line with either 6% or 7% could not be operated with equipment routinely operated on the national railroad system, there was no reason to operate the FRA (Federal Railroad Administration) compatible Passenger Railroad Electric Multiple Unit equipment. Since there will be no interchange with the national railroad system, cars need not be built to meet FRA buff strength requirements, greatly reducing weight.

The rail transit train that was tested was designated the "EMU R2", the same train as tested in Level 2 screening as the Heavy Rail Transit Alternative. This was developed to meet the specific needs of the corridor. It used consists of a 5-car unit with a 2-unit limit. All axles are powered. Regenerative, disc and emergency track brakes would be available. Top speed was set at 80 mph. The train was tested with overhead catenary power supply at 25,000 V A.C., although it is assumed that trains would be capable of also drawing power from 750 V D.C. catenary if required for through-running over RTD lines in Metro Denver. This would avoid the need for passengers to change vehicles. Each car has an average seated capacity of 59 people allowing space for skis, luggage and some space dedicated to food service. The trains are expected to have food on board and other amenities suited to traveling between the airport and Vail. Cars were assumed to have two quarter point doors, each about 36" wide. Cars will have flat floors about 28 inches above top of rail. The platform height at each station will match this for easy boarding with skis and luggage. A real world example of a type of train that would appear to be very suitable for the I-70 Mountain Corridor is the Swiss Federal Railways RBDe560 series regional train (see Photo).

Monorail/Advanced Guideway

The CIFGA Monorail and Advanced Guideway System have been somewhat redefined; traditional monorail and urban maglev. The conventional monorail would utilize the technology in service since the 1950s at Disneyland, now under construction in Las Vegas and in use on many systems in Japan and elsewhere. This is called a "straddle" or Alweg monorail and uses rubber tires on concrete beams. The Advanced Guideway System has been refined to utilize the emerging technology now known as "Urban Maglev." CIFGA has recently chosen this technology.

The conventional monorail was created based on information provided by Hitachi, the largest producer of monorails worldwide, for the largest of its three model sizes. These trains are available "off-the-shelf" and specifications are well documented. The vehicle straddles a guideway. The large model that has been chosen has a flat floor. The bogies have rubber tires that ride both on top of and on the sides of the narrow guideway beams. It is assumed that the trains will be six cars long holding 70 seated passengers each. It is also assumed that the monorail will have regenerative and disk brakes. Top speed is limited to 60 mph by the use of rubber tires. Nominal line voltage for the conventional monorail is 7420 AC. It is also assumed that doors will have level boarding. Again, standard monorail (non-FRA compliant) car body construction was assumed.

Maglev systems have been under development since the 1960s. Two types are being actively tested. One is a German attraction-based design where the magnets on the track are attracted to electromagnets on the car, which are used to levitate the car for high speed running. Also, a Japanese repulsion based design where the magnets on the track push the car away to levitate it in a trough for high speed running.

The German design, which was being planned for a new line from Berlin to Hamburg, was recently defunded. However, the German consortium is installing a 20-mile demonstration line between Shanghai and its airport. Tests runs are scheduled to start in 2003. Top speed is planned for about 250 mph. The Japanese design is still undergoing full scale testing in a section of the planned track built outside of Tokyo. In the U.S., active studies of maglev implementation are underway for a route between Pittsburgh and its airport and in the Washington-Baltimore corridor.

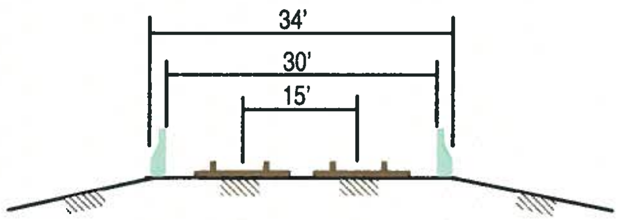
Although both systems would be capable of operating in the I-70 Mountain Corridor, neither is sufficiently advanced to generate reliable cost and performance data. Data provided by CIFGA was utilized in this study.

ALIGNMENT DESCRIPTION

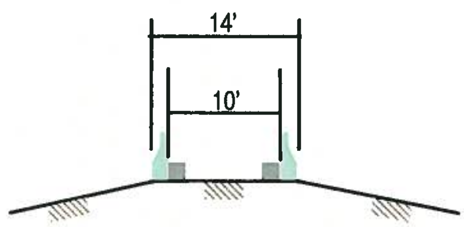
The FGT alignment analysis process was undertaken as part of the I-70 Programmatic Environmental Impact Statement to determine the character of the physical footprint of the transit alternatives on the I-70 Mountain Corridor generally from C-470 to Vail (as further detailed below). Built on the results of the Level 2 Screening Report, this report documents the analysis of alignments that support the vehicle technologies surviving second level screening. Alignment Studies were required to estimate capital costs.

Typical Section Development

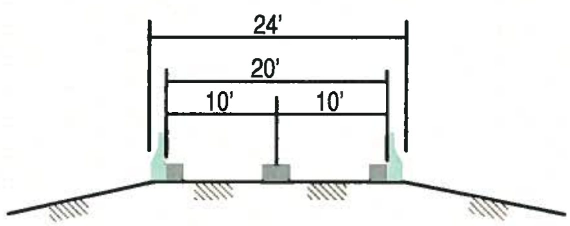
Based on the similarities in the various technologies listed above, four (4) basic typical sections were established. The dimensional elements necessary to accommodate just the transit modes are four basic sections are shown below:



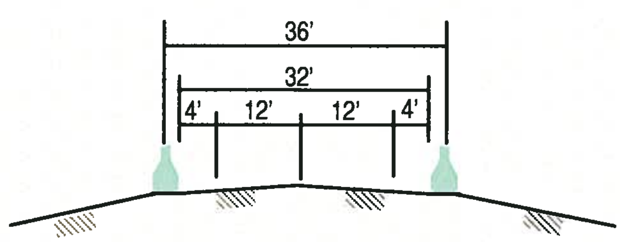
34-foot section – Rail Transit, Monorail, and Maglev



14-foot section – Bus in Guideway – Peak Direction (Diesel and Dual Mode)



24-foot section – Bus in Guideway – Dual Direction (Diesel and Dual Mode)



36-foot section – Bus in Transitway

Alignment Alternatives

Again, grouping common characteristics of the remaining technologies, an alignment design criterion was determined. From the table below, 2 basic alignment alternatives were initially selected for detailed study: the 6% FRA-compliant and the Highway (7%) alignments.

Grade	Criteria	Typical Section	Limits	Technologies
6%	Suitable for Heavy Rail Transit and Passenger Railroad EMU (FRA Compliant)	34'	This alignment was developed for the entire corridor from the C-470 area to Vail and included one major sub-alternative (see below)	All technologies, (heavy rail and passenger rail technologies were basis of typical section.)
Highway (7%)	Non-FRA-compliant, AASHTO	34'	C-470 to Vail excluding Clear Creek County (J.F. Sato & Associates incorporated appropriate space for the various typical sections in their analysis of the highway widening alternatives)	Rail, Monorail, and Maglev
Highway (7%)	AASHTO	14' 24'	C-470 to the Eisenhower Tunnel* excluding Clear Creek County (J.F Sato & Associates incorporated appropriate space for the various typical sections in their analysis of the highway widening alternatives)	Diesel and Dual Mode Bus
Highway (7%)	AASHTO	36'	C-470 to the Eisenhower Tunnel* excluding Clear Creek County (J.F. Sato & Associates incorporated appropriate space for the various typical sections in their analysis of the highway widening alternatives)	Diesel Bus

*Initial limits from C-470 to Dillon, also includes option from the Hyland Hills Interchange to the east side of Eisenhower/Johnson Tunnels

It was not the intent to limit the technology to any one alignment. For instance, all technologies could use the 6% Heavy Rail/Rail Passenger alignment. The intent was to show the most representative range of the operating character of FGT technologies. In the technology operational analysis, technologies were assigned to an alignment alternative based on where they would best perform.

Several of these alternatives had variations of grade and alignment creating more than one option for each alternative. Several of the alternatives followed the existing I-70 roadway and one of the alternatives did not. The alternatives that followed I-70 were evaluated by TranSystems from the Hogback to Vail, excluding Clear Creek County (the portion in Clear Creek County was evaluated by JF Sato using the same criteria). The 6% alignment that did not follow the existing I-70 roadway was assessed from the Hogback through Vail and included Clear Creek County. Below is a list of the criteria that were used to develop the various alternatives.

Design Criteria
6% FGT (Heavy Rail, Rail Passenger) vs. Highway (Light Rail, RTT)

Design Standards	6%	HWY
— Maximum Grade	6%	7% +
— Vertical Curves		
• Crest (K min value)	500	290 (70 mph, SSD)
• Sag (K min value)	1000	150 (70 mph)
— Horizontal Criteria		
• Minimum Curve Radius	955'	750' (45mph)

Footprints for Fixed Guideway Transit Alignments

The FGT alternative includes monorail, rail, bus-in-guideway, and bus-in-transitway. To simplify the analysis, it was assumed that the impacts would be identical for templates with the same overall width even if the technology specific configuration within the templates differed.

If possible, the Heavy Rail/Rail Passenger alignment (6%) was located immediately adjacent to the existing I-70 roadway alignment. This allowed easy access for track maintenance and called for less impact to the surrounding land (right-of-way required etc.).

Survey Data
The existing aerial survey (1981, 2-foot contour) was available from the east side of Clear Creek County to approximately one mile east of Copper Mountain Ski area. The remainder of the corridor was modeled using USGS mapping. The aerial survey mapping provided 2-foot contour accuracy for a band approximately 200-feet wide. The USGS mapping has an accuracy of +/- 40 feet. To supplement this data, a car mounted global positioning satellite (GPS) unit was used to map the pavement along the corridor from C-470 to Avon. This survey gave the designers the general alignment of the highway in both directions (which, by analytic comparisons gave the median widths) and it created a profile for the existing I-70 roadway from C-470 to Avon. This information was then incorporated into the digital terrain models that had been previously completed.

Representative sections were used to generalize segments of the corridor in developing the 6% and 7% (highway) grade alignments. In determining the representative section required at locations throughout the corridor, the horizontal alignment of the FGT first had to be determined. In areas where an aerial survey was available, the median was graphically measured to determine if the FGT could be built in the median. In areas where only USGS mapping was available, the median was visually inspected using aerial photos and then was field verified to determine if the FGT could be built in the median. If in the median, the FGT was placed immediately adjacent to the upper section of roadway. This was done to allow snow to be plowed from the FGT section into the median (if room was available). If building the FGT in the median was not feasible, the north and south sides of the roadway were evaluated to determine the ideal location of the FGT. The location was chosen based on the following criteria: space available, shadowing, existing terrain (including proximity to water courses), location of highway access points, potential locations for stations/platforms, and connection to alignments done by others (at the Clear Creek County lines and in Dowd Canyon).

Once the horizontal location was determined, the vertical location was determined (elevated or on grade). This was done based on the elevation at that location (greater/less than 8000') and the surrounding terrain (flat/steep etc).

Upon the determination of the location (horizontal and vertical), the representative section was chosen to best fit the conditions of the alignment segment. Three basic sections were used in the development of the alignments: structured on-grade and bridged. Within each of these sections there are variations such as whether the section requires a retaining wall, is adjacent to the roadway or slightly detached, or whether the section is benched into an adjacent hillside or on structure.

Special Alignment Studies - CIFGA
The character of the technology proposed by CIFGA in 2001 (the ability to operate at grades at or above 10%) created several special study cases within the corridor. In general, the CIFGA technology was assumed to follow the highway (7%) alignment alternative. The special studies were completed based on comments/recommendations from members of the CIFGA organization.
Kermit's Alignment - The one deviation that was studied to the greatest detail was an alignment that departed the existing I-70 roadway at the bottom of Floyd Hill, went over Kermit's Bar and Grill on US6 and stayed north of I-70 until rejoining I-70 between the twin tunnels and Idaho Springs. The grades for the CIFGA alignment were not limited and therefore provided more flexibility in the location of the horizontal and vertical alignments. This alternative was developed to the point of having a preliminary horizontal and vertical alignment, which was provided as input to the Train Performance Calculator. The goal of this study was to see what differences there were in overall travel time due to the alternative alignment. The results show only minor time savings (minutes over the entire trip length of greater than 1.2 hours). The summary of these RailSim studies can be found in the appendix (Interstate 70 7% CIFGA Monorail Summary & Interstate 70 7% Kermit CIFGA Monorail Summary).
Continental Divide Alignment - The second significant deviation for CIFGA was based on the suggestion to go over the Continental Divide. This alternative was not studied further based on anticipated environmental impacts and the Forest Service's unlikely approval of any alignment in that area.
Snake Creek Alignment - This was a deviation of the 6% alignment that was primarily driven by CIFGA's desire to use the original pioneer bore from the Eisenhower tunnel locations studies and to capture the potential ridership from the Keystone resort area. Two sub-alternatives were looked at to get around the Dillon Reservoir, one south and one east. These alternatives were only sketched on USGS maps and were not taken to the level of detail of the main 6% alignment. A map showing the Snake Creek Alignment can be found in the appendix.
From alignment description report, Sept. 2002

Cross sections were developed based on the logic described above. The toes of slope were generated and drawn on corridor mapping as an impact area. This process also created construction impacts for the alternative. Fifteen feet of width outside of the toe of slope on the side of the FGT template not bordering the roadway was added to account for construction activities. This was only applied to sections that were not in the median. It was assumed that if the FGT alternatives were in the median, the construction will be completed within the bordering roadway.

A summary of the representative sections for the FGT alternatives can be found in the appendix of this report.

Rail Transit Technology - 6% v 7% grades
As described above, in identifying the 6% alignment it was found necessary to deviate from the current alignment of I-70 for extended distances. In addition, extensive tunneling was required. These undesirable conditions led the Project Team to question the necessity for this alignment. In essence,

the Team asked TranSystems to analyze the feasibility of creating a single Rail Transit mode that combines the performance characteristics of Electric Light Rail with the capacity and operational characteristics of Heavy Rail. During the evaluation of Heavy Rail Rapid Transit and Light Rail Transit systems, it was noted that many systems were operating on extreme gradients. A number of rail routes in Switzerland (MOB, GFM, and RhB) run passenger trains on grades up to 7% for short distances (without rack assists), and historical systems that ran in San Francisco and Seattle with grades in the 7% to 12% range. Upon review of the rail transit design guidebooks compiled by the American Public Transportation Association and the Transportation Research Board, it was concluded that operation on the I-70 highway gradient would be feasible with suitable equipment. See the "Summary of Modes Tested" section for a description.

Conventional Monorail Technology
The rubber-tired Hitachi monorail train now being utilized in this study can readily handle 6% grades. Grades 7-8% require heating of the beam for ice melting to maintain adhesion for traction and braking. Typical sections were developed specifically for monorail. One specific design criterion adopted was to always place the beam high enough so that trains would run, at least, five feet off the ground, eliminating the need to perform most snow removal.

Urban Maglev Technology
This is the technology currently under consideration by CIFGA. Most maglev research has been focused on high-speed, long distance lines so relatively little information is available. The same alignment as Conventional Monorail was used.

Bus Alternatives
The two diesel bus alternatives (transitway and guideway) have also been redefined to have construction of the facility only between the east side of Eisenhower/Johnson Tunnels and Hyland Hills, the current end of the six-lane configuration of I-70. Currently, congestion rarely occurs east of this point. These alternatives are now designated as the Truncated Diesel Bus-in-Guideway and Truncated Diesel Bus-in-Transitway. The Dual Mode Bus-in-Guideway continues to be considered as being built westbound from Jefferson, and terminating westbound at the east side of the continental divide tunnel with the eastbound originating at Silverthorne. This arrangement allows the dual-mode buses to have access to electric power to climb the approach to the west portal of the continental divide tunnel and Floyd Hill under electric power (to achieve higher speeds and lower noise levels). The final alternative modification was to consolidate the two remaining rail alternatives as Rail Transit alternative, operating in the same "highway" alignment as the other transit alternatives.

Assumptions

In all cases the FGT was assumed to be barrier separated from the existing roadway. Options that located the alignment away from the roadway by more than 100 feet, assumed a 15-foot service road near the FGT alignment in the locations where the separation occurred. If the alignment was bordering the existing roadway, it was assumed that the existing roadway would serve as the maintenance access, eliminating the need for an additional maintenance roadway. Anytime the FGT was immediately adjacent to the roadway and above 8000 feet in elevation, the section was elevated to allow for the management of snow. (For a complete explanation of snow removal/storage, see the Snow Removal Report appendix).

Conclusions

Because of the level of detailed survey information, the alignments studied are conceptual in nature. Modifications may be needed as the project progresses. These modifications may include slight changes in grade or in horizontal alignment to accommodate operational conditions (single track versus double track, station location, etc.) and identified environmental constraints not known at this time. The impacts shown in the alignment files are as accurate as the base maps that were used to create the cross sections. Upon receipt of more accurate data, the location of stations in the corridor and other features for the transit alternative alignments can be modified to reflect these changes.

TRAIN PERFORMANCE CALCULATOR

The Railsim 7® Train Performance Calculator (TPC) was utilized to model train performance of the three FGT and three RTT alternatives. This particular Train Performance Calculator has gained recognition within the industry as one of the most comprehensive simulators used today. The Norfolk Southern Railway uses Railsim 7® for use exclusive as a planning and costing tool. Railsim 7® was also used for a major capacity study of the congested segment of the Northeast Corridor between Newark, NJ and Penn Station, New York City.

The TPC was used to project performance characteristics of all of the types of equipment selected in Level 2 screening over the proposed FGT alignment from C-470 to Vail. In this phase of the study the only alignment tested was the "Highway" alignment, so the grades and curves of the existing I-70 roadway were input using the TPC's Database Editor. The TPC was used as a planning tool to:

- Develop trip time predictions for the FGT alignments (required to calculate operating costs and fleet size requirement analyses, a key part of capital costs)
- Predict energy consumption (kWh for electrically-powered trains and gallons for diesel-powered bus; kWh was also an input for sizing the electrical distribution system).

In summary, the TPC was used to generate detailed and highly accurate performance characteristics of trains and buses operating over a specified alignment. The performance data includes time, distance, velocity and acceleration on grades, among the many types of output.

The TPC Report Generator function summarizes performance from the raw output files (numerous data points are recorded each second of the simulated run, typically one to two hours long). To date, text-based Train Summary Reports have been produced for each run. The report provides an overview of the selected TPC run(s), by station. It includes a header identifying the report and the geographic limits of the run, as well as all option and parameter settings, station arrive and leave or pass times (for express runs) based on cumulative running time from the beginning of the run, as well as distance operated, average velocity (with and without station stops), peak power demand and energy consumption for and End to End run. The TPC can also produce user-specified graphic plot reports.

Summary of Transit Modes Tested

Railsim 7® has an extensive library of rail equipment. There are 344 North American Locomotives, 128 North American Coaches, 64 North American Multiple Unit Cars, 220 North American Transit Vehicles, 292 World Wide Multiple Unit Cars, and 412 World Wide Transit Vehicles. With this roster to choose from, it was possible to select the best type of equipment available as a starting point for creation of custom-built train sets utilizing the capability of the TPC to build "user-defined" rolling stock to meet the specific needs of the corridor, most notably the grades up to 7%. The same approach was used to simulate the non-rail systems (monorail and urban maglev) and buses (both diesel and dual mode). It was also possible to define these as TPC rolling stock types, with appropriate characteristics.

The terminals and stop patterns set in the TPC runs were those established as part of the overall study, and as refined in the development of the operating plan.

The characteristics of each mode were described in an earlier section (Summary of Transit Modes Tested, p.1). The following section provides mode-specific parameters input in TPC and the resulting average speeds and energy usage.

RTT Alternatives
Both a Diesel and Dual Mode bus were modeled from user defined vehicles and were built to simulate buses, primarily to estimate electricity consumption, to allow sizing an electric power distribution system for trolleybuses and dual mode buses. Diesel fuel requirements were also calculated using Railsim. Railsim's rubber-tired vehicle resistance coefficient was used for the bus runs. Only the segment on the Transitway/Guideway was tested in the TPC. Stop patterns utilized were those established in the Operating Plan. Separate runs were conducted the three bus alternatives for each of the four stop patterns in both directions. Running time and distance for the segments off I-70 were calculated using DeLorme software. For the two Truncated Diesel Bus alternatives, JF Sato provided running time for the section of I-70 between Jefferson and Hyland Hills. Energy requirements were estimated for the sections not modeled in the TPC based on mileage of proposed buses since all buses would run on gasoline this section.

Diesel Bus, Transitway and Guideway
When in the Transitway, the maximum speed was set at 65mph, which is the maximum posted speed on this portion of I-70. It was assumed that the Transitway would be built with standard highway superelevation and speed on curves was set appropriately. The Diesel bus in transitway had an average speed of 43.9 mph for the portion of the routes on I-70 averaged for the two directions. Diesel buses on Guideway were tested with a maximum speed of 70 mph, because the Guideway would keep buses on the alignment. This bus had an average speed of 49.2 mph.

Dual Mode Bus on Guideway
Top speed on the Guideway was set at 75mph. Some adjustment were made to the running time calculated by Delorme for the segments off I-70 to account for operating the heavy dual mode buses on diesel power on heavy grades on Berthoud Pass (*en route* to Winter Park and Vail Pass). Simulation showed travel on I-70 at an average speed of 54.9 mph.

Rail Transit
Top speed was set at 80 mph as curvature would not allow higher speeds virtually anywhere in the corridor. TPC runs were conducted with twelve inches maximum superelevation and six inches of cant deficiency. In some sections with steep downgrades it was necessary to test with civil speed limits imposed to prevent trains from running away. Station dwell time was assumed to be 45 seconds at each station (2 minutes at Denver Union Station). In order to collect all the running time and energy consumption data required to complete operating and capital cost estimates, TPC runs were conducted

(in both directions) between:

- Denver International Airport (DIA) and Vail
- DIA and Frisco
- Jefferson Station (US 6/C-470) and Vail
- Jefferson Station and Frisco.

The ten car EMU R2 train performed at an average speed of 52.3 mph (on the Jefferson-Vail run, averaged for the two directions). The run time between (DIA) and Vail was 2 hours 37 minutes, using 8237 kWh of electricity westbound and 5898 eastbound.

Conventional Monorail
Top speed is limited to 60 mph by the use of large rubber tires. The RailSim 7 "rubber tire" friction coefficient was used. Acceptable cant deficiency was set at 6 inches. The same stop pattern and station dwell time was used as for rail transit. Its average speed was 42.5 mph with a maximum speed of 60 mph an elapsed time of 2:42. For the westbound DIA to Vail trip, the monorail used 4133 kWh and 2323 kWh for the eastbound trip.

Urban Maglev
Since this is a new mode, no empirical data exists from existing systems. Most of the data entered into the TPC was provided by CIFGA, including a 100 mph top speed, to reflect lack of friction resistance. Those included: rolling resistance, journal, and flange resistance. Again, the same stop pattern and station dwell time was used as for rail transit. The Urban Maglev operated at an average speed of 61.5 mph when traveling between DIA and Vail with an end-to-end running time of 2:10, including dwell time.

OPERATING PLAN

This section describes the assumptions regarding the alignments and operating parameters that were made for each mode. A sketch-operating plan was developed for each modal alternative. This was a two-phase effort.

In the first phase JF Sato used their travel demand forecasting model to develop Year 2020 ridership estimates, by time of day and by station, for a single day type – winter Saturday, the heaviest day of travel – based on three different assumptions of average fares; 5¢, 10¢ and 25¢ per mile. In this phase three operating plans were developed for each mode (one designed to serve the ridership associated with each fare level), but only for this day type. The result was a schedule of headways at various times of day. With this it was possible to calculate the number of vehicle miles and crew hours. Other components, such as station agents and dispatching were also identified. Operating costs were calculated using these factors. Results are presented in Table X. The Project Team determined that, of these, the 10¢ per mile level provided the best balance between attracting enough riders to make a significant contribution toward reducing congestion and recovering a substantial portion of operating costs from fares. In fact, on this heaviest day type, all modes covered all of their operating costs; some modes had an operating surplus, which would be available to cover deficits on other, lighter travel days. The model of seeking to cover a given portion of operating costs, and not focus on capital costs for making this decision, is similar to the approach used on highway construction projects where vehicle operating costs are not considered.

In the second phase, JF Sato utilized average speeds and travel times developed by TranSystems in the first phase as inputs to the travel demand forecasting model to develop ridership levels for each mode for each of the seven representative day types. TranSystems then established appropriate operating plans for each mode for each of the typical day types. JF Sato also provided a calendar which established how many days of each of the seven day types would occur over the year. The result was that TranSystems was able to establish total annual operating costs for each mode. Capital costs for building the infrastructure (including maintenance facilities) and purchase of vehicles could also be derived from the sketch operating plans.

The I-70 PEIS covers the corridor from the intersection of I-70/US 6/C-470 west to Vail. Capital cost estimates have focused on construction of infrastructure in this corridor. However, for the purpose of designing and calculating operating costs the FGT/RTT service, it has been assumed that service would run through to the Denver Metro area, although over undefined routes. The FGT modes would operate to downtown and DIA.

RTT Alternatives Descriptions
All of the bus alternatives were based on the same route structure. These involve origins at four points in the Denver Metro area (downtown, DIA, south and north) and various terminals on the west end. For simplicity, all routes were assumed to operate all day long, everyday. See Summary of Transit Modes Tested for a description of the technologies.

Route	Frequency-Am Peak (Winter Sat) (in minutes)	Frequency-Am Peak (Low Weekday) (in minutes)	Number of Stops
Route 1: Westminster to Central City	15	12	6: Westminster, Arvada, Ward Rd, Jefferson, U.S. 6, Casinos
Route 2: Tech Center Winter Park	6	4	5: Tech Center, Mineral Springs, Jefferson, Empire, Winter Park
Route 3: Tech Center Arapahoe Basin	6	10	6: Tech Center, Mineral Springs, Jefferson, Silverthorne, Keystone, Arapahoe Basin
Route 4: Westminster Breckenridge	4	6	6: Westminster, Arvada, Ward Rd, Frisco, Breckenridge
Route 5: DIA-Vail	6	10	7: DIA, Pena, Stapleton, Jefferson, Frisco, Copper Mountain, Vail
Route 6: Denver Union Station-Glenwood Springs	4	10	3 in Corridor and 8 West of Vail: DUS, Jefferson, Frisco, Vail , Edwards, Wolcott, Eagle Village, Eagle Airport, Gypsum, Dotsero, Glenwood Springs
Route 7: Denver Union Station – Frisco Local	8	7	10: DUS, Cold Spring, Jefferson, El Rancho, US 6, Idaho Springs, Empire, Georgetown, Loveland, Silverthorne, Frisco

Diesel bus in transitway:
This alternative travels in a transitway from either Jefferson to the east portal of the continental divide tunnel or with a transit way for only Jefferson to the Clear Creek County line and then enters into mixed traffic between the Clear Creek County line (Floyd Hill) and the eastern portal of the Eisenhower/Johnson Tunnel. It was assumed that the Transitway would end at the west side of the Eisenhower/Johnson Tunnel. A transitway refers to a limited access roadway designated for the exclusive use of transit vehicles or other designated vehicles. Several aspects of transitways are both strengths and weaknesses. For example, transitways are not necessarily vehicle specific and consequently emergency vehicles may use it. Existing bus transitway systems are located in Pittsburgh and Ottawa (Canada).

Diesel bus in guideway:
A guideway refers to a transit facility which uses buses equipped with horizontal guidewheels which run tightly against a vertical beam or the edge of the roadway. Such specialized facilities cannot be utilized by other vehicles. Guideways may operate at higher speeds than transitways because vehicles are mechanically guided. The only high speed bus guideway system is the O-Bahn in Adelaide, Australia. TranSystems conducted a comprehensive site visit to this system and found it to be a very appropriate model for the I-70 corridor. A written technical report and a video were provided to CDOT.

Dual mode in Guideway
The Dual mode bus in guideway option uses an articulated bus powered by electricity in the guideway and diesel off the guideway. This option has the advantage of providing electric power to quickly and quietly climb mountain grades. This alternative assumes that a single direction Continental Divide tunnel would be provided for use in the peak direction for the buses. The arrangement for inserting reverse-peak direction buses at the front of the Tunnel queue described above would be also be

applied.

Rail Transit

Station stops were assumed at: Vail, Copper Mountain, Frisco, Silverthorne, Loveland, Georgetown, Empire, Idaho Springs, US 6, El Rancho, Jefferson, Denver Union Station and Denver International Airport. Because the same general technology has already been selected as the Locally Preferred Alternative for routes in the Denver area this should not be a problem. At this point in the analysis, it was assumed that sufficient capacity would exist for the Intermountain Corridor trains. Because preliminary ridership estimates showed high levels of ridership, with resulting frequent service, a skip stop operating plan was assumed in the corridor. Even with only half of the trains stopping, intermediate stops would have quite frequent service, while all passengers would benefit from faster service. The ridership projections provided by JF Sato indicated that that is a significant drop-off in ridership west of Frisco. Therefore, it is proposed to terminate a significant number of trains at Frisco. This, in turn, would allow construction of the line west of Frisco with a single track. Two, two-mile long passing tracks would enable the operation of trains with no delay if they are close to schedule. A single track Continental Divide tunnel is also proposed; this will be relatively short and should cause very little delay.

Conventional Monorail

The same station stops and station dwell time as the rail transit alternative were assumed. While the operating plan assumed that trains would operate through to downtown Denver and DIA, this is not the same technology Denver has selected as the Locally Preferred Alternative; there may be a need to transfer between the Mountain Corridor system and RTD lines at Jefferson (US 6/C-470). Because of the smaller capacity of monorail trains, more frequent service is required. Therefore, single guideway alternatives are not feasible west of Frisco. However, for the short distance involved, this approach is feasible for the Continental Divide Tunnel. TranSystems also conducted a comprehensive site visit to monorail in Japan. Again, safe, reliable service is provided, although capital costs are high. A technical report was provided to CDOT.

Urban Maglev

Again, the same station stops and dwell times were assumed for the Urban Maglev and a wide Rail Transit alternative. Similar to the Conventional Monorail, the Urban Maglev is not the technology adopted by the Locally Preferred Alternative for RTD. While it has been assumed that passengers will be able to ride through to Metro Denver points; there may still be a need to transfer between the Mountain Corridor system and RTD lines at Jefferson (US 6/C-470).

Summary of Operating Costs

As described in the Operating Plan section, operating costs were computed for the sketch operating plans for each modal alternative for the seven different day types: a winter Thursday, winter Saturday, winter Sunday, summer Thursday, summer Saturday, summer Sunday, and low ridership weekday. Annual system operating costs were developed based on the calendar provided by JF Sato which identified how many days of each type would need to be operated.

The operating plans allowed calculation of the number of vehicle miles operated, fuel or power consumed, crew hours, as well as hours for station staff, dispatch staff, management and support staff, and casualty and liability costs. This section describes how costs were applied to these elements. All costs were calculated at constant 2002 levels, without inflation.

Vehicle Mile Cost

Vehicle Mile Cost represents the cost per vehicle mile, not including fuel. This essentially represents an assignment of costs for vehicle maintenance and cleaning. When comparing trains to buses it is important to consider that each car of train is a unit; whereas, a bus is only one unit. This component essentially represents an assignment of costs for vehicle maintenance and cleaning. In this system different modes were assigned different costs:

Alternative	Vehicle Mile Cost	Per Seat Mile
Diesel Bus in Transitway (Truncated)	$0.79	$0.017
Diesel Bus in Guideway (Truncated)	$0.79	$0.017
Dual Mode Bus in Guideway	$0.91	$0.013
Heavy Rail	$1.10	$0.018
Conventional Monorail	$8.58 (train)	$0.024
Urban Maglev	$9.90 (train)	$0.026

Fuel or Power Consumed

The total fuel or electric power consumed was determined differently for rail, monorail, and urban maglev than it was for the buses. For rail, monorail and urban maglev the TPC simulation output provided the power consumed for the entire length of each trip in each direction. A price of $0.10 per Kwh was assigned.

The Diesel Bus fuel quantity was the sum of two calculations. One set of simulations was done using the TPC to determine the amount of fuel used in the transitway or guideway portion. This sum was added to a figure representing service on I-70 east and west of the transitway or guideway. This was added to a third quantity for service extending out of the I-70 corridor. The Diesel Bus mileage from the Railsim output was applied to the distance of the bus routes outside the I-70. A cost of $1.60 per gallon was assumed for diesel fuel. The Dual Mode Bus alternative combined electric power used in the guideway with the fuel used in diesel mode off the guideway.

Crew Person Hours

Crew person hours represent the total hours required to crew the vehicles. Crew members operate vehicles, participate in fare collection/inspection activities and assist in emergencies (a decision was made early in the I-70 PEIS process that no unmanned, automated systems would be appropriate for operation in this long corridor, much of which is located in remote areas.) This is based on the total amount of time the vehicles require to make the round trip plus an allowance of an additional 15% to cover schedule recovery time and administrative time (checkin/checkout, etc.). Buses had one person (the driver); whereas, the crew for rail, monorail, and urban maglev varied. For rail, two (an operator and a conductor) were assigned to five car trains and three (add an assistant conductor) were assigned to ten car trains. For the relatively short monorail two crew members (an operator and a conductor) were assigned and three crew members were assigned for urban maglev. Since the maglev has two large cars it was necessary to assign a conductor to each car in addition to the operator. No food service staff costs (or revenue) were calculated because it was assumed that food/beverage service would be self-supporting. Crew person costs were calculated based on a $16.00/hour wage and fringe benefits of 60%.

Other Labor Costs
Labor Cost includes the crew, station staff, dispatch staff, management, and other support staff. Maintenance labor is accounted for in the Vehicle Mile Cost, above. Similarly fare collection related labor is accounted for both station staff and in the management staff.

Station and Dispatch staff and Management staff were calculated as follows:

- Station Staff: $16.00 per hour with an additional 60% for fringe benefits ($25.60)
- Dispatch Staff: $19.20 per hour with an additional 60% for fringe benefits ($30.72)
- Management: $24.00 per hour with an additional 60% for fringe benefits ($38.40)

Station staffing was tailored to meet the needs of the station. Those needs were a function of the station usage provided by Sato's travel demand forecast. In conjunction with the ridership, station staff was also a function of location on the system. Once labor requirements were determined for each location they were held constant throughout the operations analysis. Thus it is necessary that these locations be staffed the same way for all modes evaluated.

Station	Staffing	Station	Staffing
VAIL	7	IDAHO SPRINGS	0
COPPER MTN	5	US-6	0
FRISCO	7	EL RANCH0	3
SILVERTHORNE	5	JEFFERSON	3
LOVELAND	5	ARVADA	3
GEORGETOWN	0	UNION STATION	17
EMPIRE JNCT	3	AIRPORT	5
Subtotal	32	Subtotal	31
	Total	**63**	

Casualty and Liability Costs
Casualty costs and liability costs were computed to represent the total cost of liabilities and casualties relating to vehicle operations, vehicle maintenance, non-vehicle maintenance, general administration, administration and support, ticketing and fare collection, system security and the total modal expense. Costs for the I-70 transit alternatives were estimated based on data on the directly operated transit included in the National Transit Database 2000.

Alternatives	Vehicle Miles Operated	Liability and Casualty Cost

Diesel Bus in Transitway (Truncated)	58,063,000.00	$	3,226,000.00
Diesel Bus in Guideway (Truncated)	49,588,000.00	$	2,754,900.00
Dual Mode Bus in Guideway	33,720,000.00	$	1,873,400.00
Rail Transit	37,456,000.00	$	5,525,000.00
Conventional Monorail	7,056,000.00	$	8,879,000.00
Urban Maglev	6,672,000.00	$	11,994,600.00

All the transit alternative's Liability and Casualty Costs were derived from linear regressions of the Casualty & Liability Costs/Total Modal Expense category as the independent variable and Total Actual Vehicle miles as a dependent variable controlled for the mode studied. Linear Regressions were done with outliers excluded and correlation of 0.9 to 1. Bus costs were derived from linear regressions from the data controlled for buses. Similarly Rail Transit costs were derived from linear regression of the Casualty & Liability Costs/Total Modal Expense category controlling for all rail modes (commuter, heavy, and light rail). Monorail costs were derived also from linear regression for all rail modes but the data were weighted for monorail. Lastly, Urban Maglev costs were derived from the monorail cost with a factor of 1.35 miles applied to represent additional costs associated with new technology.

CAPITAL COST ESTIMATES

Six capital cost alternatives were developed for transit in the I-70 Mountain Corridor. They are as follows:

Alternative	Width (ft)	Location
Truncated Bus-in-Transitway	36	Hyland Hills to East Side of Eisenhower/Johnson Tunnel
Truncated Bus-in-Guideway	24	Hyland Hills to East Side of Eisenhower/Johnson Tunnel
Dual Mode Bus-in-Guideway	24	Jefferson Station to Silverthorne (WB to Eisenhower/Johnson Tunnel)
Rail Transit	34	Jefferson Station to Vail
Conventional Monorail	34	Jefferson Station to Vail
Urban Maglev	34	Jefferson Station to Vail

Each of these alternatives had been previously developed to the point that the representative sections were chosen for the length of the alignment. Therefore it had been previously determined if the alternative was on structure or on grade or on the north, south or median of the roadway. Quantities were determined based on this information. See appendix for quantity summaries.

Elements of Capital Cost Estimate

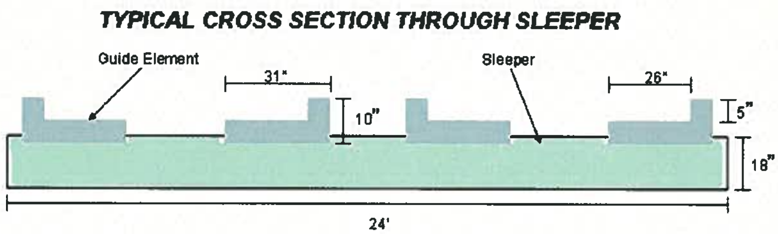
Quantities were calculated using both a computer model (where data was available) and GPS data in combination with USGS mapping. Each alternative was then utilized to develop quantities for grading, bridges, retaining walls, track (for rail), beamway (monorail, maglev), roadway /guideway (for buses), electrification (for all modes except diesel bus), maintenance facilities & equipment, and rolling stock. Each of these quantities were then broken down by segment so a cost per segment could be calculated. In Clear Creek County, JF Sato provided the quantities for grading, bridges, asphalt (as appropriate) and TranSystems quantified electrification, track/beamway/guideway, and maintenance for this section.

Truncated Bus-in-Transitway
The truncated bus-in-transitway ran from the Hyland Hills Interchange to the east side of the Eisenhower/Johnson Tunnel. This alternative was be very similar to a roadway in that the buses would operate within a standard width roadway that is constructed of asphalt and will be separated from traffic with concrete barriers. This entire option falls within Clear Creek County. As a result, TranSystems calculated costs for maintenance, rolling stock and electrification. JF Sato calculated the quantities such as bridge, structure, earthwork and other transitway costs as required.

Truncated Bus-in-Guideway
The diesel bus-in-guideway option began at Hyland Hills Interchange and ran to the east side of the Eisenhower/Johnson Tunnel. This alternative had two variations for the guideway systems within the alternative. The first option is a single guideway that has the trackway and the guide beam all in one.

The second option is similar to an existing system in Adelaide, Australia (see photograph below). This systems has sleepers and guide elements that are placed separately (as shown below). The difference between the existing system in Australia and this project is that I-70 systems, the soil and existing ground conditions are much more stable and therefore would not require caissons to be drilled to act as a foundation for the sleepers. For the I-70 Mountain Corridor, it was assumed that the soil conditions would allow base course material to be relied upon eliminating the need for pilings.

This entire option falls within Clear Creek County. As a result, TranSystems calculated costs for maintenance, rolling stock, guide elements and electrification. JF Sato calculated the quantities such as bridge, structure, earthwork and other guideway costs as required.



Guided Bus system in Adelaide, Australia

Dual Mode Bus-in-Guideway

The dual mode bus-in-guideway began at Jefferson station and ended in Silverthorne. This option was bi-directional from Jefferson station to the east side of the Continental Divide Tunnel, peak direction through the tunnel and eastbound only from Silverthorne to the west portal of the Tunnel.

This option falls in Jefferson County, Clear Creek County and in Summit County. JF Sato calculated the costs for earthwork, structure, bridge and base course for the portion of the alignment that falls in Clear Creek County. TranSystems calculated guideway costs, maintenance, rolling stock and electrification within Clear Creek County and all costs outside of Clear Creek County.

Rail Transit

The rail transit option also began at the Jefferson station and continued along the I-70 roadway to Vail. This alternative varies between single and double track depending on its location in the corridor. A single-track section was used to get through the Continental Divide Tunnel due to geologic issues as well as cost considerations. A single-track section, with passing sidings, was also used from approximately Frisco west to Vail. The following chart summarizes single and double track locations:

Segment	Double Track	Single Track
Jefferson Station - Hyland Hills	X	
Hyland Hills - Empire Junction/US 40	X	
Empire Junction/US 40 - Loveland/US 6	X	
Loveland/US 6 - East Side of Tunnel	X	
Eisenhower/Johnson Tunnel		X
West Side of Tunnel – Frisco	X	
Frisco – Vail		X

This option falls in Jefferson County, Clear Creek County, Summit County and Eagle County. JF Sato calculated the costs for earthwork, structure, bridge and base course for the portion of the alignment that falls in Clear Creek County. TranSystems calculated guideway costs, maintenance, rolling stock and electrification within Clear Creek County and all costs outside of Clear Creek County. This included rail structure/trackwork, signals, stations, fare collection interlockings and general maintenance costs. JF Sato calculated the tunnel costs for this option..

Monorail

The Monorail option began at the Jefferson station and generally continued along the I-70 roadway through Vail. It was assumed that the Monorail would be dual direction for the entire length of the alternative, except for the tunnel. The representative cross sections for this option can be found in the appendix.

Capital Costs for Monorail – General cost of the structure was first calculated. This was done anywhere that the alignment was elevated on structure adjacent to the roadway. This cost included caissons, pier bents and running beams. The second cost calculated for the Monorail was the guideway structure. This item included running rails and power rails. Earthwork and retaining walls were also found based on the representative section that was used. The last cost for the Monorail was a general engineering cost. This included costs for highway reconstruction where needed to accommodate for the Monorail, fencing costs for the Monorail structure and a cost for utilities.

Urban Magnetic Levitation

The Urban Maglev option began at the Jefferson station and generally continued along the I-70 roadway to Vail. It was assumed that the Maglev would be dual direction for the entire length of the alternative, except though the Continental Divide Tunnel. The representative cross sections for this option can be found in the appendix.

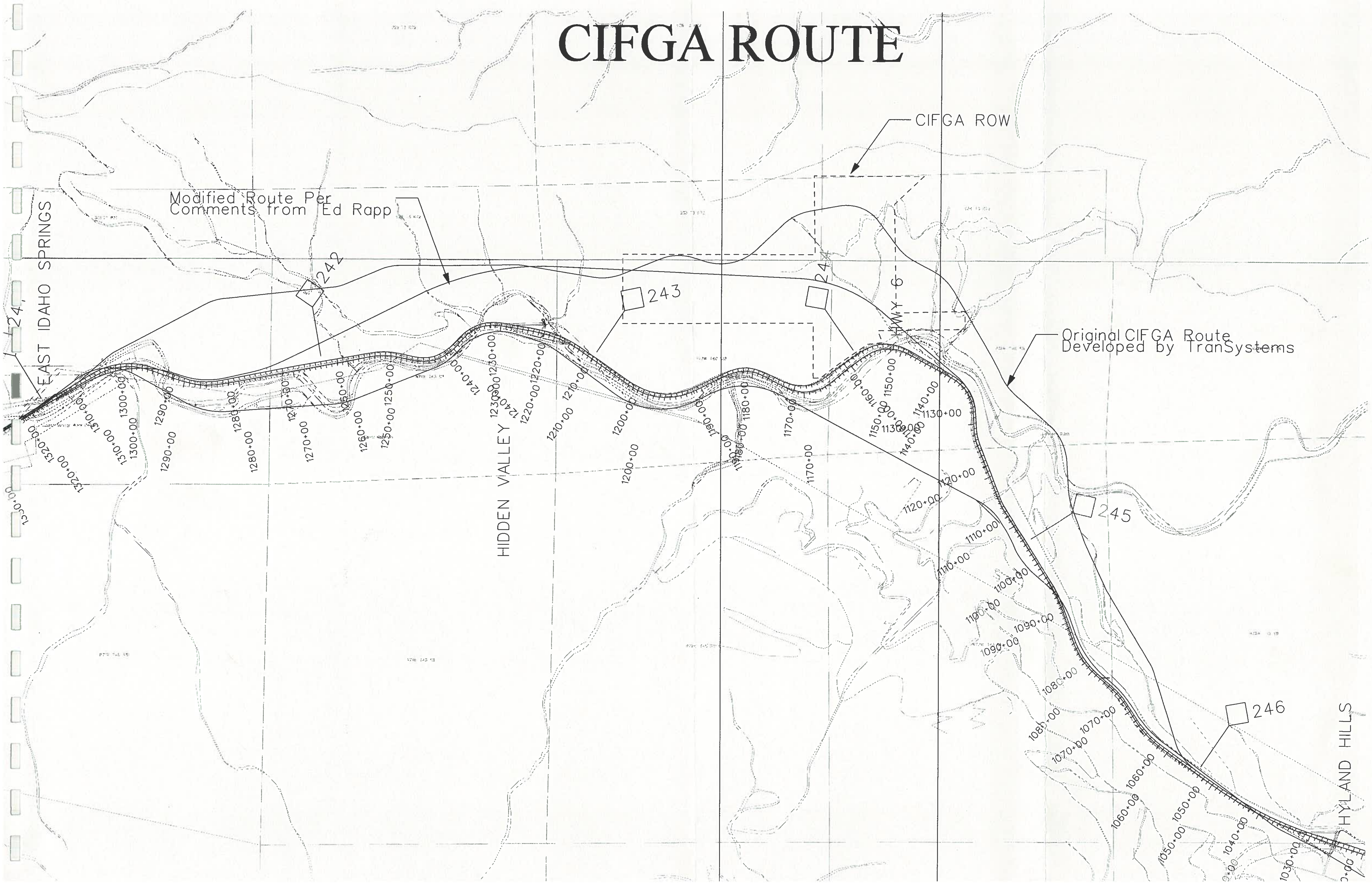
Capital Costs for Maglev – General cost of the structure was first calculated. This was done anywhere that the alignment was elevated on structure adjacent to the roadway. This cost included caissons, pier bents and running beams. The second cost calculated for the Maglev was the guideway structure. This item included running rails and power rails. Earthwork and retaining walls were also found based on the representative section that was used. The last cost for the Maglev was a general engineering cost. This included costs for highway reconstruction where needed to accommodate for the Maglev, fencing costs for the Maglev structure and a cost for utilities.

Summary of Capital Cost Estimate

Technology	Construction Items Cost	Contingencies Cost*	Total Cost	Segment Length	Notes
Bus in Guideway	$244,605,320	$431,374,392	$675,979,712	30.65 miles	Does not include structure, walls, basecourse, earthwork or tunnels
Bus in Transitway	$185,283,000	$326,756,349	$512,039,349	30.65 miles	Does not include structure, walls, basecourse, earthwork, asphalt, conc. Barrier or tunnels
Heavy Rail	$2,209,550,130	$3,896,658,275	$6,106,208,405	86.8 miles	Does not include basecourse, earthwork, walls or stuctures in Clear Creek County
Monorail	$2,453,048,160	$4,252,984,818	$6,706,032,976	86.8 miles	Does not include basecourse, earthwork, walls or stuctures in Clear Creek County
Maglev	$2,543,253,160	$4,485,161,182	$7,028,414,342	86.8 miles	Does not include basecourse, earthwork, walls or stuctures in Clear Creek County

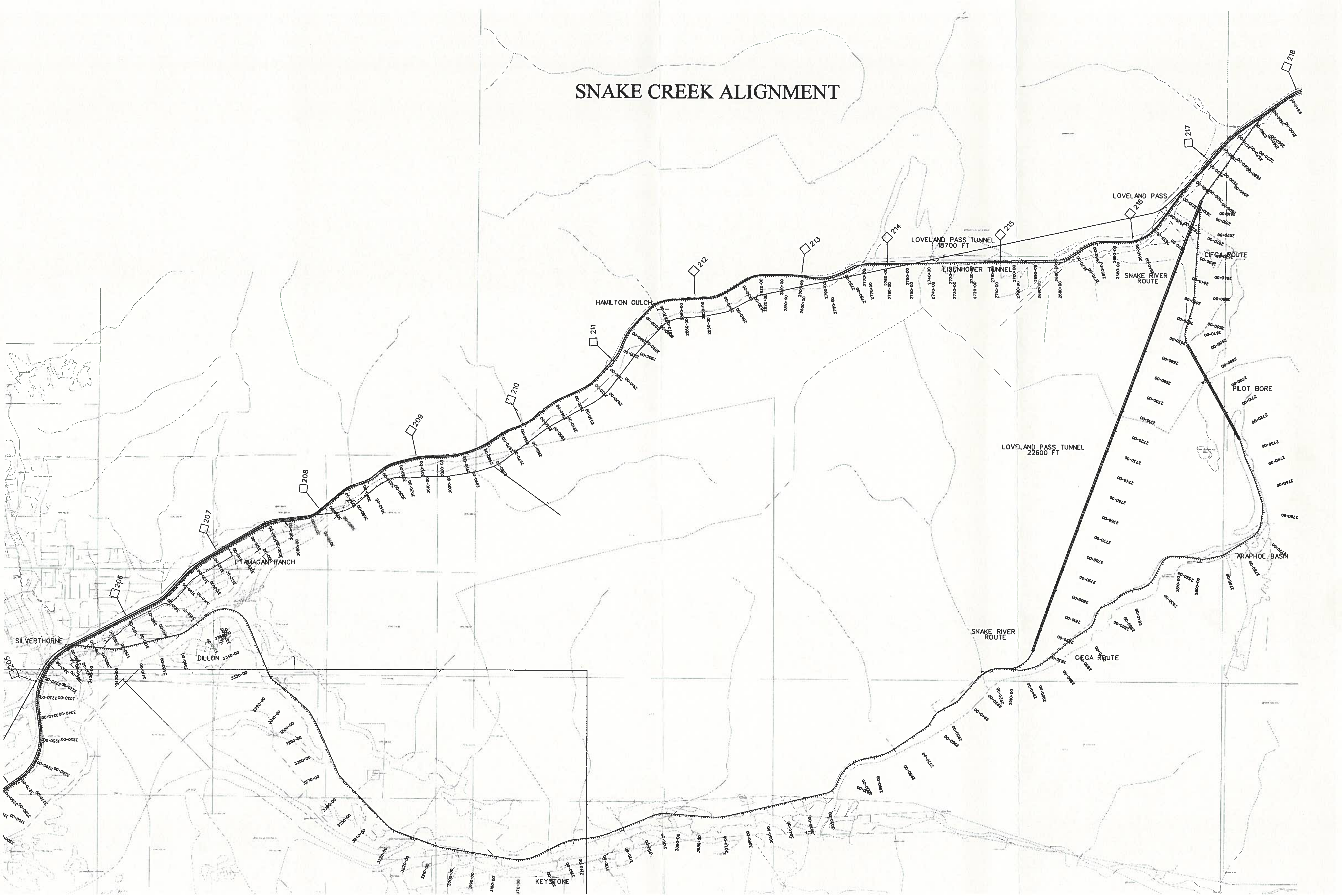
*Contingency factors as given to TranSystems by JF Sato
See appendix for complete cost breakdown

CIFGA ROUTE



CIFGA ROW
Modified Route Per
Comments from Ed Rapp
Original CIFGA Route
Developed by TranSystems
EAST IDAHO SPRINGS
HIDDEN VALLEY
HYLAND HILLS
HWY 6
242
243
244
245
246

SNAKE CREEK ALIGNMENT



Interstate 70 7% Kermit CIFGA Monorail Summary

Station ID	Event State	Interval Time Hrs:Min	Elapsed Time Hrs:Min	Distance Feet	Average Spd. Mph	Max. Spd. Mph	Make Up Percent	Peak Power kw	Power Consumption kwh
6TH AVE WEST	Departure	0:00	0:00	0			N.A.		0
GOLDEN / C-470	Arrival	0:02	0:02	10495.37	54.5	94.43	0	7494.9	137.3
GOLDEN / C-470	Departure	0:01	0:03	0	40.59		0	0	0
ELRANCHO / EVERGREEN	Arrival	0:07	0:10	39797.68	65.99	100	0	7489.5	447.52
ELRANCHO / EVERGREEN	Departure	0:01	0:11	0	59.48		0	0	0
IDAHO SPRINGS	Arrival	0:10	0:20	64200.29	75.78	99.51	0	7509.16	508.86
IDAHO SPRINGS	Departure	0:01	0:21	0	70.31		0	0	0
EMPIRE	Arrival	0:05	0:26	38000.48	80.19	100	0	7496.91	300.08
EMPIRE	Departure	0:01	0:27	0	70.39		0	0	0
GEORGETOWN	Arrival	0:03	0:30	21997.44	75.63	100	0	7497.87	171.61
GEORGETOWN	Departure	0:01	0:31	0	61.65		0	0	0
LOVELAND	Arrival	0:08	0:39	66007.67	89.49	100	0	7504.59	705.95
LOVELAND	Departure	0:01	0:40	0	82.14		0	0	0
ILVERTHORNE / DILLON	Arrival	0:07	0:47	51999.96	83.29	100.01	0	7495.5	123.42
ILVERTHORNE / DILLON	Departure	0:01	0:48	0	75.32		0	0	0
FRISCO	Arrival	0:04	0:52	24696.11	79.88	100.01	0	7509.01	182.44
FRISCO	Departure	0:01	0:52	0	65.83		0	0	0
COPPER MOUNTAIN	Arrival	0:04	0:57	33197.47	84.55	100	0	7505.2	251.08
COPPER MOUNTAIN	Departure	0:01	0:58	0	72.38		0	0	0
VAIL	Arrival	0:14	1:12	113402.96	90.62	100	0	7491.09	365.11
Run Total (With Dwells)		1:12		463795.43	73.42	100.01	0	7509.16	3193.37
Run Total (Without Dwells)		1:05		463795.43	81.05	100.01	N.A.	7509.16	3193.37

Interstate 70 7% CIFGA Monorail Summary

Station ID	Event State	Interval Time Hrs:Min	Elapsed Time Hrs:Min	Distance Feet	Average Spd. Mph	Max. Spd. Mph	Make Up Percent	Peak Power kw	Power Consumption kwh
6TH AVE WEST	Departure	0:00	0:00	0			N.A.		0
GOLDEN / C-470	Arrival	0:02	0:02	10495.37	54.5	94.43	0	7494.9	137.3
GOLDEN / C-470	Departure	0:01	0:03	0	40.59		0	0	0
ELRANCHO / EVERGREEN	Arrival	0:07	0:10	39797.68	65.99	100	0	7489.5	447.52
ELRANCHO / EVERGREEN	Departure	0:01	0:11	0	59.48		0	0	0
IDAHO SPRINGS	Arrival	0:09	0:20	64201.3	78.14	97.01	0	7509.16	334.66
IDAHO SPRINGS	Departure	0:01	0:21	0	72.33		0	0	0
EMPIRE	Arrival	0:05	0:26	38000.45	80.19	100	0	7496.91	300.22
EMPIRE	Departure	0:01	0:27	0	70.39		0	0	0
GEORGETOWN	Arrival	0:03	0:30	21995.77	75.63	100	0	7497.86	171.59
GEORGETOWN	Departure	0:01	0:31	0	61.64		0	0	0
LOVELAND	Arrival	0:08	0:39	66007.42	89.49	100	0	7504.69	705.94
LOVELAND	Departure	0:01	0:40	0	82.14		0	0	0
ILVERTHORNE / DILLON	Arrival	0:07	0:47	51999.18	83.26	100.01	0	7495.52	123.43
ILVERTHORNE / DILLON	Departure	0:01	0:48	0	75.31		0	0	0
FRISCO	Arrival	0:04	0:51	24697.07	79.88	100.01	0	7509.01	182.44
FRISCO	Departure	0:01	0:52	0	65.83		0	0	0
COPPER MOUNTAIN	Arrival	0:04	0:57	33197.38	84.55	100	0	7505.2	251.08
COPPER MOUNTAIN	Departure	0:01	0:57	0	72.38		0	0	0
VAIL	Arrival	0:14	1:11	113407.63	90.62	100	0	7491.09	365.12
Run Total (With Dwells)		1:11		463799.25	73.72	100.01	0	7509.16	3019.31
Run Total (Without Dwells)		1:05		463799.25	81.41	100.01	N.A.	7509.16	3019.31

1/20/2003 13:12 BID ITEMS	COST PER UNIT	QUANTITY	COST
Walls (SF)	90.00	1387297.00	124,856,730.00
Earthwork (CY)	20.00	725116.00	14,502,320.00
Pavement (TON)	70.00	0.00	0.00
Base Course (CY)	40.00	309417.00	12,376,680.00
Barrier (Type 7)(LF)	60.00	0.00	0.00
Special Structures (SF)	200.00	0.00	0.00
Tunnel (Twin Tunnels) (LF)	15000	0.00	0.00
Tunnel (South Bore EJMT) (LF)	30000	0.00	0.00
Interchanges (EACH)	7000000	0.00	0.00
Heavy Rail Structure (SF)	200	3235560.00	647,112,000.00
Heavy Rail Trackwork (TF)	150	769696.00	115,454,400.00
Maintenance Facilities	3	Variable	74,600,000.0
Mobile maintenance equipment	9264000	1.00	9,264,000.00
Signals and Controls	1000000	96.00	96,000,000.00
Interlockings	1000000	16.00	16,000,000.00
Stations/Parking (Large)	10000000	2.00	20,000,000.00
Stations/Parking (Medium)	6000000	4.00	24,000,000.00
Stations/Parking (Small)	3000000	4.00	12,000,000.00
Fare Collection (fare vending machines)	38000	188.00	7,144,000.00
Passenger Rolling stock	2600000	285.00	741,000,000.00
General Construction	45240000	1.00	45,240,000.00
Total			1,959,550,130.00

	% Range		% Used	Cost	
Project Construction Bid Items(per segment)	Project Dependent		N/A	$1,209,286,130.00	
Lump Sum Bid Items	Project Dependent		N/A	$750,264,000.00	
Project Construction Bid Items	Project Dependent		N/A	$1,959,550,130.00	(A)
Contingencies*	(15% - 30%) of (A)		30.00%	$587,865,039.00	(B)
ITS	(6-10%) of (A+B) Default = 6%		0.00%	$0.00	(C)
Drainage/Utilities	(3-10%)of (A+B) Default = 6%		10.00%	$254,741,516.90	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%		1.00%	$28,021,566.86	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%		7.00%	$198,112,477.69	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%		7.00%	$211,980,351.13	(G)
Total of Construction Bid Items	(A+B+C+D+E+F+G)			$3,240,271,081.58	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%		2.00%	$64,805,421.63	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%		12.00%	$388,832,529.79	(J)
Subtotal of Construction Cost	(H+I+J)			$3,693,909,033.01	(K)
Total Construction Engineering	17% of (K)		17.00%	$627,964,535.61	(L)
Total Preliminary Engineering**	15% of (K)		15.00%	$554,086,354.95	(M)
Right of Way	Project Dependent		2.00%	$64,805,421.63	(N)
Utilities	Project Dependent		N/A	$0.00	(O)
	COST	QUANTITY			
Tunnel (Twin Tunnels) (LF)	15000.00	0.00		0.00	
Tunnel (South Bore EJMT) (LF)	30000.00	0.00		0.00	
Interchanges (EACH)	1.00	0.00		0.00	
Electrification	255000000	1.00		255,000,000.00	
Total Project Cost				$5,195,765,345.20	(P)

*Contingencies includes environmental mitigation costs

**Total Preliminary Engineering should include cost of developing NEPA documents

Estimate Worksheet							
Hyland Hills to Jeff. Station							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Walls (SF)	393376	90			$35,403,840.00		
Earthwork (CY)	247681	20			$4,953,620.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	32761	40			$1,310,440.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Heavy Rail Structure	1598000	200			$319,600,000.00		
Heavy Rail Trackwork (TF)	146000	150			$21,900,000.00		
Maintenance Facilities	1	35500000			$35,500,000.00		
Signals and Controls	15	1000000			$15,000,000.00		
Interlockings	2	1000000			$2,000,000.00		
Stations/Parking (Large)	1	10000000			$10,000,000.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Stations/Parking (Small)	1	3000000			$3,000,000.00		
Fare Collection	98	38000			$3,724,000.00		
General Construction	1	7560000			$7,560,000.00		
Total accounted construciton items					$459,951,900.00	(A)	Carried to S
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$137,985,570.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$59,793,747.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$6,577,312.17	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$46,501,597.04	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$49,756,708.83	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$760,566,835.05	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$15,211,336.70	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$91,268,020.21	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$867,046,191.95	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$147,397,852.63	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$130,056,928.79	(M)	
Right of Way	Project Dependent		2.00%		$15,211,336.70	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Electrification	1	50000000			$50,000,000.00		
Total Segment Cost					$1,209,712,310.08	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
US 40 to Hyland Hills							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	93960	40			$3,758,400.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Heavy Rail Structure	0	200			$0.00		
Heavy Rail Trackwork	155136	150			$23,270,400.00		
Maintenance Facilities	0	0			$0.00		
Signals and Controls	16	1000000			$16,000,000.00		
Interlockings	3	1000000			$3,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Stations/Parking (Small)	0	3000000			$0.00		
Fare Collection	6	38000			$228,000.00		
General Construction	1	7730000			$7,730,000.00		
Total accounted construciton items					$53,986,800.00	(A)	Carried to S
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$16,196,040.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$7,018,284.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$772,011.24	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$5,458,119.47	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$5,840,187.83	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$89,271,442.54	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$1,785,428.85	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$10,712,573.10	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$101,769,444.49	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$17,300,805.56	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$15,265,416.67	(M)	
Right of Way	Project Dependent		2.00%		$1,785,428.85	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Electrification	1	51000000			$51,000,000.00		
Total Segment Cost					**$187,121,095.58**	**(P)**	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
Us 6 to US 40							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	108494	40			$4,339,760.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Heavy Rail Structure	0	200			$0.00		
Heavy Rail Trackwork	174240	150			$26,136,000.00		
Maintenance Facilities	0	0			$0.00		
Signals and Controls	18	1000000			$18,000,000.00		
interlockings	1	1000000			$1,000,000.00		
Stations/Parking (Large)	0	1000000			$0.00		
Stations/Parking (Medium)	1	6000000			$6,000,000.00		
Stations/Parking (Small)	1	3000000			$3,000,000.00		
Fare Collection	14	38000			$532,000.00		
General Construction	1	7210000			$7,210,000.00		
Total accounted construciton items					$66,217,760.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$19,865,328.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$8,608,308.80	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$946,913.97	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$6,694,681.75	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$7,163,309.48	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$109,496,302.00	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$2,189,926.04	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$13,139,556.24	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$124,825,784.28	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$21,220,383.33	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$18,723,867.64	(M)	
Right of Way	Project Dependent		2.00%		$2,189,926.04	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	60000000			$60,000,000.00		
Total Segment Cost					$226,959,961.29	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet								
East EJMT to US 6								
	% Range		**% Used**					
Stated Assumptions								
Project Construction Items								
Item Description	Quantity	Per Unit Cost			Cost			
Walls (SF)	0	90			$0.00			
Earthwork (CY)	0	20			$0.00			
Pavement (TON)	0	70			$0.00			
Base Course (CY)	3359	40			$134,360.00			
Barrier (Type 7)(LF)	0	60			$0.00			
Special Structures (SF)	0	200			$0.00			
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00			
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00			
Interchanges (EACH)	0	1			$0.00			
Heavy Rail Structure	0	200			$0.00			
Heavy Rail Trackwork	12144	150			$1,821,600.00			
Maintenance Facilities	0	0			$0.00			
Signals and Controls	2	1000000			$2,000,000.00			
Interlockings	1	1000000			$1,000,000.00			
Stations/Parking (Large)	0	10000000			$0.00			
Stations/Parking (Medium)	0	6000000			$0.00			
Stations/Parking (Small)	2	3000000			$6,000,000.00			
Fare Collection	3	38000			$114,000.00			
General Construction	1	5020000			$5,020,000.00			
Total accounted construciton items					$16,089,960.00	(a)	Carried to	Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$4,826,988.00	(B)		
Establised as a percentage								
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)		
	Default = 6%							
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$2,091,694.80	(D)		
	Default = 6%							
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$230,086.43	(E)		
	Default = 5%							
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$1,626,711.05	(F)		
	Default = 20%							
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$1,740,580.82	(G)		
	Default = 7%							
Total of Construction Items	(a+b+c+d+e+f+g)				$26,606,021.09	(H)		
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$532,120.42	(I)		
	Default = 2%							
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$3,192,722.53	(J)		
	Default = 12%							
Subtotal of Construction Cost	(h+I+j)				$30,330,864.05	(K)		
Total Construction Engineering	17% of (k)		17.00%	Carrie	$5,156,246.89	(L)		
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$4,549,629.61	(M)		
Right of Way	Project Dependent		2.00%		$532,120.42	(N)		
Utilities	Project Dependent		N/A			(O)		
Tunnel (Twin Tunnels)	15000	0			$0.00			
Tunnel (South Bore EJMT)	30000	0			$0.00			
Interchanges	1	0			$0.00			
Electrification	1	3000000			$3,000,000.00			
Total Segment Cost					**$43,568,860.96**	(P)		
Be certain to check that proper values have been carried to Sheet One								

Estimate Worksheet							
West to East Continental Divide							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Heavy Rail Structure	0	200			$0.00		
Heavy Rail Trackwork	6336	150			$950,400.00		
Maintenance Facilities	0				$0.00		
Signals and Controls	2	1000000			$2,000,000.00		
Interlockings	2	1000000			$2,000,000.00		
Stations/Parking (Large)	1	10000000			$10,000,000.00		
Stations/Parking (Medium)	2	6000000			$12,000,000.00		
Stations/Parking (Small)		3000000			$0.00		
Fare Collection	42	38000			$1,596,000.00		
General Construction	1	20000			$20,000.00		
Total accounted construciton items					$28,566,400.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$8,569,920.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$3,713,632.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$408,499.52	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$2,888,091.61	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$3,090,258.02	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$47,236,801.15	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$944,736.02	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$5,668,416.14	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$53,849,953.31	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$9,154,492.06	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$8,077,493.00	(M)	
Right of Way	Project Dependent		2.00%		$944,736.02	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	4500000			$4,500,000.00		
Total Segment Cost					$76,526,674.39	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
West Continental Divide to W. Vail							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Walls (SF)	993921	90			$89,452,890.00		
Earthwork (CY)	477435	20			$9,548,700.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	60865	40			$2,434,600.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Heavy Rail Structure (LF)	1415800	200			$283,160,000.00		
Heavy Rail Trackwork	260000	150			$39,000,000.00		
Maintenance Facilities	2	varies			$39,100,000.00		
Signals and Controls	41	1000000			$41,000,000.00		
Interlockings	6	1000000			$6,000,000.00		
Stations/Parking (Large)		10000000			$0.00		
Stations/Parking (Medium)	1	6000000			$6,000,000.00		
Stations/Parking (Small)		3000000			$0.00		
Fare Collection	16	38000			$608,000.00		
General Construction	1	12100000			$12,100,000.00		
Total accounted construciton items					$528,404,190.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$158,521,257.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$68,692,544.70	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$7,556,179.92	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$53,422,192.01	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$57,161,745.45	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$873,758,109.08	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$17,475,162.18	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$104,850,973.09	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$996,084,244.36	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$169,334,321.54	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$149,412,636.65	(M)	
Right of Way	Project Dependent		2.00%		$17,475,162.18	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	81500000			$81,500,000.00		
Total Segment Cost					$1,413,806,364.73	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
W. Vail to Dowds Canyon							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	9976	40			$399,120.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Heavy Rail Structure (LF)	221760	200			$44,352,000.00		
Heavy Rail Trackwork	15840	150			$2,376,000.00		
Maintenance Facilities	0	0			$0.00		
Signals and Controls	2	1000000			$2,000,000.00		
Interlockings	1	1000000			$1,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Stations/Parking (Small)	0	3000000			$0.00		
Fare Collection	9	$38,000.00			$342,000.00		
General Construction	1	5600000			$5,600,000.00		
Total accounted construciton items					$56,069,120.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$16,820,736.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)	.	0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$7,268,985.60	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$801,788.42	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$5,668,644.10	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$6,065,449.19	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$92,714,723.31	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$1,854,294.47	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$11,125,766.80	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$105,694,784.57	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$17,968,113.38	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$15,854,217.69	(M)	
Right of Way	Project Dependent		2.00%		$1,854,294.47	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	5000000			$5,000,000.00		
Total Segment Cost					$146,371,410.10	(P)	

Be certain to check that proper values have been carried to Sheet One

	2025	Winter	Saturday	AM is	0.25	0.4166667
HR: DIA-VTC		no IMC		Noon is	0.4166667	0.625
	10	cents per mile		PM is	0.625	0.7916667
	10	minute peak headways		Night is	0.7916667	0.25
	10	minute off-peak headways				

Mountain Rail System, Total of All Lines, Eastbound

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Eagle Airport	0	0	0	0	0	0	0	0	0	0
Eagle Village	0	0	0	0	0	0	0	0	0	0
Wolcott	0	0	0	0	0	0	0	0	0	0
Avon	0	0	0	0	0	0	0	0	0	0
Vail TC	2222.3158	0	1615.6982	0	1646.7538	0	853.2903	0	6338.0581	0
Copper Mtn	274.9446	126.338	727.2326	96.2846	1116.873	125.1718	701.6926	78.8738	2820.7428	426.6682
Frisco TC	1317.0702	699.3013	2569.969	559.3175	4446.744	613.3174	2504.4432	468.5069	10838.2264	2340.4431
Silverthorne TC	46.0714	381.3131	138.4328	1021.9007	171.006	918.6879	163.6072	955.3058	519.1174	3277.2075
Loveland Ski	76.6686	58.9171	355.5906	66.4138	974.634	42.3353	423.7572	43.7159	1830.6504	211.3821
Georgetown	43.3198	36.6621	119.4596	69.3481	104.6038	62.6714	136.0256	61.0099	403.4088	229.6915
Empire Jct	552.4714	92.6038	1008.201	73.9382	1549.0648	96.7937	837.7234	70.9352	3947.4606	334.2709
Idaho Spgs	110.243	35.2023	248.5508	68.0105	263.9816	76.8938	294.6446	64.0827	917.42	244.1893
US 6/Gaming	259.5706	82.6924	684.013	86.6205	1092.6574	84.8645	1532.5822	76.1665	3568.8232	330.3439
El Rancho	432.262	31.7999	682.2268	64.9632	559.1806	89.4231	601.948	79.6988	2275.6174	265.885
Jefferson	135.9794	1397.6184	262.356	2917.1727	167.1402	5747.3076	204.6432	3608.0518	770.1188	13670.1505
Arvada	0.9898	905.0451	3.5148	1511.457	2.2894	1870.5081	3.9064	1370.2175	10.7004	5657.2277
Commerce City	0.0032	309.2204	0.0016	435.2558	0.0016	385.7448	0.0004	359.086	0.0068	1489.307
Stapleton	16.288	256.502	21.1658	496.2028	14.3406	1221.1223	16.1154	550.2781	67.9098	2524.1052
DIA	0	1074.9808	0	969.5275	0	774.4276	0	488.4509	0	3307.3868
Line Totals	5488.1978	5488.1967	8436.4126	8436.4129	12109.271	12109.269	8274.3797	8274.3798	34308.2609	34308.2587

Mountain Rail System, Total of All Lines, Westbound

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
DIA	1103.0068	0	1195.9638	0	1275.2028	0	680.1878	0	4254.3612	
Stapleton	2020.5152	74.014	900.6866	110.2318	596.461	161.6202	572.3474	101.7798	4090.0102	447.6458
Commerce City	369.4358	61.6462	543.7453	109.0636	447.535	61.2476	417.4126	57.363	1778.1287	289.3204
Arvada	721.382	2.6746	709.0116	31.9644	566.936	2.2538	546.152	37.7218	2543.4816	74.6146
Jefferson	8331.1738	8.3128	4256.5126	132.0598	2735.9512	50.5372	2880.3452	152.706	18203.9828	343.6158
El Rancho	81.0932	358.9878	77.2604	686.8506	60.5028	603.0092	51.7246	609.971	270.581	2258.8186
US 6/Gaming	77.4034	1160.8462	88.5504	967.1268	91.3794	786.8284	69.5228	1166.6	326.856	4081.4014
Idaho Spgs	57.4984	205.2654	85.6492	324.0716	62.0484	198.7594	70.0514	215.3798	275.2474	943.4762
Empire Jct	91.3328	1993.4622	76.6968	1106.9478	98.4578	664.0254	67.9714	586.5944	334.4588	4351.0298
Georgetown	42.5466	80.0942	60.7158	128.5128	48.2616	73.074	46.6038	88.763	198.1278	370.444
Loveland Ski	22.4768	1131.1136	67.8108	363.1104	72.3374	147.6128	48.0956	226.7498	210.7206	1868.5866
Silverthorne TC	954.007	105.9978	1312.0812	153.998	630.0864	73.2266	1090.0662	108.422	3986.2408	441.6444
Frisco TC	2063.2302	6612.8715	1472.7392	4156.0132	1585.7564	2710.4857	931.7526	2651.2376	6053.4784	16130.608
Copper Mtn	122.0788	1665.4751	92.0234	855.67	136.588	468.3803	88.2702	538.4466	438.9604	3527.972
Vail TC	0	2596.4154	0	1813.8336	0	2406.4438	0	1018.7743	0	7835.4671
Avon	0	0	0	0	0	0	0	0	0	0
Wolcott	0	0	0	0	0	0	0	0	0	0
Eagle Village	0	0	0	0	0	0	0	0	0	0
Eagle Airport	0	0	0	0	0	0	0	0		0
Line Totals	16057.1808	16057.1768	10939.4471	10939.4544	8407.5042	8407.5044	7560.5036	7560.5091	42964.6357	42964.6447

2025	Winter
HR: DIA-VTC	no IMC
10	cents per mile
10	minute peak headways
10	minute off-peak headways
Feeder Bus CB1, Westbound	
Station	AM Ons
US 6 / Gaming	1263.5962
Blackhawk	47.5154
Central City	0
Line Totals	1311.1116
Feeder Bus CB1, Both Directions	
Station	AM Ons
Central City	46.72
Blackhawk	353.3799
US 6 / Gaming	1263.5962
Line Totals	1663.6961
Feeder Bus WP, Eastbound	
Station	AM Ons
Winter Park	587.3041
Empire Station	0
Line Totals	587.3041
Feeder Bus WP, Westbound	
Station	AM Ons
Empire Station	2049.2246
Winter Park	0
Line Totals	2049.2246
Feeder Bus WP, Both Directions	
Station	AM Ons
Winter Park	587.3041
Empire Station	2049.2246
Line Totals	2636.5287
Feeder Bus MT, Eastbound	
Station	AM Ons
Jefferson	894.0986
Mineral Sta	0.2229
Arapahoe pnR	0
Line Totals	894.3215
Feeder Bus MT, Westbound	
Station	AM Ons
Arapahoe pnR	1857.3445
Mineral Sta	1359.4189
Jefferson	0
Line Totals	3216.7634

Fare Card Machines

EB Station	Peak Fare Purchase	Feeder Bus	Peak-Feeder	Per Hour	2 minute	Machine Demand	Rounded	Adjust for min	Machines at Other Locations	Total
DIA	1103	0	1103	276	552	9.2	10	10	4	14
DUS--Denver Metra	**No ridership**					6.0	6	6	24	30
Stapleton	2037	0	2037	509	1018	17.0	17	17	2	19
Jefferson	6774	3217	3557	889	1778	29.6	30	30	5	35
El Rancho	513		513	128	257	4.3	5	5	1	6
US 6/Gaming	337		337	84	168	2.8	3	3	1	4
Idaho Spgs	168		168	42	84	1.4	2	2	1	3
Empire Jct	644	587	57	14	28	0.5	1	2	2	4
Georgetown	86		86	21	43	0.7	1	2	1	3
Loveland Ski	99		99	25	50	0.8	1	2	1	3
Silverthorne TC	1000		1000	250	500	8.3	9	9	1	10
Frisco TC	2704		2704	676	1352	22.5	23	23	4	27
Copper Mtn	397		397	99	199	3.3	4	4	1	5
Vail TC	1778		1778	444	889	14.8	15	15	1	16
West of Vail									9	9
							Totals	130	58	188

Assumptions

Peak fare purchase was based on the sum of AM ons in both directions for winter Saturday.

There will be a minimum of 2 machines at every station.

time factor in minute
2

Total cost $ 7,077,636.00

Riders will purchase round trip tickets.

It takes 2 minutes for tourists to use machines.

Tickets and passes will be sold off location at convenient stores and the like.

Feeder bus users will have already purchased through tickets at resorts of other off site locations.

Assume 20% of ridership at Jefferson, Frisco, and Vail have passes

Other locations includes: All Denver Metra Stations, Pena, Cold Springs, Westminster, Arvada, Ward RD, Tech CTR., Mineral Springs, Casinos, Winter Park, Keystone, Arapahoe Basin, Breckenridge, Vail Lionhead, Avon, Edwards, Eagle, Village, Eagle Airport, Gypsum, Dotsero, and Glenwood Springs. It is assumed that all areas with a rail station will have at least one off site ticketing location at a retail location. Those machines have been added to the closest rail station location in the table. Resorts will also have fare card machines, also included here.

Summary	Entire route						
ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV Wire	Mile	3	248	18,480	$ 4,590,432.00	$ 2,754,259.20	$ 7,344,691.20
12 KV Insulators	Cat pole	3	6,558	45	$ 295,099.20	$ 177,059.52	$ 472,158.72
12 KV Spacers	Cat pole	3	6,558	15	$ 98,366.40	$ 59,019.84	$ 157,386.24
10000 KVA Substation	Ea		12	350000	$ 4,200,000.00	$ 2,520,000.00	$ 6,720,000.00
Auto. Tie Switch	Ea.		12	5000	$ 60,000.00	$ 36,000.00	$ 96,000.00
Catenary Poles	Ea	1/200'	2,186	3000	$ 6,557,760.00	$ 3,934,656.00	$ 10,492,416.00
Catenary Poles XO	Ea	11	109	3000	$ 327,000.00	$ 196,200.00	$ 523,200.00
Catenary System Mainline	Ft		688,512	200	$ 137,702,400.00	$ 82,621,440.00	$ 220,323,840.00
Cat. Sys. XO	Ft		5,500	200	$ 1,100,000.00	$ 660,000.00	$ 1,760,000.00
Cat Sys. Passing	Ft		0	200	$ -	$ -	$ -
SCADA	Substa.	4	12	10,000	$ 120,000.00	$ 72,000.00	$ 192,000.00
Circ. Brk. Auto Reclose	Substa.		12	40,000	$ 480,000.00	$ 288,000.00	$ 768,000.00
					SUBTOTAL		$ 248,849,692
					20% CONT		$ 49,769,938
							$ 298,619,631
					Cost Rounded to	Cost Rounded to	$ 300,000,000.00

Rail

Miles	82.8	
Feet	437184	
Track feet	688512	
Substations	12	
Crossovers	11	
Passing sidings	2	
length of each siding (ft)	24.3	mi
length of single track section	128304	ft
	12.6	mi
length of single track section	66528	ft

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 82.8 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required =
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA

Segment	Jefferson Station-Hyland Hills							
ITEM DESCRIPTION	**UNIT**	**RATE**	**UNITS REQ.**	**UNIT COST**	**TOT. UNIT COST**	**LABOR COST**		**TOTAL COST**
12 KV Wire	Mile	3	40	18,480	734580	440748		1175328
12 KV Insulators	Cat pole	3	1049	45	47223	28333.8		75556.8
12 KV Spacers	Cat pole	3	1049	15	15741	9444.6		25185.6
10000 KVA Substation	Ea		2	350000	700000	420000		1120000
Auto. Tie Switch	Ea.		2	5000	10000	6000		16000
Catenary Poles	Ea	1/200'	350	3000	1049400	629640		1679040
Catenary Poles XO	Ea	5	10	3000	30000	18000		48000
Catenary System Mainline	Ft		139920	200	27984000	16790400		44774400
Cat. Sys. XO	Ft		1000	200	200000	120000		320000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	2	10,000	20000	12000		32000
Circ. Brk. Auto Reclose	Substa.		2	40,000	80000	48000		128000
					SUBTOTAL		$	49,393,510
					20% CONT		$	9,878,702
							$	59,272,212
					Cost Rounded to	Cost Rounded to	$	60,000,000

Miles	13.25
Feet	69960
Track feet	139920
Substations	2
Crossovers	2
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Jeff-Hyl

Segment **Hyland Hills-Empire Jct**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	40	18,480	734580	440748		1175328
12 KV Insulators	Cat pole	3	1049	45	47223	28333.8		75556.8
12 KV Spacers	Cat pole	3	1049	15	15741	9444.6		25185.6
10000 KVA Substation	Ea		3	350000	1050000	630000		1680000
Auto. Tie Switch	Ea.		3	5000	15000	9000		24000
Catenary Poles	Ea	1/200'	350	3000	1049400	629640		1679040
Catenary Poles XO	Ea	11	33	3000	99000	59400		158400
Catenary System Mainline	Ft		139920	200	27984000	16790400		44774400
Cat. Sys. XO	Ft		1500	200	300000	180000		480000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	3	10,000	30000	18000		48000
Circ. Brk. Auto Reclose	Substa.		3	40,000	120000	72000		192000
					SUBTOTAL		$	50,311,910
					20% CONT		$	10,062,382
							$	60,374,292
					Cost Rounded to	Cost Rounded to	$	60,000,000

Miles	13.25
Feet	69960
Track feet	139920
Substations	3
Crossovers	3
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Empire Jct-Loveland**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	50	18,480	914760	548856		1463616
12 KV Insulators	Cat pole	3	1307	45	58806	35283.6		94089.6
12 KV Spacers	Cat pole	3	1307	15	19602	11761.2		31363.2
10000 KVA Substation	Ea		1	350000	350000	210000		560000
Auto. Tie Switch	Ea.		1	5000	5000	3000		8000
Catenary Poles	Ea	1/200'	436	3000	1306800	784080		2090880
Catenary Poles XO	Ea	11	11	3000	33000	19800		52800
Catenary System Mainline	Ft		174240	200	34848000	20908800		55756800
Cat. Sys. XO	Ft		500	200	100000	60000		160000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	1	10,000	10000	6000		16000
Circ. Brk. Auto Reclose	Substa.		1	40,000	40000	24000		64000
					SUBTOTAL		$	60,297,549
					20% CONT		$	12,059,510
							$	72,357,059
					Cost Rounded to	Cost Rounded to	$	70,000,000

Miles	16.5
Feet	87120
Track feet	174240
Substations	1
Crossovers	1
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Loveland-Tunnel**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	2	18,480	33264	19958.4		53222.4
12 KV Insulators	Cat pole	3	48	45	2138.4	1283.04		3421.44
12 KV Spacers	Cat pole	3	48	15	712.8	427.68		1140.48
10000 KVA Substation	Ea		1	350000	350000	210000		560000
Auto. Tie Switch	Ea.		1	5000	5000	3000		8000
Catenary Poles	Ea	1/200'	16	3000	47520	28512		76032
Catenary Poles XO	Ea	11	11	3000	33000	19800		52800
Catenary System Mainline	Ft		6336	200	1267200	760320		2027520
Cat. Sys. XO	Ft		500	200	100000	60000		160000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	1	10,000	10000	6000		16000
Circ. Brk. Auto Reclose	Substa.		1	40,000	40000	24000		64000
					SUBTOTAL		$	3,022,136
					20% CONT		$	604,427
							$	3,626,564
					Cost Rounded to	Cost Rounded to	$	4,000,000

Miles	0.6
Feet	3168
Track feet	6336
Substations	1
Crossovers	1
Passing sidings	0

Assumptions
System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Eisenhower Tunnel**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	7	18,480	127512	76507.2		204019.2
12 KV Insulators	Cat pole	3	182	45	8197.2	4918.32		13115.52
12 KV Spacers	Cat pole	3	182	15	2732.4	1639.44		4371.84
10000 KVA Substation	Ea		0	350000	0	0		0
Auto. Tie Switch	Ea.		0	5000	0	0		0
Catenary mounting brackets	Ea	1/200'	61	3000	182160	109296		291456
Catenary Poles XO	Ea	11	0	3000	0	0		0
Catenary System Mainline	Ft		12144	200	2428800	1457280		3886080
Cat. Sys. XO	Ft		0	200	0	0		0
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	0	10,000	0	0		0
Circ. Brk. Auto Reclose	Substa.		0	40,000	0	0		0
					SUBTOTAL		$	4,399,043
					20% CONT		$	879,809
							$	5,278,851
					Cost Rounded to	Cost Rounded to	$	5,000,000

Miles	2.3
Feet	12144
Track feet	12144
Substations	0
Crossovers	0
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) One track

Ike Tunnel

Segment **Tunnel-Vail**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	111	18,480	2045736	1227441.6		3273177.6
12 KV Insulators	Cat pole	3	2922	45	131511.6	78906.96		210418.56
12 KV Spacers	Cat pole	3	2922	15	43837.2	26302.32		70139.52
10000 KVA Substation	Ea		5	350000	1750000	1050000		2800000
Auto. Tie Switch	Ea.		5	5000	25000	15000		40000
Catenary Poles	Ea	1/200'	974	3000	2922480	1753488		4675968
Catenary Poles XO	Ea	11	44	3000	132000	79200		211200
Catenary System Mainline	Ft		215952	200	43190400	25914240		69104640
Cat. Sys. XO	Ft		2000	200	400000	240000		640000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	5	10,000	50000	30000		80000
Circ. Brk. Auto Reclose	Substa.		5	40,000	200000	120000		320000
					SUBTOTAL		$	81,425,544
					20% CONT		$	16,285,109
							$	97,710,652
					Cost Rounded to	Cost Rounded to	$	100,000,000

Rail		
Miles	36.9	
Feet	194832	
Track feet	215952	
Substations	5	
Crossovers	4	
Passing sidings	2	
length of each siding (ft)	10,560	
length of single track section	24.3	mi
	128304	ft
length of single track section	12.6	mi
	66528	ft

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart east of Frisco, one track with passing siding spaced 4 miles apart west of Frisco

Total Facilities Costs

Project Construction Items				
Item Description	Quantity		Per Unit Cost	Cost
Square foot indoor space	301,098.00	$	115.00	$34,626,270.00
Track needed	46,953.60	$	150.00	$7,043,040.00
Turnouts	44.00	$	75,000.00	$3,300,000.00
			Sub total	$44,969,310.00
Equipment				
Track Machinery Equipment				
Wheel Lathe	1	$	1,800,000.00	$1,800,000.00
Jacks	15	$	750,000.00	$11,250,000.00
Mechanical Washer	2	$	200,000.00	$400,000.00
			Sub total	$13,450,000.00
			Total	$58,419,310.00
Mobile Maintenance Equipment				
Catenary inspection and service car	1	$	3,000,000.00	$3,000,000.00
Maintenance locomotives	2	$	2,500,000.00	$5,000,000.00
Snowplows	2	$	300,000.00	$600,000.00
Maintenance trucks, per track mile	83	$	8,000.00	$664,000.00
			Sub total	$9,264,000.00
			Total	$67,683,310.00
Passenger Railcar Fleet	285	$	2,600,000.00	$741,000,000.00
			Total	$808,683,310.00

Assumptions

Track length at yards was calculated by taking the aggregate length of the cars required to be able to be stored. 30% was added to the total for non-storage track (only 15% at Vail).

Size of buildings assumed trains will require 35ft width (includes the width of the train and 20 ft.between tracks, per AREMA Standards.

Heavy track maintenance will be contracted. Full capacity for snow removal and overhead wire maintenance will be provided.

Square foot indoor space represents the sum of three yards: Vail, Frisco, and Denver.

	A	B	C	D
1				
2				
3	**Denver Facility**: inspection, light maintenance and			
4	cleaning. Yard capacity for 80% of the rolling stock.	Quantity	Price	
5	Square Foot Indoor Space	91,924.00	115	$ 10,571,260.00
6	Track needed	23476.8	150	$3,521,520.00
7	Turnouts	22.00	75000	$1,650,000.00
8				$15,742,780.00
9	**Project Construction Items**			
10	Jacks	5	750000	$3,750,000.00
11	Mechanical Washer	1	200000	200000
12			Total	$ 35,435,560.00
13	Shop sized for four 5 car units. Additional 40% sqare footage indoor space for car washer, parts storage, storage of maintenance trucks, offices and locker facilitites and commissary.			

	A	B	C	D
1				
2				
3	**Frisco Facility** for Inspection, Overhaul, light and heavy maintenance			
4	and cleaning with yard capacity for 40% of the fleet	**Quantity**	**Per Unit Cost**	**Cost**
5	Indoor Square Foot	157,584.00	$ 115.00	$ 18,122,160.00
6	Track needed	11738.4	$ 150.00	$ 1,760,760.00
7	Turnouts	16.00	$ 75,000.00	$ 1,200,000.00
8			sub total	$ 21,082,920.00
9	**Project Construction Items**			
10	Item Description	**Quantity**	**Per Unit Cost**	**Cost**
11	Jacks	10	$ 750,000.00	$ 7,500,000.00
12	Wheel lathe	1	$ 1,800,000.00	$ 1,800,000.00
13	Shop car mover	1	$ 300,000.00	$ 300,000.00
14			Total	$ 30,682,920.00
15				
16	Shop sized for six 5 car units. Additional 60% sqare footage indoor space for car washer, parts warehouse, craft shop, storage of maintenance trucks, administrative offices (including dispatch office), SCADA Control Center, traffic control center, training room, and locker facilitites and commissary.			

	A	B	C	D
1				
2				
3	**Vail Facility** for light car maintenance and			
4	cleaning with yard capacity for 40% of the fleet			
5		Quantity	Price	
6	Indoor Square Foot	51,590.00	115	$ 5,932,850.00
7	Track needed	11,738.40	150	$ 1,760,760.00
8	Turnouts	6.00	75000	$ 450,000.00
9			Total	$ 8,143,610.00
10				
11	**Project Construction Items**			
12	Item Description	Quantity	Per Unit Cost	Cost
13	Mechanical Washer	1	200000	$ 200,000.00
14			Total	$ 8,343,610.00
15				
16				
17	Shop sized for one 5 car unit. Additional 100% square footage for ancilary facilities including car washer and commissary.			

1/20/2003 12:47 BID ITEMS	COST PER UNIT	QUANTITY	COST		
Structures (SF)	150.00	0.00	0.00		
Walls (SF)	90.00	874872.00	78,738,480.00		
Earthwork (CY)	20.00	615134.00	12,302,680.00		
Pavement (TON)	70.00	0.00	0.00		
Base Course (CY)	40.00	0.00	0.00		
Barrier (Type 7)(LF)	60.00	0.00	0.00		
Special Structures (SF)	200.00	0.00	0.00		
Tunnel (Twin Tunnels) (LF)	15000	0.00	0.00		
Tunnel (South Bore EJMT) (LF)	30000	0.00	0.00		
Interchanges (EACH)	0	0.00	0.00		
Maglev Stucture (LF)	4000	185740.00	742,960,000.00		
Maglev Guideway	500	455304.00	227,652,000.00		
Maintenance Facilities	variable	3.00	104,150,000.00		
Mobile Maintenance Equipment	variable	1.00	11,100,000.00		
Signals and Controls	1200000	93.00	111,600,000.00		
Stations/Parking (Large)	3	10000000.00	30,000,000.00		
Stations/Parking (Medium)	3	6000000.00	18,000,000.00		
Station/Parking (Small)	4	3000000.00	12,000,000.00		
Fare Collection (Vending Machines)	230	37000.00	8,510,000.00		
Passenger Rolling Stock	52	16000000.00	832,000,000.00		
General Engineering (LS)	1	45240000	45,240,000.00		
Total			2,234,253,160.00		

	% Range		% Used		Cost	
Project Construction Bid Items					$1,391,153,160.00	
Lump Sum Bid Items					$843,100,000.00	
Project Construction Bid Items	Project Dependent		N/A		$2,234,253,160.00	(A)
Contingencies*	(15% - 30%) of (A)		30.00%		$670,275,948.00	(B)
ITS	(6-10%) of (A+B) Default = 6%		0.00%		$0.00	(C)
Drainage/Utilities	(3-10%)of (A+B) Default = 6%		10.00%		$290,452,910.80	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%		1.00%		$31,949,820.19	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%		7.00%		$225,885,228.73	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%		7.00%		$241,697,194.74	(G)
Total of Construction Bid Items	(A+B+C+D+E+F+G)				$3,694,514,262.46	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%		2.00%		$73,890,285.25	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%		12.00%		$443,341,711.49	(J)
Subtotal of Construction Cost	(H+I+J)				$4,211,746,259.20	(K)
Total Construction Engineering	17% of (K)		17.00%		$715,996,864.06	(L)
Total Preliminary Engineering**	15% of (K)		15.00%		$631,761,938.88	(M)
Right of Way	Project Dependent		2.00%		$73,890,285.25	(N)
Utilities	Project Dependent		N/A		$0.00	(O)
	COST	QUANTITY				
Tunnel (Twin Tunnels) (LF)	15000.00	0.00			0.00	
Tunnel (South Bore EJMT) (LF)	30000.00	0.00			0.00	
Interchanges (EACH)	1.00	0.00			0.00	
Electrification	299000000	1.00			309,000,000.00	
Total Project Cost					$5,942,395,347.39	(P)

*Contingencies includes environmental mitigation costs
**Total Preliminary Engineering should include cost of developing NEPA documents

Estimate Worksheet

	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	393376	90			$35,403,840.00		
Earthwork (CY)	247681	20			$4,953,620.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Maglev Stucture (LF)	47000	4000			$188,000,000.00		
Maglev Guideway	69960	500			$34,980,000.00		
Maintenance Facilities	1	42750000			$42,750,000.00		
Signals and Controls	15	1200000			$18,000,000.00		
Stations/Parking (Large)	1	10000000.00			$10,000,000.00		
Stations/Parking (Medium)	0	6000000.00			$0.00		
Stations/Parking (Small)	1	3000000.00			$3,000,000.00		
Fare Collection (Vending Machines)	132	37000.00			$4,884,000.00		
General Engineering (LS)	1	7560000			$7,560,000.00		
Total accounted construciton Items					$349,531,460.00	(A)	Carried to S
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$104,859,438.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$45,439,089.80	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$4,998,299.88	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$35,337,980.14	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$37,811,638.75	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$577,977,906.56	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$11,559,558.13	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$69,357,348.79	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$658,894,813.48	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$112,012,118.29	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$98,834,222.02	(M)	
Right of Way	Project Dependent		2.00%		$11,559,558.13	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Electrification	1	60000000			$60,000,000.00		
Total Segment Cost					$941,300,711.93	(P)	
Be certain to check that proper values have been carried to Sheet One							

heet One

Estimate Worksheet

	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Maglev Stucture (LF)	0	4000			$0.00		
Maglev Guideway	72240	500			$36,120,000.00		
Maintenance Facilities	0	0			$0.00		
Signals and Controls	16	1200000			$19,200,000.00		
Stations/Parking (Large)	0	10000000.00			$0.00		
Stations/Parking (Medium)	0	6000000.00			$0.00		
Stations/Parking (Small)	0	3000000.00			$0.00		
Fare Collection (Vending Machines)	7	37000.00			$259,000.00		
General Engineering (LS)	1	7730000			$7,730,000.00		
					$0.00		
Total accounted construciton items					$63,309,000.00	(A)	Carried to S
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$18,992,700.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$8,230,170.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$905,318.70	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$6,400,603.21	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$6,848,645.43	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$104,686,437.34	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$2,093,728.75	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$12,562,372.48	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$119,342,538.57	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$20,288,231.56	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$17,901,380.79	(M)	
Right of Way	Project Dependent		2.00%		$2,093,728.75	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Electrification	1	60000000			$60,000,000.00		
Total Segment Cost					$219,625,879.66	(P)	

Be certain to check that proper values have been carried to Sheet One

heet One

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Maglev Stucture (LF)	0	4000			$0.00		
Maglev Guideway	87120	500			$43,560,000.00		
Maintenance Facilities	0	0			$0.00		
Signals and Controls	18	1200000			$21,600,000.00		
Stations/Parking (Large)		10000000.00			$0.00		
Stations/Parking (Medium)	1	6000000.00			$6,000,000.00		
Stations/Parking (Small)	1	3000000.00			$3,000,000.00		
Fare Collection (Fare Vending Machines)	13	37000.00			$481,000.00		
General Engineering (LS)	1	7210000			$7,210,000.00		
Total accounted construciton items					$81,851,000.00	(a)	Carried to Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$24,555,300.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$10,640,630.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		1.00%	Carrie	$1,170,469.30	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		7.00%	Carrie	$8,275,217.95	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$8,854,483.21	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$135,347,100.46	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$2,706,942.01	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$16,241,652.06	(J)	
Subtotal of Construction Cost	(h+i+j)				$154,295,694.52	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$26,230,268.07	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$23,144,354.18	(M)	
Right of Way	Project Dependent		2.00%		$2,706,942.01	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	70000000			$70,000,000.00		
Total Segment Cost					$276,377,258.78	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Maglev Stucture (LF)	0	4000			$0.00		
Maglev Guideway	3168	500			$1,584,000.00		
Maintenance Facilities	0	0			$0.00		
Signals and Controls	2	1200000			$2,400,000.00		
Stations/Parking (Large)	0	10000000.00			$0.00		
Stations/Parking (Medium)	0	6000000.00			$0.00		
Stations/Parking (Small)	2	3000000.00			$6,000,000.00		
Fare Collection (Fare Vending Machines)	3	37000.00			$111,000.00		
General Engineering (LS)	1	5020000			$5,020,000.00		
Total accounted construciton Items					$15,115,000.00	(a)	Carried to Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$4,534,500.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$1,964,950.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		1.00%	Carrie	$216,144.50	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		7.00%	Carrie	$1,528,141.62	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$1,635,111.53	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$24,993,847.64	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$499,876.95	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$2,999,261.72	(J)	
Subtotal of Construction Cost	(h+i+j)				$28,492,986.31	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$4,843,807.67	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$4,273,947.95	(M)	
Right of Way	Project Dependent		2.00%		$499,876.95	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	4000000			$4,000,000.00		
Total Segment Cost					$42,110,618.89	(P)	

Be certain to check that proper values have been carried to Sheet One

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Maglev Stucture (LF)	0	4000			$0.00		
Maglev Guideway	12144	500			$6,072,000.00		
Maintenance Facilities	0	0			$0.00		
Signals and Controls	1	1200000			$1,200,000.00		
Stations/Parking (Large)	1	10000000.00			$10,000,000.00		
Stations/Parking (Medium)	2	6000000.00			$12,000,000.00		
Stations/Parking (Small)	0	3000000.00			$0.00		
Fare Collection (Fare Vending Machines)	47	37000.00			$1,739,000.00		
General Engineering (LS)	1	20000			$20,000.00		
Total accounted construciton items					$31,031,000.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$9,309,300.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$4,034,030.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$443,743.30	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$3,137,265.13	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$3,356,873.69	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$51,312,212.12	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$1,026,244.24	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$6,157,465.45	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$58,495,921.82	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$9,944,306.71	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$8,774,388.27	(M)	
Right of Way	Project Dependent		2.00%		$1,026,244.24	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrication	1	5000000			$5,000,000.00		
Total Segment Cost					$83,240,861.04	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet

	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	481496	90			$43,334,640.00		
Earthwork (CY)	367453	20			$7,349,060.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Maglev Stucture (LF)	122900	4000			$491,600,000.00		
Maglev Guideway	194832	500			$97,416,000.00		
Maintenance Facilities	2	variable			$61,400,000.00		
Signals and Controls	41	1200000			$49,200,000.00		
Stations/Parking (Large)	1	10000000.00			$10,000,000.00		
Stations/Parking (Medium))	0	6000000.00			$0.00		
Stations (Large)	0	3000000.00			$0.00		
Fare Collection (Fare Vending Machines)	19	37000.00			$703,000.00		
General Engineering (LS)	1	12100000			$12,100,000.00		
Total accounted construciton items					$773,102,700.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$231,930,810.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$100,503,351.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$11,055,368.61	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$78,161,456.07	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$83,632,758.00	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$1,278,386,443.68	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$25,567,728.87	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$153,406,373.24	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$1,457,360,545.80	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$247,751,292.79	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$218,604,081.87	(M)	
Right of Way	Project Dependent		2.00%		$25,567,728.87	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	100000000			$100,000,000.00		
Total Segment Cost					$2,049,283,649.32	(P)	

Be certain to check that proper values have been carried to Sheet One

Estimate Worksheet								
	% Range		% Used					
Stated Assumptions								
Project Construction Items								
Item Description	Quantity	Per Unit Cost			Cost			
Structures (SF)	0	150			$0.00			
Walls (SF)	0	90			$0.00			
Earthwork (CY)	0	20			$0.00			
Pavement (TON)	0	70			$0.00			
Base Course (CY)	0	40			$0.00			
Barrier (Type 7)(LF)	0	60			$0.00			
Special Structures (SF)	0	200			$0.00			
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00			
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00			
Interchanges (EACH)	0	1			$0.00			
Maglev Stucture (LF)	15840	4000			$63,360,000.00			
Maglev Guideway	15840	500			$7,920,000.00			
Maintenance Facilities	0	0			$0.00			
Signals and Controls	0	1200000			$0.00			
Stations/Parking (Large)	0	10000000.00			$0.00			
Stations/Parking (Medium)	0	6000000.00			$0.00			
Station/Parking (Small)	0	3000000.00			$0.00			
Fare Collection (Fare Vending Machines)	9	37000.00			$333,000.00			
General Engineering (LS)	1	5600000			$5,600,000.00			
Total accounted construciton items					$77,213,000.00	(a)	Carried to	Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carried to	$23,163,900.00	(B)		
Establised as a percentage								
ITS	(6-10%) of (a+b)		0.00%	Carried to	$0.00	(C)		
	Default = 6%							
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carried to	$10,037,690.00	(D)		
	Default = 6%							
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carried to	$1,104,145.90	(E)		
	Default = 5%							
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carried to	$7,806,311.51	(F)		
	Default = 20%							
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carried to	$8,352,753.32	(G)		
	Default = 7%							
Total of Construction Items	(a+b+c+d+e+f+g)				$127,677,800.73	(H)		
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carried to	$2,553,556.01	(I)		
	Default = 2%							
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carried to	$15,321,336.09	(J)		
	Default = 12%							
Subtotal of Construction Cost	(h+i+j)				$145,552,692.83	(K)		
Total Construction Engineering	17% of (k)		17.00%	Carried to	$24,743,957.78	(L)		
Total Preliminary Engineering	15% of (k)		15.00%	Carried to	$21,832,903.93	(M)		
Right of Way	Project Dependent		2.00%		$2,553,556.01	(N)		
Utilities	Project Dependent		N/A			(O)		
Tunnel (Twin Tunnels)	15000	0			$0.00			
Tunnel (South Bore EJMT)	30000	0			$0.00			
Interchanges	1	0			$0.00			
Electrification	1	10000000			$10,000,000.00			
Total Segment Cost					$204,683,110.56	(P)		

AGT

	Fare Card Machines									
EB Station	**Peak Fare Purchase**	**Feeder Bus**	**Peak-Feeder**	**Per Hour**	**2 minute**	**Machine Demand**	**Rounded**	**Adjust for min**	**Machines at Other Locations**	**Total**
DIA	1244	0	1244	311	622	10.4	11	11	4	15
DUS--Denver Metra	**No ridership**					6.0	6	6	24	30
Stapleton	4807	0	4807	1202	2404	40.1	41	41	2	43
Jefferson	5681	1003	4678	1169	2339	39.0	39	39	5	44
El Rancho	670	0	670	168	335	5.6	6	6	1	7
US 6/Gaming	341	325	16	4	8	0.1	1	2	1	3
Idaho Spgs	195	0	195	49	98	1.6	2	2	1	3
Empire Jct	701	637	64	16	32	0.5	1	2	2	4
Georgetown	109	0	109	27	55	0.9	1	2	1	3
Loveland Ski	112	0	112	28	56	0.9	1	2	1	3
Silverthorne TC	1130	0	1130	283	565	9.4	10	10	1	11
Frisco TC	3138	0	3138	784	1569	26.1	27	27	4	31
Copper Mtn	426	0	426	107	213	3.6	4	4	1	5
Vail TC	2049	0	2049	512	1024	17.1	18	18	1	19
West of Vail									9	9
							Totals	172	58	230

Assumptions

Peak fare purchase was based on the sum of AM ons in both directions for winter Saturday.

There will be a minimum of 2 machines at every station.

Riders will purchase round trip tickets.

time factor in minute
2

Total cost $ 8,658,810.00

It takes 2 minutes for tourists to use machines.

Tickets and passes will be sold off location at convenient stores and the like.

Feeder bus users will have already purchased through tickets at resorts of other off site locations.

Assume 20% of ridership at Jefferson, Frisco, and Vail have passes

Other locations includes: All Denver Metra Stations, Pena, Cold Springs, Westminster, Arvada, Ward RD, Tech CTR., Mineral Springs, Casinos, Winter Park, Keystone, Arapahoe Basin, Breckenridge, Vail Lionhead, Avon, Edwards, Eagle, Village, Eagle Airport, Gypsum, Dotsero, and Glenwood Springs. It is assumed that all areas with a rail station will have at least one off site ticketing location at a retail location. Those machines have been added to the closest rail station location in the table. Resorts will also have fare card machines, also included here.

2025	Winter
HR: DIA-VTC	no IMC
10	cents per mile
10	minute peak headways
10	minute off-peak headways
Feeder Bus CB1, Westbound	
Station	AM Ons
US 6 / Gaming	1263.5962
Blackhawk	47.5154
Central City	0
Line Totals	1311.1116
Feeder Bus CB1, Both Directions	
Station	AM Ons
Central City	46.72
Blackhawk	353.3799
US 6 / Gaming	1263.5962
Line Totals	1663.6961
Feeder Bus WP, Eastbound	
Station	AM Ons
Winter Park	587.3041
Empire Station	0
Line Totals	587.3041
Feeder Bus WP, Westbound	
Station	AM Ons
Empire Station	2049.2246
Winter Park	0
Line Totals	2049.2246
Feeder Bus WP, Both Directions	
Station	AM Ons
Winter Park	587.3041
Empire Station	2049.2246
Line Totals	2636.5287
Feeder Bus MT, Eastbound	
Station	AM Ons
Jefferson	894.0986
Mineral Sta	0.2229
Arapahoe pnR	0
Line Totals	894.3215
Feeder Bus MT, Westbound	
Station	AM Ons
Arapahoe pnR	1857.3445
Mineral Sta	1359.4189
Jefferson	0
Line Totals	3216.7634

Summary	Entire route						
ITEM DESCRIPTION	**UNIT**	**RATE**	**UNITS REQ.**	**UNIT COST**	**TOT. UNIT COST**	**LABOR COST**	**TOTAL COST**
12 KV Wire	Mile	3	248	18,480	$ 4,590,432.00	$ 2,754,259.20	$ 7,344,691.20
12 KV Insulators	Cat pole	3	6,558	45	$ 295,099.20	$ 177,059.52	$ 472,158.72
12 KV Spacers	Cat pole	3	6,558	15	$ 98,366.40	$ 59,019.84	$ 157,386.24
10000 KVA Substation	Ea		17	350000	$ 5,950,000.00	$ 3,570,000.00	$ 9,520,000.00
Auto. Tie Switch	Ea.		17	5000	$ 85,000.00	$ 51,000.00	$ 136,000.00
Catenary Poles	Ea	1/200'	2,186	3000	$ 6,557,760.00	$ 3,934,656.00	$ 10,492,416.00
Catenary Poles XO	Ea	11	99	3000	$ 297,000.00	$ 178,200.00	$ 475,200.00
Catenary System Mainline	Ft		548,592	200	$ 109,718,400.00	$ 65,831,040.00	$ 175,549,440.00
Contact rails & supports	Ft		139,920				
Cat. Sys. XO	Ft		5,500	200	$ 1,100,000.00	$ 660,000.00	$ 1,760,000.00
Cat Sys. Passing	Ft		0	200	$ -	$ -	$ -
SCADA	Substa.	4	17	10,000	$ 170,000.00	$ 102,000.00	$ 272,000.00
Circ. Brk. Auto Reclose	Substa.		17	40,000	$ 680,000.00	$ 408,000.00	$ 1,088,000.00
					SUBTOTAL		$ 207,267,292
					20% Mag add		$ 41,453,458
							$ 248,720,751
					Cost Rounded to	Cost Rounded to	$ 300,000,000.00

Rail

Miles	82.8	
Feet	437184	
Track feet	688512	
Substations	17	
Crossovers	11	
Passing sidings	2	
length of each siding (ft)	24.3	mi
length of single track section	128304	ft
	12.6	mi
length of single track section	66528	ft

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 82.8 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required =
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA

Segment	Jefferson Station-Hyland Hills							
ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	40	18,480	734580	440748		1175328
12 KV Insulators	Cat pole	3	1049	45	47223	28333.8		75556.8
12 KV Spacers	Cat pole	3	1049	15	15741	9444.6		25185.6
10000 KVA Substation	Ea		7	350000	2450000	1470000		3920000
Auto. Tie Switch	Ea.		7	5000	35000	21000		56000
Catenary Poles	Ea	1/200'	350	3000	1049400	629640		1679040
Contact rails & supports	Ft		139920	160	22387200	13432320		35819520
Contact rails XO	Ft		1000	200	200000	120000		320000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	7	10,000	70000	42000		112000
Circ. Brk. Auto Reclose	Substa.		7	40,000	280000	168000		448000
					SUBTOTAL		$	43,630,630
					20% CONT		$	8,726,126
							$	52,356,756
					Cost Rounded to	Cost Rounded to	$	60,000,000

Miles	13.25
Feet	69960
Track feet	139920
Substations	7
Crossovers	2
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Hyland Hills-Empire Jct**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	40	18,480	734580	440748		1175328
12 KV Insulators	Cat pole	3	1049	45	47223	28333.8		75556.8
12 KV Spacers	Cat pole	3	1049	15	15741	9444.6		25185.6
10000 KVA Substation	Ea		3	350000	1050000	630000		1680000
Auto. Tie Switch	Ea.		3	5000	15000	9000		24000
Catenary Poles	Ea	1/200'	350	3000	1049400	629640		1679040
Catenary Poles XO	Ea	11	33	3000	99000	59400		158400
Catenary System Mainline	Ft		139920	200	27984000	16790400		44774400
Cat. Sys. XO	Ft		1500	200	300000	180000		480000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	3	10,000	30000	18000		48000
Circ. Brk. Auto Reclose	Substa.		3	40,000	120000	72000		192000
					SUBTOTAL		$	50,311,910
					20% CONT		$	10,062,382
							$	60,374,292
					Cost Rounded to	Cost Rounded to	$	60,000,000

Miles	13.25
Feet	69960
Track feet	139920
Substations	3
Crossovers	3
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Empire Jct-Loveland**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	50	18,480	914760	548856		1463616
12 KV Insulators	Cat pole	3	1307	45	58806	35283.6		94089.6
12 KV Spacers	Cat pole	3	1307	15	19602	11761.2		31363.2
10000 KVA Substation	Ea		1	350000	350000	210000		560000
Auto. Tie Switch	Ea.		1	5000	5000	3000		8000
Catenary Poles	Ea	1/200'	436	3000	1306800	784080		2090880
Catenary Poles XO	Ea	11	11	3000	33000	19800		52800
Catenary System Mainline	Ft		174240	200	34848000	20908800		55756800
Cat. Sys. XO	Ft		500	200	100000	60000		160000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	1	10,000	10000	6000		16000
Circ. Brk. Auto Reclose	Substa.		1	40,000	40000	24000		64000
					SUBTOTAL		$	60,297,549
					20% CONT		$	12,059,510
							$	72,357,059
					Cost Rounded to	Cost Rounded to	$	70,000,000

Miles	16.5
Feet	87120
Track feet	174240
Substations	1
Crossovers	1
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Emp-Love

Segment **Loveland-Tunnel**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV Wire	Mile	3	2	18,480	33264	19958.4	53222.4
12 KV Insulators	Cat pole	3	48	45	2138.4	1283.04	3421.44
12 KV Spacers	Cat pole	3	48	15	712.8	427.68	1140.48
10000 KVA Substation	Ea		1	350000	350000	210000	560000
Auto. Tie Switch	Ea.		1	5000	5000	3000	8000
Catenary Poles	Ea	1/200'	16	3000	47520	28512	76032
Catenary Poles XO	Ea	11	11	3000	33000	19800	52800
Catenary System Mainline	Ft		6336	200	1267200	760320	2027520
Cat. Sys. XO	Ft		500	200	100000	60000	160000
Cat Sys. Passing	Ft		0	200	0	0	0
SCADA	Substa.	4	1	10,000	10000	6000	16000
Circ. Brk. Auto Reclose	Substa.		1	40,000	40000	24000	64000
					SUBTOTAL		$ 3,022,136
					20% CONT		$ 604,427
							$ 3,626,564
					Cost Rounded to	Cost Rounded to	$ 4,000,000

Miles	0.6
Feet	3168
Track feet	6336
Substations	1
Crossovers	1
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Eisenhower Tunnel**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	7	18,480	127512	76507.2		204019.2
12 KV Insulators	Cat pole	3	182	45	8197.2	4918.32		13115.52
12 KV Spacers	Cat pole	3	182	15	2732.4	1639.44		4371.84
10000 KVA Substation	Ea		0	350000	0	0		0
Auto. Tie Switch	Ea.		0	5000	0	0		0
Catenary mounting brackets	Ea	1/200'	61	3000	182160	109296		291456
Catenary Poles XO	Ea	11	0	3000	0	0		0
Catenary System Mainline	Ft		12144	200	2428800	1457280		3886080
Cat. Sys. XO	Ft		0	200	0	0		0
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	0	10,000	0	0		0
Circ. Brk. Auto Reclose	Substa.		0	40,000	0	0		0
					SUBTOTAL		$	4,399,043
					20% CONT		$	879,809
							$	5,278,851
					Cost Rounded to	Cost Rounded to	$	5,000,000

Miles	2.3
Feet	12144
Track feet	12144
Substations	0
Crossovers	0
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.

System Length = 86.6 miles

A.) Base Consist = 10 cars/train

B.) Base Energy required in KWH = 6,191 KWH

C.) Energy required in KVA = B.x1.38 = 8,544 KVA

D.) Number of consists required = 6

E.) Energy required one direction = CxD = 561,264 KVA

F.) Energy required for both directions = 2xE = 102,528 KVA

G.) Substations required(one/ stop+2) = 11

H.) Substation KVA = F/G = 8,544 KVA

I.) One track

Ike Tunnel

Segment **Tunnel-Vail**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	111	18,480	2045736	1227441.6		3273177.6
12 KV Insulators	Cat pole	3	2922	45	131511.6	78906.96		210418.56
12 KV Spacers	Cat pole	3	2922	15	43837.2	26302.32		70139.52
10000 KVA Substation	Ea		5	350000	1750000	1050000		2800000
Auto. Tie Switch	Ea.		5	5000	25000	15000		40000
Catenary Poles	Ea	1/200'	974	3000	2922480	1753488		4675968
Catenary Poles XO	Ea	11	44	3000	132000	79200		211200
Catenary System Mainline	Ft		215952	200	43190400	25914240		69104640
Cat. Sys. XO	Ft		2000	200	400000	240000		640000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	5	10,000	50000	30000		80000
Circ. Brk. Auto Reclose	Substa.		5	40,000	200000	120000		320000
					SUBTOTAL		$	81,425,544
					20% CONT		$	16,285,109
							$	97,710,652
					Cost Rounded to	Cost Rounded to	$	100,000,000

Rail		
Miles	36.9	
Feet	194832	
Track feet	215952	
Substations	5	
Crossovers	4	
Passing sidings	2	
length of each siding (ft)	10,560	
length of single track section	24.3	mi
	128304	ft
length of single track section	12.6	mi
	66528	ft

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Maglev

Project Construction Items			
Item Description	Quantity	Per Unit Cost	Cost
Square foot indoor space	533,820.00	$ 150.00	$80,073,000.00
Track needed (TF)	40,934.40	$ 180.00	$7,368,192.00
Turnouts	176.00	$ 90,000.00	$15,840,000.00
Transfer Table Structure	1.00	$ 600,000.00	$600,000.00
		Sub total	$103,881,192.00
Equipment			
Jacks	15	$ 90,000.00	$1,350,000.00
Mechanical Washer	2	$ 240,000.00	$480,000.00
		Sub total	$1,830,000.00
		Total	$105,711,192.00
Mobile Maintenance Equipment			
Inspection and service car	1	$ 3,600,000.00	$3,600,000.00
Maintenance cars	2	$ 3,000,000.00	$6,000,000.00
Snowplows	2	$ 360,000.00	$720,000.00
Maintenance trucks, per track mile	83	$ 9,600.00	$796,800.00
		Sub total	$11,116,800.00
		Total	$116,827,992.00
Passenger Railcar Fleet	52	$ 16,000,000.00	$832,000,000.00
		Total	$948,827,992.00

Assumptions

Track length at yards was calculated by taking the aggregate length of the cars required to be able to be stored. 30% was added to the total for non-storage track (only 15% at Vail).

Size of buildings assumed trains will require 35ft width (includes the width of the train and 20 ft.between tracks, per AREMA Standards.

Heavy track maintenance will be contracted. Full capacity for snow removal and overhead wire maintenance will be provided.

Square foot indoor space represents the sum of three yards: Vail, Frisco, and Denver.

	A	B	C	D
1				
2				
3	**Denver Facility**: inspection, light maintenance and			
4	cleaning. Yard capacity for 80% of the rolling stock.	Quantity	Price	
5	Square Foot Indoor Space	241,080.00	$ 150.00	$ 36,162,000.00
6	Guideway	20467.2	$ 180.00	$3,684,096.00
7	Turnouts	31.00	$ 90,000.00	$2,790,000.00
8				$42,636,096.00
9	**Project Equipment Items**			
10	Jacks	5	75000	$375,000.00
11	Mechanical Washer	1	$ 240,000.00	$ 240,000.00
12			Total	$ 85,887,192.00
13	Shop sized for four 3 car units. Additional 40% sqare footage indoor space for car washer, parts storage, storage of maintenance trucks, offices and locker facilitites and commissary.			

	A	B	C	D
1				
2				
3	**Frisco Facility** for Inspection, Overhaul, light and heavy maintenance			
4	and cleaning with yard capacity for 40% of the fleet	**Quantity**	**Per Unit Cost**	**Cost**
5	Square Foot Indoor Space	206,640.00	$ 150.00	$ 30,996,000.00
6	Guideway	10233.6	$ 180.00	$1,842,048.00
7	Turnouts	16.00	$ 90,000.00	$1,440,000.00
8	Transfer Table Structure	1	$ 600,000.00	$600,000.00
9			sub	$34,878,048.00
10	**Project Equipment Items**			
11	Item Description	**Quantity**	**Per Unit Cost**	**Cost**
12	Jacks	10	$ 75,000.00	$ 750,000.00
13	Shop car mover	1	$ 300,000.00	$ 300,000.00
14			Total	
15				
16	Shop sized for six 3 car units. Additional 60% sqare footage indoor space for car washer, parts warehouse, craft shop, storage of maintenance trucks, administrative offices (including dispatch office), SCADA Control Center, traffic control center, training room, and locker facilitites and commissary.			
17				
18				

	A	B	C	D
1				
2				
3	**Vail Facility** for light car maintenance and			
4	cleaning with yard capacity for 40% of the fleet			
5		Quantity	Price	
6	Square Foot Indoor Space	86,100.00	$ 150.00	$ 12,915,000.00
7	Guideway	10233.6	$ 180.00	$1,842,048.00
8	Turnouts	129.00	$ 90,000.00	$11,610,000.00
9				$26,367,048.00
10				
11	**Project Equipment Items**			
12	Item Description	Quantity	Per Unit Cost	Cost
13	Mechanical Washer	1	$ 240,000.00	$ 240,000.00
14			Total	$ 26,607,048.00
15				
16				
17	Shop sized for one 5 car unit. Additional 100% square footage for ancilary facilities including car washer and commissary.			

1/20/2003 13:08						
BID ITEMS	**COST PER UNIT**	**QUANTITY**	**COST**			
Structures (SF)	150.00	0.00	0.00			
Walls (SF)	90.00	874872.00	78,738,480.00			
Earthwork (CY)	20.00	615134.00	12,302,680.00			
Pavement (TON)	70.00	0.00	0.00			
Base Course (CY)	40.00	0.00	0.00			
Barrier (Type 7)(LF)	60.00	0.00	0.00			
Special Structures (SF)	200.00	0.00	0.00			
Tunnel (Twin Tunnels) (LF)	15000	0.00	0.00			
Tunnel (South Bore EJMT) (LF)	30000	0.00	0.00			
Interchanges (EACH)	7000000	0.00	0.00			
Monorail Structure (LF)	4000	185740.00	742,960,000.00			
Monorail Guideway	500	455304.00	227,652,000.00			
Maintenance Facilities	Variable	3.00	85,520,000.00			
Mobile Maintenance Equipment	Variable		10,100,000.00			
Signals and Controls	1200000	94.00	112,800,000.00			
Stations/Parking (Large)	10000000	2.00	20,000,000.00			
Stations/Parking (Medium)	6000000	4.00	24,000,000.00			
Stations/Parking (Small)	3000000	4.00	12,000,000.00			
Fare Collection	37000	230.00	8,510,000.00			
General Engineering (LS)	45240000	1.00	45,240,000.00			
Passenger Rolling Stock	4322500	190.00	821,275,000.00			
Total			2,201,098,160.00			
	% Range		**% Used**		**Cost**	
					$1,353,373,480.00	
					$821,275,000.00	
Project Construction Bid Items	Project Dependent		N/A		$2,174,648,480.00	(A)
Contingencies*	(15% - 30%) of (A)		30.00%		$652,394,544.00	(B)
ITS	(6-10%) of (A+B) Default = 6%		0.00%		$0.00	(C)
Drainage/Utilities	(3-10%)of (A+B) Default = 6%		10.00%		$282,704,302.40	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%		1.00%		$31,097,473.26	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%		7.00%		$219,859,135.98	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%		7.00%		$235,249,275.49	(G)
Total of Construction Bid Items	(A+B+C+D+E+F+G)				$3,595,953,211.14	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%		2.00%		$71,919,064.22	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%		12.00%		$431,514,385.34	(J)
Subtotal of Construction Cost	(H+I+J)				$4,099,386,660.69	(K)
Total Construction Engineering	17% of (K)		17.00%		$696,895,732.32	(L)
Total Preliminary Engineering**	15% of (K)		15.00%		$614,907,999.10	(M)
Right of Way	Project Dependent		2.00%		$71,919,064.22	(N)
Utilities	Project Dependent		N/A		$0.00	(O)
	COST	QUANTITY				
Tunnel (Twin Tunnels) (LF)	15000.00	0.00			0.00	
Tunnel (South Bore EJMT) (LF)	30000.00	0.00			0.00	
Interchanges (EACH)	1.00	0.00			0.00	
Electrification	Variable	1.00			251,950,000.00	
Total Project Cost					$5,735,059,456.34	(P)

*Contingencies includes environmental mitigation costs

**Total Preliminary Engineering should include cost of developing NEPA documents

Estimate Worksheet					
	% Range		% Used		
Stated Assumptions					
Project Construction Items					
Item Description	Quantity	Per Unit Cost			Cost
Structures (SF)	0	150			$0.00
Walls (SF)	393376	90			$35,403,840.00
Earthwork (CY)	247681	20			$4,953,620.00
Pavement (TON)	0	70			$0.00
Base Course (CY)	0	40			$0.00
Barrier (Type 7)(LF)	0	60			$0.00
Special Structures (SF)	0	200			$0.00
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00
Interchanges (EACH)	0	1			$0.00
Monorail Structure	47000	4000			$188,000,000.00
Monorail Guideway	69960	500			$34,980,000.00
Maintenance Facilities	1	1			$25,350,000.00
Mobile Maintenance Equipment	1	575000			575000
Signals and Controls	15	1200000			$18,000,000.00
Stations/Parking (Large)	1	10000000.00			$10,000,000.00
Stations/Parking (Medium)	0	6000000.00			$0.00
Stations/Parking (Small)	1	3000000.00			$3,000,000.00
Fare Collection (Vending Machines)	132	37000.00			$4,884,000.00
General Engineering (LS)	1	7560000			$7,560,000.00
					$0.00
Total accounted construciton items					$332,706,460.00
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$99,811,938.00
Establised as a percentage					
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00
	Default = 6%				
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$43,251,839.80
	Default = 6%				
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$4,757,702.38
	Default = 5%				
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$33,636,955.81
	Default = 20%				
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$35,991,542.72
	Default = 7%				
Total of Construction Items	(a+b+c+d+e+f+g)				$550,156,438.71
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$11,003,128.77
	Default = 2%				
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$66,018,772.65
	Default = 12%				
Subtotal of Construction Cost	(h+i+j)				$627,178,340.13
Total Construction Engineering	17% of (k)		17.00%	Carrie	$106,620,317.82
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$94,076,751.02
Right of Way	Project Dependent		2.00%		$11,003,128.77
Utilities	Project Dependent		N/A		
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00
Interchanges (EACH)	1	0			$0.00
Electrification	1	43,650,000.00			$43,650,000.00
Total Segment Cost					$882,528,537.74
Be certain to check that proper values have been carried to Sheet One					

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Monorail Structure	0	40000			$0.00		
Monorail Guideway	72240	500			$36,120,000.00		
Maintenance Facilities					$0.00		
Mobile Maintenance Equipment							
Signals and Controls	16	1200000			$19,200,000.00		
Stations/Parking(Large)	0	10000000.00			$0.00		
Stations/Parking(Medium)	0	6000000.00			$0.00		
Stations/Parking(Small)	0	3000000.00			$0.00		
Fare Collection (Vending Machines)	7	37000.00			$259,000.00		
General Engineering (LS)	1	7730000			$7,730,000.00		
					$0.00		
Total accounted construciton items					$63,309,000.00	(A)	Carried to S
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$18,992,700.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$8,230,170.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$905,318.70	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$6,400,603.21	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$6,848,645.43	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$104,686,437.34	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$2,093,728.75	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$12,562,372.48	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$119,342,538.57	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$20,288,231.56	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$17,901,380.79	(M)	
Right of Way	Project Dependent		2.00%		$2,093,728.75	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Electrification	1	50500000			$50,500,000.00		
Total Segment Cost					$210,125,879.66	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet

Item	% Range / Quantity	Per Unit Cost	% Used		Cost		
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	80			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Monorail Structure	0	4000			$0.00		
Monorail Guideway	87120	500			$43,560,000.00		
Maintenance Facilities					$0.00		
Mobile Maintenance Equipment							
Signals and Controls	18	1200000			$21,600,000.00		
Stations/Parking (Large)	0	10000000.00			$0.00		
Stations/Parking (Medium)	1	6000000.00			$6,000,000.00		
Stations/Parking (Small)	1	3000000.00			$3,000,000.00		
Fare Collection (Fare Vending Machines)	13	37000.00			$481,000.00		
General Engineering (LS)	1	7210000			$7,210,000.00		
Total accounted construciton items					$81,851,000.00	(a)	Carried to Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$24,555,300.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$10,640,630.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		1.00%	Carrie	$1,170,469.30	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		7.00%	Carrie	$8,275,217.95	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$8,854,483.21	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$135,347,100.46	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$2,706,942.01	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$16,241,652.06	(J)	
Subtotal of Construction Cost	(h+i+j)				$154,295,694.52	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$26,230,268.07	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$23,144,354.18	(M)	
Right of Way	Project Dependent		2.00%		$2,706,942.01	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	60500000			$60,500,000.00		
Total Segment Cost					$286,877,258.78	(P)	

Be certain to check that proper values have been carried to Sheet One

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Monorail Structure	0	4000			$0.00		
Monorail Guideway	3168	500			$1,584,000.00		
Maintenance Facilities					$0.00		
Mobile Maintenance Equipment							
Signals and Controls	2	1200000			$2,400,000.00		
Stations/Parking (Large)	0	10000000.00			$0.00		
Stations/Parking (Medium)	0	6000000.00			$0.00		
Station/Parking (Small)	2	3000000.00			$6,000,000.00		
Fare Collection (Fare Vending Machines)	3	37000.00			$111,000.00		
General Engineering (LS)	1	5020000			$5,020,000.00		
Total accounted construciton items					$15,115,000.00	(a)	Carried to Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$4,534,500.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$1,964,950.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		1.00%	Carrie	$216,144.50	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		7.00%	Carrie	$1,528,141.62	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$1,635,111.53	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$24,993,847.64	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$499,876.95	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$2,999,261.72	(J)	
Subtotal of Construction Cost	(h+i+j)				$28,492,986.31	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$4,843,807.67	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$4,273,947.95	(M)	
Right of Way	Project Dependent		2.00%		$499,876.95	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchenges	1	0			$0.00		
Electrification	1	3000000			$3,000,000.00		
Total Segment Cost					$41,110,618.89	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet								
	% Range		% Used					
Stated Assumptions								
Project Construction Items								
Item Description	Quantity	Per Unit Cost			Cost			
Structures (SF)	0	150			$0.00			
Walls (SF)	0	90			$0.00			
Earthwork (CY)	0	20			$0.00			
Pavement (TON)	0	70			$0.00			
Base Course (CY)	0	40			$0.00			
Barrier (Type 7)(LF)	0	60			$0.00			
Special Structures (SF)	0	200			$0.00			
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00			
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00			
Interchanges (EACH)	0	1			$0.00			
Monorail Structure	0	4000			$0.00			
Monorail Guideway	12144	500			$6,072,000.00			
Maintenance Facilities	0	0			$0.00			
Mobile Maintenance Equipment	0	0			$0.00			
Signals and Controls	2	1200000			$2,400,000.00			
Stations/Parking (Large)	1	10000000.00			$10,000,000.00			
Stations/Parking (Medium)	2	6000000.00			$12,000,000.00			
Stations/Parking (Small)	0	3000000.00			$0.00			
Fare Collection (Fare Vending Machines)	47	37000.00			$1,739,000.00			
General Engineering (LS)	1	20000			$20,000.00			
Total accounted construciton items					$32,231,000.00	(a)	Carried to	Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$9,669,300.00	(B)		
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)		
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$4,190,030.00	(D)		
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		1.00%	Carrie	$460,903.30	(E)		
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		7.00%	Carrie	$3,258,586.33	(F)		
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$3,486,687.37	(G)		
Total of Construction Items	(a+b+c+d+e+f+g)				$53,296,507.01	(H)		
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$1,065,930.14	(I)		
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$6,395,580.84	(J)		
Subtotal of Construction Cost	(h+i+j)				$60,758,017.99	(K)		
Total Construction Engineering	17% of (k)		17.00%	Carrie	$10,328,863.06	(L)		
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$9,113,702.70	(M)		
Right of Way	Project Dependent		2.00%		$1,065,930.14	(N)		
Utilities	Project Dependent		N/A			(O)		
Tunnel (Twin Tunnels)	15000	0			$0.00			
Tunnel (South Bore EJMT)	30000	0			$0.00			
Interchanges	1	0			$0.00			
Electrification	1	4500000			$4,500,000.00			
Total Segment Cost					$85,766,513.88	(P)		
Be certain to check that proper values have been carried to Sheet One								

Estimate Worksheet								
	% Range		**% Used**					
Stated Assumptions								
Project Construction Items								
Item Description	Quantity	Per Unit Cost			Cost			
Structures (SF)	0	150			$0.00			
Walls (SF)	481496	90			$43,334,640.00			
Earthwork (CY)	367453	20			$7,349,060.00			
Pavement (TON)	0	70			$0.00			
Base Course (CY)	0	40			$0.00			
Barrier (Type 7)(LF)	0	60			$0.00			
Special Structures (SF)	0	200			$0.00			
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00			
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00			
Interchanges (EACH)	0	1			$0.00			
Monorail Structure (LF)	122900	4000			$491,600,000.00			
Monorail Guideway (LF)	194832	500			$97,416,000.00			
Maintenance Facilities	2	variable			$31,025,320.00			
Mobile Maintenance Equipment		1250000			1250000			
Signals and Controls	41	1200000			$60,170,000.00			37340000
Stations/Parking (Large)	0	10000000.00			$0.00			22830000
Stations/Parking (Medium)	1	6000000.00			$6,000,000.00			
Station/Parking (Small)	0	3000000.00			$0.00			
Fare Collection (Fare Vending Machines)	19	37000.00			$703,000.00			
General Engineering (LS)	1	12100000			$12,100,000.00			
Total accounted construciton items					$750,948,020.00	(a)	Carried to Sheet One	
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$225,284,406.00	(B)		
Estabilsed as a percentage								
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)		
	Default = 6%							
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$97,623,242.60	(D)		
	Default = 6%							
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$10,738,556.69	(E)		
	Default = 5%							
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$75,921,595.77	(F)		
	Default = 20%							
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$81,236,107.47	(G)		
	Default = 7%							
Total of Construction Items	(a+b+c+d+e+f+g)				$1,241,751,928.53	(H)		
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$24,835,038.57	(I)		
	Dafault = 2%							
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$149,010,231.42	(J)		
	Default = 12%							
Subtotal of Construction Cost	(h+i+j)				$1,415,597,198.52	(K)		
Total Construction Engineering	17% of (k)		17.00%	Carrie	$240,651,523.75	(L)		
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$212,339,579.78	(M)		
Right of Way	Project Dependent		2.00%		$24,835,038.57	(N)		
Utilities	Project Dependent		N/A			(O)		
Tunnel (Twin Turinels)	15000	0			$0.00			
Tunnel (South Bore EJMT)	30000	0			$0.00			
Interchanges	1	0			$0.00			
Electrification	1	81500000			$81,500,000.00			
Total Segment Cost					$1,974,923,340.62	(P)		
Be certain to check that proper values have been carried to Sheet One								

Estimate Worksheet

	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures (SF)	0	150			$0.00		
Walls (SF)	0	90			$0.00		
Earthwork (CY)	0	20			$0.00		
Pavement (TON)	0	70			$0.00		
Base Course (CY)	0	40			$0.00		
Barrier (Type 7)(LF)	0	60			$0.00		
Special Structures (SF)	0	200			$0.00		
Tunnel (Twin Tunnels) (LF)	0	15000			$0.00		
Tunnel (South Bore EJMT) (LF)	0	30000			$0.00		
Interchanges (EACH)	0	1			$0.00		
Monorail Structure (LF)	15840	4000			$63,360,000.00		
Monorail Guideway (LF)	15840	500			$7,920,000.00		
Maintenance Facilities	0	0			$0.00		
Mobile Maintenance Equipment	0	0			$0.00		
Signals and Controls	0	1200000			$0.00		
Stations/Parking (Large)	0	12000000.00			$0.00		
Stations/Parking (Medium)	0	6000000.00			$0.00		
Station/Parking (Small)	0	3000000.00			$0.00		
Fare Collection (Fare Vending Machines)	9	37000.00			$333,000.00		
General Engineering (LS)	1	5600000			$5,600,000.00		
Total accounted construciton items					$77,213,000.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carried to	$23,163,900.00	(B)	
Estabilsed as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carried to	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carried to	$10,037,690.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carried to	$1,104,145.90	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carried to	$7,806,311.51	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carried to	$8,352,753.32	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$127,677,800.73	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carried to	$2,553,556.01	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carried to	$15,321,336.09	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$145,552,692.83	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carried to	$24,743,957.78	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carried to	$21,832,903.93	(M)	
Right of Way	Project Dependent		2.00%		$2,553,556.01	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	1	8300000			$8,300,000.00		
Total Segment Cost					$202,983,110.56	(P)	

Be certain to check that proper values have been carried to Sheet One

2025	Winter
HR: DIA-VTC	no IMC
10	cents per mile
10	minute peak headways
10	minute off-peak headways
Feeder Bus CB1, Westbound	
Station	AM Ons
US 6 / Gaming	1263.5962
Blackhawk	47.5154
Central City	0
Line Totals	1311.1116
Feeder Bus CB1, Both Directions	
Station	AM Ons
Central City	46.72
Blackhawk	353.3799
US 6 / Gaming	1263.5962
Line Totals	1663.6961
Feeder Bus WP, Eastbound	
Station	AM Ons
Winter Park	587.3041
Empire Station	0
Line Totals	587.3041
Feeder Bus WP, Westbound	
Station	AM Ons
Empire Station	2049.2246
Winter Park	0
Line Totals	2049.2246
Feeder Bus WP, Both Directions	
Station	AM Ons
Winter Park	587.3041
Empire Station	2049.2246
Line Totals	2636.5287
Feeder Bus MT, Eastbound	
Station	AM Ons
Jefferson	894.0986
Mineral Sta	0.2229
Arapahoe pnR	0
Line Totals	894.3215
Feeder Bus MT, Westbound	
Station	AM Ons
Arapahoe pnR	1857.3445
Mineral Sta	1359.4189
Jefferson	0
Line Totals	3216.7634

AGT

	Fare Card Machines									
EB Station	**Peak Fare Purchase**	**Feeder Bus**	**Peak-Feeder**	**Per Hour**	**2 minute**	**Fare Machine**	**Rounded**	**Adjust for min**	**Machines at Other Locations**	**Total**
DIA	1244	0	1244	311	622	10.4	11	11	4	15
DUS--Denver Metra	**No ridership**					6.0	6	6	24	30
Stapleton	4807	0	4807	1202	2404	40.1	41	41	2	43
Jefferson	5681	1003	4678	1169	2339	39.0	39	39	5	44
El Rancho	670	0	670	168	335	5.6	6	6	1	7
US 6/Gaming	341	325	16	4	8	0.1	1	2	1	3
Idaho Spgs	195	0	195	49	98	1.6	2	2	1	3
Empire Jct	701	637	64	16	32	0.5	1	2	2	4
Georgetown	109	0	109	27	55	0.9	1	2	1	3
Loveland Ski	112	0	112	28	56	0.9	1	2	1	3
Silverthorne TC	1130	0	1130	283	565	9.4	10	10	1	11
Frisco TC	3138	0	3138	784	1569	26.1	27	27	4	31
Copper Mtn	426	0	426	107	213	3.6	4	4	1	5
Vail TC	2049	0	2049	512	1024	17.1	18	18	1	19
West of Vail									9	9
							Totals	172	58	230

Assumptions

Peak fare purchase was based on the sum of AM ons in both directions for winter Saturday.

There will be a minimum of 2 machines at every station.

time factor in minute
2

Total cost $ 8,658,810.00

Riders will purchase round trip tickets.

It takes 2 minutes for tourists to use machines.

Tickets and passes will be sold off location at convenient stores and the like.

Feeder bus users will have already purchased through tickets at resorts of other off site locations.

Assume 20% of ridership at Jefferson, Frisco, and Vail have passes

Other locations includes: All Denver Metra Stations, Pena, Cold Springs, Westminster, Arvada, Ward RD, Tech CTR., Mineral Springs, Casinos, Winter Park, Keystone, Arapahoe Basin, Breckenridge, Vail Lionhead, Avon, Edwards, Eagle, Village, Eagle Airport, Gypsum, Dotsero, and Glenwood Springs. It is assumed that all areas with a rail station will have at least one off site ticketing location at a retail location. Those machines have been added to the closest rail station location in the table. Resorts will also have fare card machines, also included here.

Monorail Total Facilities Costs

Project Construction Items

Item Description	Quantity	Per Unit Cost	Cost
Square foot indoor space	269,696.00	$ 115.00	$31,015,040.00
Track needed (TF)	40,857.60	$ 150.00	$6,128,640.00
Turnouts	94.00	$ 75,000.00	$7,050,000.00
Transfer Table Structure	1.00	$ 500,000.00	$500,000.00
		Sub total	$44,693,680.00
Equipment			
Jacks	15	$ 75,000.00	$1,125,000.00
Mechanical Washer	2	$ 200,000.00	$400,000.00
		Sub total	$1,525,000.00
		Total	$46,218,680.00
Mobile Maintenance Equipment			
Inspection and service car	1	$ 3,000,000.00	$3,000,000.00
Maintenance cars	2	$ 2,500,000.00	$5,000,000.00
Snowplows	2	$ 300,000.00	$600,000.00
Maintenance trucks, per track mile	83	$ 8,000.00	$664,000.00
		Sub total	$9,264,000.00
		Total	$55,482,680.00
Passenger Railcar Fleet	190	$ 4,322,500.00	$821,275,000.00
		Total	$876,757,680.00

Assumptions

Track length at yards was calculated by taking the aggregate length of the cars required to be able to be stored. 30% was added to the total for non-storage track (only 15% at Vail).

Size of buildings assumed trains will require 35ft width (includes the width of the train and 20 ft.between tracks, per AREMA Standards.

Heavy track maintenance will be contracted. Full capacity for snow removal and overhead wire maintenance will be provided.

Square foot indoor space represents the sum of three yards: Vail, Frisco, and Denver.

	A	B	C	D
1				
2				
3	**Denver Facility**: inspection, light maintenance and			
4	cleaning. Yard capacity for 80% of the rolling stock.	Quantity	Price	
5	Square Foot Indoor Space	87,808.00	125	$ 10,976,000.00
6	Guideway	20428.8	150	$3,064,320.00
7	Turnouts	31.00	75000	$2,325,000.00
8				
9				$16,365,320.00
10	**Project Equipment Items**			
11	Jacks	5	75000	$375,000.00
12	Mechanical Washer	1	200000	$ 200,000.00
13			Total	$ 575,000.00
14	Shop sized for four 3 car units. Additional 40% sqare footage indoor space for car washer, parts storage, storage of maintenance trucks, offices and locker facilitites and commissary.			

	A	B	C	D
1				
2				
3	**Frisco Facility** for Inspection, Overhaul, light and heavy maintenance			
4	and cleaning with yard capacity for 40% of the fleet	**Quantity**	**Per Unit Cost**	**Cost**
5	Square Foot Indoor Space	150,528.00	125	$ 18,816,000.00
6	Guideway	10214.4	150	$1,532,160.00
7	Turnouts	16.00	75000	$1,200,000.00
8	Transfer Table Structure	1	500000	$500,000.00
9			sub	$22,048,160.00
10	**Project Equipment Items**			
11	Item Description	**Quantity**	**Per Unit Cost**	**Cost**
12	Jacks	10	$ 75,000.00	$ 750,000.00
13	Shop car mover	1	$ 300,000.00	$ 300,000.00
14				
15				
16	Shop sized for six 3 car units. Additional 60% sqare footage indoor space for car washer, parts warehouse, craft shop, storage of maintenance trucks, administrative offices (including dispatch office), SCADA Control Center, traffic control center, training room, and locker facilitites and commissary.			
17				
18				

	A	B	C	D
1				
2				
3	**Vail Facility** for light car maintenance and			
4	cleaning with yard capacity for 40% of the fleet			
5		Quantity	Price	
6	Square Foot Indoor Space	31,360.00	125	$ 3,920,000.00
7	Guideway	10214.4	150	$1,532,160.00
8	Turnouts	47.00	75000	$3,525,000.00
9				$8,977,160.00
10				
11	**Project Equipment Items**			
12	Item Description	Quantity	Per Unit Cost	Cost
13	Mechanical Washer	1	200000	$ 200,000.00
14			Total	$ 9,177,160.00
15				
16				
17	Shop sized for one 5 car unit. Additional 100% square footage for ancilary facilities including car washer and commissary.			

Summary	Entire route						
ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV Wire	Mile	3	248	18,480	$ 4,590,432.00	$ 2,754,259.20	$ 7,344,691.20
12 KV Insulators	Cat pole	3	6,558	45	$ 295,099.20	$ 177,059.52	$ 472,158.72
12 KV Spacers	Cat pole	3	6,558	15	$ 98,366.40	$ 59,019.84	$ 157,386.24
10000 KVA Substation	Ea		17	350000	$ 5,950,000.00	$ 3,570,000.00	$ 9,520,000.00
Auto. Tie Switch	Ea.		17	5000	$ 85,000.00	$ 51,000.00	$ 136,000.00
Catenary Poles	Ea	1/200'	2,186	3000	$ 6,557,760.00	$ 3,934,656.00	$ 10,492,416.00
Catenary Poles XO	Ea	11	99	3000	$ 297,000.00	$ 178,200.00	$ 475,200.00
Catenary System Mainline	Ft		548,592	200	$ 109,718,400.00	$ 65,831,040.00	$ 175,549,440.00
Contact rails & supports	Ft		139,920				
Cat. Sys. XO	Ft		5,500	200	$ 1,100,000.00	$ 660,000.00	$ 1,760,000.00
Cat Sys. Passing	Ft		0	200	$ -	$ -	$ -
SCADA	Substa.	4	17	10,000	$ 170,000.00	$ 102,000.00	$ 272,000.00
Circ. Brk. Auto Reclose	Substa.		17	40,000	$ 680,000.00	$ 408,000.00	$ 1,088,000.00
					SUBTOTAL		$ 207,267,292
					20% CONT		$ 41,453,458
							$ 248,720,751
					Cost Rounded to	Cost Rounded to	$ 300,000,000.00

Rail

Miles	82.8	
Feet	437184	
Track feet	688512	
Substations	17	
Crossovers	11	
Passing sidings	2	
length of each siding (ft)	24.3	mi
length of single track section	128304	ft
	12.6	mi
length of single track section	66528	ft

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 82.8 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required =
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA

Segment	Jefferson Station-Hyland Hills						
ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV Wire	Mile	3	40	18,480	734580	440748	1175328
12 KV Insulators	Cat pole	3	1049	45	47223	28333.8	75556.8
12 KV Spacers	Cat pole	3	1049	15	15741	9444.6	25185.6
10000 KVA Substation	Ea		7	350000	2450000	1470000	3920000
Auto. Tie Switch	Ea.		7	5000	35000	21000	56000
Catenary Poles	Ea	1/200'	350	3000	1049400	629640	1679040
Contact rails & supports	Ft		139920	160	22387200	13432320	35819520
Contact rails XO	Ft		1000	200	200000	120000	320000
Cat Sys. Passing	Ft		0	200	0	0	0
SCADA	Substa.	4	7	10,000	70000	42000	112000
Circ. Brk. Auto Reclose	Substa.		7	40,000	280000	168000	448000
					SUBTOTAL		$ 43,630,630
					20% CONT		$ 8,726,126
							$ 52,356,756
					Cost Rounded to	Cost Rounded to	$ 60,000,000

Miles	13.25
Feet	69960
Track feet	139920
Substations	7
Crossovers	2
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Jeff-Hyl

Segment **Hyland Hills-Empire Jct**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV Wire	Mile	3	40	18,480	734580	440748	1175328
12 KV Insulators	Cat pole	3	1049	45	47223	28333.8	75556.8
12 KV Spacers	Cat pole	3	1049	15	15741	9444.6	25185.6
10000 KVA Substation	Ea		3	350000	1050000	630000	1680000
Auto. Tie Switch	Ea.		3	5000	15000	9000	24000
Catenary Poles	Ea	1/200'	350	3000	1049400	629640	1679040
Catenary Poles XO	Ea	11	33	3000	99000	59400	158400
Catenary System Mainline	Ft		139920	200	27984000	16790400	44774400
Cat. Sys. XO	Ft		1500	200	300000	180000	480000
Cat Sys. Passing	Ft		0	200	0	0	0
SCADA	Substa.	4	3	10,000	30000	18000	48000
Circ. Brk. Auto Reclose	Substa.		3	40,000	120000	72000	192000
					SUBTOTAL		$ 50,311,910
					20% CONT		$ 10,062,382
							$ 60,374,292
					Cost Rounded to	Cost Rounded to	$ 60,000,000

Miles	13.25
Feet	69960
Track feet	139920
Substations	3
Crossovers	3
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Empire Jct-Loveland**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	50	18,480	914760	548856		1463616
12 KV Insulators	Cat pole	3	1307	45	58806	35283.6		94089.6
12 KV Spacers	Cat pole	3	1307	15	19602	11761.2		31363.2
10000 KVA Substation	Ea		1	350000	350000	210000		560000
Auto. Tie Switch	Ea.		1	5000	5000	3000		8000
Catenary Poles	Ea	1/200'	436	3000	1306800	784080		2090880
Catenary Poles XO	Ea	11	11	3000	33000	19800		52800
Catenary System Mainline	Ft		174240	200	34848000	20908800		55756800
Cat. Sys. XO	Ft		500	200	100000	60000		160000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	1	10,000	10000	6000		16000
Circ. Brk. Auto Reclose	Substa.		1	40,000	40000	24000		64000
					SUBTOTAL		$	60,297,549
					20% CONT		$	12,059,510
							$	72,357,059
					Cost Rounded to	Cost Rounded to	$	70,000,000

Miles	16.5
Feet	87120
Track feet	174240
Substations	1
Crossovers	1
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Emp-Love

Segment **Loveland-Tunnel**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV Wire	Mile	3	2	18,480	33264	19958.4	53222.4
12 KV Insulators	Cat pole	3	48	45	2138.4	1283.04	3421.44
12 KV Spacers	Cat pole	3	48	15	712.8	427.68	1140.48
10000 KVA Substation	Ea		1	350000	350000	210000	560000
Auto. Tie Switch	Ea.		1	5000	5000	3000	8000
Catenary Poles	Ea	1/200'	16	3000	47520	28512	76032
Catenary Poles XO	Ea	11	11	3000	33000	19800	52800
Catenary System Mainline	Ft		6336	200	1267200	760320	2027520
Cat. Sys. XO	Ft		500	200	100000	60000	160000
Cat Sys. Passing	Ft		0	200	0	0	0
SCADA	Substa.	4	1	10,000	10000	6000	16000
Circ. Brk. Auto Reclose	Substa.		1	40,000	40000	24000	64000
					SUBTOTAL		$ 3,022,136
					20% CONT		$ 604,427
							$ 3,626,564
					Cost Rounded to	Cost Rounded to	$ 4,000,000

Miles	0.6
Feet	3168
Track feet	6336
Substations	1
Crossovers	1
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) Double track with crossovers spaced 8 miles apart

Segment **Eisenhower Tunnel**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	7	18,480	127512	76507.2		204019.2
12 KV Insulators	Cat pole	3	182	45	8197.2	4918.32		13115.52
12 KV Spacers	Cat pole	3	182	15	2732.4	1639.44		4371.84
10000 KVA Substation	Ea		0	350000	0	0		0
Auto. Tie Switch	Ea.		0	5000	0	0		0
Catenary mounting brackets	Ea	1/200'	61	3000	182160	109296		291456
Catenary Poles XO	Ea	11	0	3000	0	0		0
Catenary System Mainline	Ft		12144	200	2428800	1457280		3886080
Cat. Sys. XO	Ft		0	200	0	0		0
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	0	10,000	0	0		0
Circ. Brk. Auto Reclose	Substa.		0	40,000	0	0		0
					SUBTOTAL		$	4,399,043
					20% CONT		$	879,809
							$	5,278,851
					Cost Rounded to	Cost Rounded to	$	5,000,000

Miles	2.3
Feet	12144
Track feet	12144
Substations	0
Crossovers	0
Passing sidings	0

Assumptions

System Voltage = 25,000 v.a.c.
System Length = 86.6 miles
A.) Base Consist = 10 cars/train
B.) Base Energy required in KWH = 6,191 KWH
C.) Energy required in KVA = B.x1.38 = 8,544 KVA
D.) Number of consists required = 6
E.) Energy required one direction = CxD = 561,264 KVA
F.) Energy required for both directions = 2xE = 102,528 KVA
G.) Substations required(one/ stop+2) = 11
H.) Substation KVA = F/G = 8,544 KVA
I.) One track

Ike Tunnel

Segment **Tunnel-Vail**

ITEM DESCRIPTION	UNIT	RATE	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST		TOTAL COST
12 KV Wire	Mile	3	111	18,480	2045736	1227441.6		3273177.6
12 KV Insulators	Cat pole	3	2922	45	131511.6	78906.96		210418.56
12 KV Spacers	Cat pole	3	2922	15	43837.2	26302.32		70139.52
10000 KVA Substation	Ea		5	350000	1750000	1050000		2800000
Auto. Tie Switch	Ea.		5	5000	25000	15000		40000
Catenary Poles	Ea	1/200'	974	3000	2922480	1753488		4675968
Catenary Poles XO	Ea	11	44	3000	132000	79200		211200
Catenary System Mainline	Ft		215952	200	43190400	25914240		69104640
Cat. Sys. XO	Ft		2000	200	400000	240000		640000
Cat Sys. Passing	Ft		0	200	0	0		0
SCADA	Substa.	4	5	10,000	50000	30000		80000
Circ. Brk. Auto Reclose	Substa.		5	40,000	200000	120000		320000
					SUBTOTAL		$	81,425,544
					20% CONT		$	16,285,109
							$	97,710,652
					Cost Rounded to	Cost Rounded to	$	100,000,000

Rail		Assumptions
Miles	36.9	System Voltage = 25,000 v.a.c.
Feet	194832	System Length = 86.6 miles
Track feet	215952	A.) Base Consist = 10 cars/train
Substations	5	B.) Base Energy required in KWH = 6,191 KWH
Crossovers	4	C.) Energy required in KVA = B.x1.38 = 8,544 KVA
Passing sidings	2	D.) Number of consists required = 6
length of each siding (ft)	10,560	E.) Energy required one direction = CxD = 561,264 KVA
length of single track section	24.3 mi	F.) Energy required for both directions = 2xE = 102,528 KVA
	128304 ft	G.) Substations required(one/ stop+2) = 11
length of single track section	12.6 mi	H.) Substation KVA = F/G = 8,544 KVA
	66528 ft	I.) Double track with crossovers spaced 8 miles apart

1/20/2003 13:23

BID ITEMS	COST PER UNIT	QUANTITY	COST
Structures	150.00	0	0.00
Walls	90.00	0	0.00
Earthwork	20.00	0	0.00
Pavement	70.00	0	0.00
Base Course	40.00	0	0.00
Barrier	60.00	0	0.00
Special Structures	200.00	0	0.00
Tunnel (Twin Tunnels)	15000	0	$0.00
Tunnel (South Bore EJMT)	30000	0	$0.00
Interchanges	0	0	$0.00
Maintenance Facilities	Variable	2	$58,500,000.00
Mobile Maintenance Vehicles	Variable	21	$1,200,000.00
Ramps for Busses	2000000	6	$12,000,000.00
Stations/Parking (Large)	10000000	1	$10,000,000.00
Stations/Parking (Medium)	6000000	1	$6,000,000.00
Station (Small)	3000000	4	$12,000,000.00
Fare Collection (Fare vending machines)	37000	118	$4,366,000.00
Passenger Rollingstock	325000	241	$78,325,000.00
Automatic Vehicle Location System	2892000	1	$2,892,000.00
Total			185,283,000.00

	% Range		% Used	Cost	
Project Construction Bid Items (per segment)				$102,866,000.00	
Lump Sum Items				$82,417,000.00	
Project Construction Bid Items	Project Dependent		N/A	$185,283,000.00	(A)
Contingencies*	(15% - 30%) of (A)		30.00%	$55,584,900.00	(B)
ITS	(6-10%) of (A+B) Default = 6%		0.00%	$0.00	(C)
Drainage/Utilities	(3-10%)of (A+B) Default = 6%		10.00%	$24,086,790.00	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%		2.00%	$5,299,093.80	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%		10.00%	$27,025,378.38	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%		7.00%	$20,809,541.35	(G)
Total of Construction Bid Items	(A+B+C+D+E+F+G)			$318,088,703.53	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%		2.00%	$6,361,774.07	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%		12.00%	$38,170,644.42	(J)
Subtotal of Construction Cost	(H+I+J)			$362,621,122.03	(K)
Total Construction Engineering	17% of (K)		17.00%	$61,645,590.74	(L)
Total Preliminary Engineering**	15% of (K)		15.00%	$54,393,168.30	(M)
Right of Way	Project Dependent		2.00%	$6,361,774.07	(N)
Utilities	Project Dependent		N/A	$0.00	(O)
	COST	QUANTITY			
Tunnel (Twin Tunnels) (LF)	15000.00	0.00		0.00	
Tunnel (South Bore EJMT) (LF)	30000.00			0.00	
Interchanges (EACH)	0.00			0.00	
Total Project Cost				$485,021,655.15	(P)

*Contingencies includes environmental mitigation costs
**Total Preliminary Engineering should include cost of developing NEPA documents

Estimate Worksheet							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Special Structures	0	200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Maintenance Facilities	0	$0.00			$0.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	1	6000000			$6,000,000.00		
Station (Small)	1	3000000			$3,000,000.00		
Fare Collection	13	37000			$481,000.00		
Total accounted construciton items					$13,481,000.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$4,044,300.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$1,752,530.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		2.00%	Carrie	$385,556.60	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		10.00%	Carrie	$1,966,338.66	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$1,514,080.77	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$23,143,606.03	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$462,876.12	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$2,777,256.72	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$26,383,938.87	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$4,485,269.61	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$3,957,590.83	(M)	
Right of Way	Project Dependent		2.00%		$462,876.12	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Total Segment Cost					$35,289,676.43	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Special Structures	0	200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)		30000			$0.00		
Interchanges					$0.00		
Maintenance Facilities	1	$42,000,000.00			$42,000,000.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	1	10000000			$10,000,000.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	1	3000000			$3,000,000.00		
Fare Collection	49	37000			$1,813,000.00		
Total accounted construciton items					$60,813,000.00	(A)	Carried to S
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$18,243,900.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$7,905,690.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		2.00%	Carrie	$1,739,251.80	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		10.00%	Carrie	$8,870,184.18	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$6,830,041.82	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$104,402,067.80	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$2,088,041.36	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$12,528,248.14	(J)	
Subtotal of Construction Cost	(h+i+j)				$119,018,357.29	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$20,233,120.74	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$17,852,753.59	(M)	
Right of Way	Project Dependent		2.00%		$2,088,041.36	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Total Segment Cost					$159,192,272.98	(P)	

Be certain to check that proper values have been carried to Sheet One

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Special Structures	0	200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Maintenance Facilities	1	$16,500,000.00			$16,500,000.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	2	3000000			$6,000,000.00		
Fare Collection	56	37000			$2,072,000.00		
Total accounted construciton items					$28,572,000.00	(a)	Carried to Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$8,571,600.00	(B)	
ITS	(6-10%) of (a+b) Default = 8%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$3,714,360.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		2.00%	Carrie	$817,159.20	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		10.00%	Carrie	$4,167,511.92	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$3,208,984.18	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$49,051,615.30	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$981,032.31	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$5,886,193.84	(J)	
Subtotal of Construction Cost	(h+i+j)				$55,916,841.44	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$9,506,203.04	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$8,387,526.22	(M)	
Right of Way	Project Dependent		2.00%		$981,032.31	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Total Segment Cost					$74,793,903.01	(P)	

Be certain to check that proper values have been carried to Sheet One

Diesel Bus in Transitway Total Facilities Costs

Project Construction Items				
Item Description	Quantity		Per Unit Cost	Cost
Square foot indoor space	586,161.56	$	105.00	$61,546,964.06
Miscellaneous Equipment and furnishings	Variable		Variable	$1,350,000.00
				$0.00
			Sub total	$62,896,964.06
Mobile Maintenance Equipment				
Guideway double ended truck	2	$	400,000.00	$800,000.00
Miscellaneous trucks	5	$	50,000.00	$250,000.00
Toe Trucks	2	$	100,000.00	$200,000.00
Road Supervision (mini vans)	12	$	30,000.00	$360,000.00
			Sub total	$1,610,000.00
			Total	$64,506,964.06
Passenger Railcar Fleet	241.00	$	325,000.00	$78,325,000.00
Automatic Vehicle Location System	241.00	$	12,000.00	$2,892,000.00
			Subtotal	$81,217,000.00
			Total	$208,620,928.13

Assumptions

Track length at yards was calculated by taking the aggregate length of the cars required to be able to be stored. 30% was added to the total for non-storage track (only 15% at Vail).

Size of buildings assumed trains will require 35ft width (includes the width of the train and 20 ft.between tracks, per AREMA Standards. Passenger rolling stock does not include paratransit vehicles. The inter urban system is not required to operate ADA complimentary service and the buses are ADA compatible with lifts. However, the feeder bus will be required to offer complimentary service. Those costs

Square foot indoor space represents the sum of three yards: Vail, Frisco, and Denver.

Automatic Vehicle Location System shall include equipment, office space and dispatch costs.

	A	B	C	D
1				
2				
3	**Denver Facility**: Heavy maintenance, cleaning, fueling,			
4	and adminstration.	Quantity	Price	
5	Square Foot Indoor Space	388,800.00	105	$ 40,824,000.00
6	Miscellaneous Equipment and furnishings	1	1000000	$1,000,000.00
7				$0.00
8				$41,824,000.00
9				
10				
11			Total	$41,824,000.00
12	Shop sized to hold 80% of the fleet indoors with a 100% for administrative offices, fueling, and heavy			
13	Indoor space with the length of the Diesel bus, 45', width 8.5' and 14' lanes			

	A	B	C	D
1				
2				
3	**Frisco Facility** for Inspection, Overhaul, light and heavy maintenance			
4	and cleaning with yard capacity for 40% of the fleet	**Quantity**	**Per Unit Cost**	**Cost**
5	Indoor Square Foot	153,697.50	$ 105.00	$ 16,138,237.50
6	Miscellaneous Equipment and furnishings	1	$ 250,000.00	$ 250,000.00
7				$ -
8			sub total	$ 16,388,237.50
9	**Project Construction Items**			
10	Item Description	**Quantity**	**Per Unit Cost**	**Cost**
11				$ -
12				$ -
13				$ -
14			Total	$ 16,388,237.50
15				
16	An additional 15% was added to the floor space			

	A	B	C	D
1				
2				
3	**Glenwood Facility** for light car maintenance and			
4	cleaning with yard capacity for 10% of the fleet			
5		Quantity	Price	
6	Indoor Square Foot	43,664.06	105	$ 4,584,726.56
7	Miscellaneous Equipment and furnishings	1.00	100000	$ 100,000.00
8				
9			Total	$ 4,684,726.56
10				
11	**Project Construction Items**			
12	Item Description	Quantity	Per Unit Cost	Cost
13				$ -
14			Total	$ 4,684,726.56
15				
16				
17	An additional 15% was added to the floor space			

1/20/2003 13:20

BID ITEMS	COST PER UNIT	QUANTITY	COST
Structures	150.00	0	0.00
Walls	90.00	0	0.00
Earthwork	20.00	0	0.00
Pavement	70.00	0	0.00
Base Course	40.00	0	0.00
Barrier	60.00	0	0.00
Special Structures	200.00	0	0.00
Tunnel (Twin Tunnels)	15000	0	0.00
Tunnel (South Bore EJMT)	30000	0	0.00
Interchanges	0	0	0.00
Guided Busway Track	315	165528	$52,141,320.00
Maintenance Facilities	Variable	2	$60,500,000.00
Mobile Maintenance Equipment	Variable	21	$2,000,000.00
Ramps for Busses	2000000	6	$12,000,000.00
Stations/Parking (Large)	10000000	1	$10,000,000.00
Stations/Parking (Medium)	6000000	1	$6,000,000.00
Station (Small)	3000000	4	$12,000,000.00
Fare Collection (Fare vending machines)	37000	118	$4,366,000.00
Passenger Rollingstock	325000	254	$82,550,000.00
Automatic Vehicle Location System	3048000	1	$3,048,000.00
Total			244,605,320.00

	% Range	% Used	Cost	
Project Construction Bib Items			$157,007,320.00	
Lump Sum Items			$87,598,000.00	
Project Construction Bid Items	Project Dependent	N/A	$244,605,320.00	(A)
Contingencies*	(15% - 30%) of (A)	30.00%	$73,381,596.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.00%	$0.00	(C)
Drainage/Utilities	(3-10%)of (A+B) Default = 6%	10.00%	$31,798,691.60	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	1.00%	$3,497,856.08	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	7.00%	$24,729,842.46	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	7.00%	$26,460,931.43	(G)
Total of Construction Bid Items	(A+B+C+D+E+F+G)		$404,474,237.56	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.00%	$8,089,484.75	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	12.00%	$48,536,908.51	(J)
Subtotal of Construction Cost	(H+I+J)		$461,100,630.82	(K)
Total Construction Engineering	17% of (K)	17.00%	$78,387,107.24	(L)
Total Preliminary Engineering**	15% of (K)	15.00%	$69,165,094.62	(M)
Right of Way	Project Dependent	2.00%	$8,089,484.75	(N)
Utilities	Project Dependent	N/A	$0.00	(O)
	COST	QUANTITY		
Tunnel (Twin Tunnels) (LF)	15000.00	0.00	0.00	
Tunnel (South Bore EJMT) (LF)	30000.00		0.00	
Interchanges (EACH)	0.00		0.00	
Total Project Cost			$616,742,317.44	(P)

*Contingencies includes environmental mitigation costs

**Total Preliminary Engineering should include cost of developing NEPA documents

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Special Structures	0	200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	75240	315			$23,700,600.00		
Maintenance Facilities	1	$42,000,000.00			$42,000,000.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	1	10000000			$10,000,000.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	1	3000000			$3,000,000.00		
Fare Collection	49	37000			$1,813,000.00		
Total accounted construciton items					$84,513,600.00	(A)	Carried to S
Contingencies Estabilsed as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$25,354,080.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$10,986,768.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		1.00%	Carrie	$1,208,544.48	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		7.00%	Carrie	$8,544,409.47	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$9,142,518.14	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$139,749,920.09	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$2,794,998.40	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$16,769,990.41	(J)	
Subtotal of Construction Cost	(h+i+j)				$159,314,908.90	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$27,083,534.51	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$23,897,236.34	(M)	
Right of Way	Project Dependent		2.00%		$2,794,998.40	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Total Segment Cost					$213,090,678.15	(P)	

Be certain to check that proper values have been carried to Sheet One

Estimate Worksheet							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Special Structures	0	200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	87120	315			$27,442,800.00		
Maintenance Facilities	0	$0.00			$0.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	1	6000000			$6,000,000.00		
Station (Small)	1	3000000			$3,000,000.00		
Fare Collection	13	37000			$481,000.00		
Total accounted construciton items					$40,923,800.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$12,277,140.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$5,320,094.00	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$585,210.34	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$4,137,437.10	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$4,427,057.70	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$67,870,739.14	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$1,353,414.78	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$8,120,488.70	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$77,144,642.63	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$13,114,589.25	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$11,571,696.39	(M)	
Right of Way	Project Dependent		2.00%		$1,353,414.78	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Total Segment Cost					$103,184,343.05	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet

	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Special Structures	0	200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	3168	315			$997,920.00		
Maintenance Facilities	1	18500000			$18,500,000.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	2	3000000			$6,000,000.00		
Fare Collection	56	37000			$2,072,000.00		
Total accounted construciton items					$31,569,920.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$9,470,976.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$4,104,089.60	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		1.00%	Carrie	$451,449.86	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		7.00%	Carrie	$3,191,750.48	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$3,415,173.02	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$52,203,358.95	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$1,044,067.18	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$6,264,403.07	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$59,511,829.21	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$10,117,010.97	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$8,926,774.38	(M)	
Right of Way	Project Dependent		2.00%		$1,044,067.18	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Total Segment Cost					$79,599,681.73	(P)	

Be certain to check that proper values have been carried to Sheet One

Diesel Bus in Guideway Floyd Hill Total Facilities Costs

Project Construction Items			
Item Description	Quantity	Per Unit Cost	Cost
Square foot indoor space	619,194.38	$ 105.00	$65,015,409.38
Miscellaneous Equipment and furnishings	Variable	Variable	$1,350,000.00
			$0.00
		Sub total	$66,365,409.38
Mobile Maintenance Equipment			
Guideway double ended truck	2	$ 400,000.00	$800,000.00
Miscellaneous trucks	5	$ 50,000.00	$250,000.00
Toe Trucks	2	$ 100,000.00	$200,000.00
Road Supervision	12	$ 30,000.00	$360,000.00
		Sub total	$1,610,000.00
		Total	$67,975,409.38
Passenger Railcar Fleet	254	$ 325,000.00	$82,550,000.00
Automatic Vehicle Location System	254	$ 10,000.00	$2,540,000.00
		Subtotal	$85,090,000.00
		Total	$219,430,818.75

Assumptions

Track length at yards was calculated by taking the aggregate length of the cars required to be able to be stored. 30% was added to the total for non-storage track (only 15% at Vail).

Size of buildings assumed trains will require 35ft width (includes the width of the train and 20 ft.between tracks, per AREMA Standards. Passenger rolling stock does not include paratransit vehicles. The inter urban system is not required to operate ADA complimentary service and the buses are ADA compatible with lifts. However, the feeder bus will be required to offer complimentary service. Those costs

Square foot indoor space represents the sum of three yards: Vail, Frisco, and Denver.

Automatic Vehicle Location System shall include equipment, office space and dispatch costs.

	A	B	C	D
1				
2				
3	**Denver Facility**: Heavy maintenance, cleaning, fueling,			
4	and adminstration.	Quantity	Price	
5	Square Foot Indoor Space	413,100.00	105	$ 43,375,500.00
6	Miscellaneous Equipment and furnishings	1	1000000	$1,000,000.00
7				$0.00
8				$44,375,500.00
9	**Mobile Maintenance Equipment**			
10	Guideway double ended truck	2	$ 400,000.00	$800,000.00
11	Miscellaneous trucks	5	$ 50,000.00	$250,000.00
12	Toe Trucks	2	$ 100,000.00	$200,000.00
13	Road Supervision (mini vans)	12	$ 30,000.00	$360,000.00
14				
15				
16			Total	$45,985,500.00
17	Shop sized to hold 80% of the fleet indoors with a 100% for administrative offices, fueling, and heavy			
18	Indoor space with the length of the Diesel bus, 45', width 8.5' and 14' lanes			

	A	B	C	D
1				
2				
3	**Frisco Facility** for Inspection, Overhaul, light and heavy maintenance			
4	and cleaning with yard capacity for 40% of the fleet	**Quantity**	**Per Unit Cost**	**Cost**
5	Indoor Square Foot	171,163.13	$ 105.00	$ 17,972,128.13
6	Miscellaneous Equipment and furnishings	1	$ 250,000.00	$ 250,000.00
7				$ -
8			sub total	$ 18,222,128.13
9	**Project Construction Items**			
10	Item Description	**Quantity**	**Per Unit Cost**	**Cost**
11				$ -
12				$ -
13				$ -
14			Total	$ 18,222,128.13
15				
16	An additional 15% was added to the floor space			

	A	B	C	D
1				
2				
3	**Glenwood Facility** for light car maintenance and			
4	cleaning with yard capacity for 10% of the fleet			
5		Quantity	Price	
6	Indoor Square Foot	34,931.25	105	$ 3,667,781.25
7	Miscellaneous Equipment and furnishings	1.00	100000	$ 100,000.00
8				
9			Total	$ 3,767,781.25
10				
11	**Project Construction Items**			
12	Item Description	Quantity	Per Unit Cost	Cost
13				$ -
14			Total	$ 3,767,781.25
15				
16				
17	An additional 15% was added to the floor space			

Stations	Peak Ons	Peak Hr	Fare Demand	Round up	Minimum	Off site	Total	Location	by loc
Westminster	620	155	5	6	0		6	1	
6th & Laurel	477	119	4	4	0		4	1	
A-Basin	26	7	0	1	0		1	1	
Arapahoe pnR	384	96	3	4	0		4	1	
Arvada	226	56	2	2	0		2	1	
Denver Union Sta	600	150	5	5	0	24	29	1	
DIA	663	166	6	6	0	4	10	1	
Jefferson Sta	825	206	7	7	0	5	12	1	
Pena pnR	457	114	4	4	0		4	1	
Silverthorne TC	662	166	6	6	0	2	8	1	
Stapleton TC	482	120	4	5	0		5	1	85
El Rancho	468	117	4	4	0	2	6	2	6
US 6 / Gaming	257	64	2	3	0		3	3	
Blackhawk	359	90	3	3	0		3	3	
Central City	325	81	3	3	0		3	3	
Empire	281	70	2	3	0	1	4	3	13
Mineral Sta	582	146	5	5	0		5	4	
Idaho Springs	1000	250	8	9	0		9	4	
Johnson Park	96	24	1	1	0		1	4	
Keystone	286	72	2	1	0		1	4	16
Winter Park	414	103	3	1	0		1	5	
Avon	418	104	3	4	0		4	5	
Bell Tower	26	6	0	1	0		1	5	
CO 9 & French	6	1	0	1	0		1	5	
CO 9 & Watson	450	113	4	4	0		4	5	
Copper Circle	309	77	3	3	0		3	5	
Copper Entrance	500	125	4	5	0	1	6	5	
Frisco TC	2097	524	17	18	0	4	22	5	
Georgetown	47	12	0	1	0	1	2	5	
Loveland Ski	46	11	0	1	0	1	2	5	
Silverthorne	1200	300	10	10	0		10	5	56
Vail TC	866	216	7	6	0	1	7	6	7
Wolcott	47	12	0	1	0		1	7	
Dotsero	40	10	0	1	0		1	7	
Eagle	67	17	1	1	0		1	7	
Eagle & I-70	218	55	2	2	0		1	7	
Edwards	512	128	4	5	0		1	7	
EGE East	149	37	1	2	0		1	7	
EGE West	3	1	0	1	0		1	7	
Glenwood Springs	1	0	0	1	0		1	7	
Gypsum	77	19	1	1	0		1	7	
Gypsum & I-70	3	1	0	1	0		1	7	
Ward Road	203	51	2	2	0		2	7	12
	16773						195		195

min

2

Assumptions
20% of riders have purchased tickects at Idaho Springs, A23Vail, Frisco, and Jefferson
10% of all riders have purchased tickets before
Only one machine per station west of Vail.
Copper Mountain was set from HRT analsysis

AGT

Fare Card Machines	
EB Station	**Machines at Other Locations**
DIA	4
DUS--Denver Metra	24
Stapleton	2
Jefferson	5
El Rancho	1
US 6/Gaming	1
Idaho Spgs	1
Empire Jct	2
Georgetown	1
Loveland Ski	1
Silverthorne TC	1
Frisco TC	4
Copper Mtn	1
Vail TC	1
West of Vail	9
	58

1/20/2003 13:29

BID ITEMS	COST PER UNIT	QUANTITY	COST
Structures	150.00	0	0.00
Walls	90.00	484108	43,569,720.00
Earthwork	20.00	203036	4,060,720.00
Pavement	70.00	0	0.00
Base Course	40.00	0	0.00
Barrier	60.00	0	0.00
Guideway Structure (LF)	3200.00	71000	227,200,000.00
Tunnel (Twin Tunnels)	15000	0	0.00
Tunnel (South Bore EJMT)	30000	0	0.00
Interchanges	0	0	0.00
Guided Busway Track	315	267168	$84,157,920.00
Maintenance Facilities	Variable	3	$84,500,000.00
Mobile Maintenance Vehicles	Variable	21	$2,000,000.00
Ramps for Busses	2000000	12	$24,000,000.00
Stations/Parking (Large)	10000000	3	$30,000,000.00
Stations/Parking (Medium)	6000000	1	$6,000,000.00
Station (Small)	3000000	9	$27,000,000.00
Fare Collection (Fare vending machines)	37000	188	$6,956,000.00
Passenger Rollingstock	900000	244	$219,600,000.00
Automatic Vehicle Location System	2928000	1	$2,928,000.00
Total			761,972,360.00

	% Range	% Used	Cost	
Project Construction Items (per segment)			$537,444,360.00	
Lump Sum Items			$224,528,000.00	
Project Construction Bid Items	Project Dependent	N/A	$761,972,360.00	(A)
Contingencies*	(15% - 30%) of (A)	30.00%	$228,591,708.00	(B)
ITS	(6-10%) of (A+B) Default = 6%	0.00%	$0.00	(C)
Drainage/Utilities	(3-10%)of (A+B) Default = 6%	10.00%	$99,056,406.80	(D)
Signing and Striping	(1-5%) of (A+B+C+D) Default = 5%	1.00%	$10,896,204.75	(E)
Construction Signing & Traffic Control	5 to 25% of (A+B+C+D+E) Default = 20%	7.00%	$77,036,167.57	(F)
Mobilization	(4 to 10%) of (A+B+C+D+E+F) Default = 7%	7.00%	$82,428,699.30	(G)
Total of Construction Bid Items	(A+B+C+D+E+F+G)		$1,259,981,546.41	(H)
Force Account - Utilities	(1 to 2%) of (H) Default = 2%	2.00%	$25,199,630.93	(I)
Force Account - Misc.	(10 to 15%) of (H) Default = 12%	12.00%	$151,197,785.57	(J)
Subtotal of Construction Cost	(H+I+J)		$1,436,378,962.91	(K)
Total Construction Engineering	17% of (K)	17.00%	$244,184,423.70	(L)
Total Preliminary Engineering**	15% of (K)	15.00%	$215,456,844.44	(M)
Right of Way	Project Dependent	2.00%	$25,199,630.93	(N)
Utilities	Project Dependent	N/A	$0.00	(O)

	COST	QUANTITY		
Tunnel (Twin Tunnels) (LF)	15000.00	0.00		0.00
Tunnel (South Bore EJMT) (LF)	30000.00			
Interchanges (EACH)	0.00			
Electrification	67,650,000.00	Variable	$67,650,000.00	
Total Project Cost				$1,921,219,861.97 (P)

*Contingencies includes environmental mitigation costs

**Total Preliminary Engineering should include cost of developing NEPA documents

Estimate Worksheet							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	393359	90			$35,402,310.00		
Earthwork	174826	20			$3,496,520.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Guideway Structure (LF)	47000	3200			$150,400,000.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	69960	315			$22,037,400.00		
Maintenance Facilities	1	$55,500,000.00			$55,500,000.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	1	10000000			$10,000,000.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	1	3000000			$3,000,000.00		
Fare Collection	85	37000			$3,145,000.00		
Total accounted construction items					$286,981,230.00	(A)	Carried to Sheet One
Contingencies Established as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$86,094,369.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$37,307,559.90	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		3.00%	Carrie	$12,311,494.77	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		15.00%	Carrie	$63,404,198.05	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$34,026,919.62	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$520,125,771.34	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$10,402,515.43	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$62,415,092.56	(J)	
Subtotal of Construction Cost	(h+i+j)				$592,943,379.32	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$100,800,374.49	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$88,941,506.90	(M)	
Right of Way	Project Dependent		2.00%		$10,402,515.43	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Electrification	Variable	$11,000,000.00			$11,000,000.00		
Total Segment Cost					$793,087,776.14	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Guideway Structure (LF)	0	3200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	75240	315			$23,700,600.00		
Maintenance Facilities	0	$0.00			$0.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	1	10000000			$10,000,000.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	1	3000000			$3,000,000.00		
Fare Collection	6	37000			$222,000.00		
Total accounted construciton Items					$40,922,600.00	(A)	Carried to Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$12,276,780.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$5,319,938.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		3.00%	Carrie	$1,755,579.54	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		15.00%	Carrie	$9,041,234.63	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$4,852,129.25	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$74,168,261.42	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$1,483,365.23	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$8,900,191.37	(J)	
Subtotal of Construction Cost	(h+I+j)				$84,551,818.02	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$14,373,809.06	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$12,682,772.70	(M)	
Right of Way	Project Dependent		2.00%		$1,483,365.23	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels) (LF)	15000	0			$0.00		
Tunnel (South Bore EJMT) (LF)	30000	0			$0.00		
Interchanges (EACH)	1	0			$0.00		
Electrification	Variable	11,000,000.00			$11,000,000.00		
Total Segment Cost					$113,091,765.02	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
	% Range		% Used				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Guideway Structure (LF)	0	3200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	87120	315			$27,442,800.00		
Maintenance Facilities	0	$0.00			$0.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	1	6000000			$6,000,000.00		
Station (Small)	1	3000000			$3,000,000.00		
Fare Collection	13	37000			$481,000.00		
Total accounted construciton items					$40,923,800.00	(a)	Carried to Sheet One
Contingencies Establised as a percentage	(15% - 30%) of (A)		30.00%	Carrie	$12,277,140.00	(B)	
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$5,320,094.00	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		3.00%	Carrie	$1,755,631.02	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		15.00%	Carrie	$9,041,499.75	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$4,852,271.53	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$74,170,436.31	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$1,483,408.73	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$8,900,452.36	(J)	
Subtotal of Construction Cost	(h+i+j)				$84,554,297.39	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$14,374,230.56	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$12,683,144.61	(M)	
Right of Way	Project Dependent		2.00%		$1,483,408.73	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	Variable	13,000,000.00			$13,000,000.00		
Total Segment Cost					$113,095,081.28	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Guideway Structure (LF)	0	3200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	3168	315			$997,920.00		
Maintenance Facilities	0	$0.00			$0.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	2	3000000			$6,000,000.00		
Fare Collection	16	37000			$592,000.00		
Total accounted construciton items					$11,589,920.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$3,476,976.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 6%		10.00%	Carrie	$1,506,689.60	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		3.00%	Carrie	$497,207.57	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		15.00%	Carrie	$2,560,618.98	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$1,374,198.85	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$21,005,610.99	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$420,112.22	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$2,520,673.32	(J)	
Subtotal of Construction Cost	(h+i+j)				$23,946,396.53	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$4,070,887.41	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$3,591,959.48	(M)	
Right of Way	Project Dependent		2.00%		$420,112.22	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	Variable	650,000.00			$650,000.00		
Total Segment Cost					$32,029,355.64	(P)	
Be certain to check that proper values have been carried to Sheet One							

Estimate Worksheet							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	Quantity	Per Unit Cost			Cost		
Structures	0	150			$0.00		
Walls	0	90			$0.00		
Earthwork	0	20			$0.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Guideway Structure (LF)	0	3200			$0.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	12144	315			$3,825,360.00		
Maintenace Falcilities	1	22,500,000.00			$22,500,000.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Stations/Parking (Large)	0	10000000			$0.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	2	3000000			$6,000,000.00		
Fare Collection	56	37000			$2,072,000.00		
Total accounted construciton items					$38,397,360.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$11,519,208.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b)		0.00%	Carrie	$0.00	(C)	
	Default = 6%						
Drainage/Water/Sewer	(3-10%)of (a+b)		10.00%	Carrie	$4,991,656.80	(D)	
	Default = 6%						
Signing and Striping	(1-5%) of (a+b+c+d)		3.00%	Carrie	$1,647,246.74	(E)	
	Default = 5%						
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e)		15.00%	Carrie	$8,483,320.73	(F)	
	Default = 20%						
Mobilization	(4 to 10%) of (a+b+c+d+e+f)		7.00%	Carrie	$4,552,715.46	(G)	
	Default = 7%						
Total of Construction Items	(a+b+c+d+e+f+g)				$69,591,507.73	(H)	
Force Account - Utilities	(1 to 2%) of (h)		2.00%	Carrie	$1,391,830.15	(I)	
	Default = 2%						
Force Account - Misc.	(10 to 15%) of (h)		12.00%	Carrie	$8,350,980.93	(J)	
	Default = 12%						
Subtotal of Construction Cost	(h+i+j)				$79,334,318.82	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$13,486,834.20	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$11,900,147.82	(M)	
Right of Way	Project Dependent		2.00%		$1,391,830.15	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	Variable	2,000,000.00			$2,000,000.00		
Total Segment Cost					$106,113,130.99	(P)	

Be certain to check that proper values have been carried to Sheet One

Estimate Worksheet							
	% Range		**% Used**				
Stated Assumptions							
Project Construction Items							
Item Description	**Quantity**	**Per Unit Cost**			**Cost**		
Structures	0	150			$0.00		
Walls	90749	90			$8,187,410.00		
Earthwork	28210	20			$564,200.00		
Pavement	0	70			$0.00		
Base Course	0	40			$0.00		
Barrier	0	60			$0.00		
Guideway Structure (LF)	24000	3200			$76,800,000.00		
Tunnel (Twin Tunnels)	0	15000			$0.00		
Tunnel (South Bore EJMT)	0	30000			$0.00		
Interchanges	0	0			$0.00		
Guided Busway Track	19536	315			$6,153,840.00		
Ramps for Busses	2	2000000			$4,000,000.00		
Maintenance Facilities	1	$6,500,000.00			$6,500,000.00		
Stations/Parking (Large)	1	10,000,000.00			$10,000,000.00		
Stations/Parking (Medium)	0	6000000			$0.00		
Station (Small)	2	3000000			$6,000,000.00		
Fare Collection	12	37000			$444,000.00		
Total accounted construciton items					$118,629,450.00	(a)	Carried to Sheet One
Contingencies	(15% - 30%) of (A)		30.00%	Carrie	$35,588,835.00	(B)	
Establised as a percentage							
ITS	(6-10%) of (a+b) Default = 6%		0.00%	Carrie	$0.00	(C)	
Drainage/Water/Sewer	(3-10%)of (a+b) Default = 8%		10.00%	Carrie	$15,421,828.50	(D)	
Signing and Striping	(1-5%) of (a+b+c+d) Default = 5%		3.00%	Carrie	$5,089,203.41	(E)	
Construction Signing & Traffic Control	5 to 25% of (a+b+c+d+e) Default = 20%		15.00%	Carrie	$26,209,397.54	(F)	
Mobilization	(4 to 10%) of (a+b+c+d+e+f) Default = 7%		7.00%	Carrie	$14,065,710.01	(G)	
Total of Construction Items	(a+b+c+d+e+f+g)				$215,004,424.45	(H)	
Force Account - Utilities	(1 to 2%) of (h) Default = 2%		2.00%	Carrie	$4,300,088.49	(I)	
Force Account - Misc.	(10 to 15%) of (h) Default = 12%		12.00%	Carrie	$25,800,530.93	(J)	
Subtotal of Construction Cost	(h+i+j)				$245,105,043.87	(K)	
Total Construction Engineering	17% of (k)		17.00%	Carrie	$41,667,857.46	(L)	
Total Preliminary Engineering	15% of (k)		15.00%	Carrie	$36,765,756.58	(M)	
Right of Way	Project Dependent		2.00%		$4,300,088.49	(N)	
Utilities	Project Dependent		N/A			(O)	
Tunnel (Twin Tunnels)	15000	0			$0.00		
Tunnel (South Bore EJMT)	30000	0			$0.00		
Interchanges	1	0			$0.00		
Electrification	Variable	30000000			$30,000,000.00		
Total Segment Cost					$327,836,746.40	(P)	

Be certain to check that proper values have been carried to Sheet One

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	247.2	$ 18,480	$ 4,568,256	$ 274,095	$ 4,842,351
12 KV INSULATORS	EA.	6564	$ 45	$ 295,380	$ 17,723	$ 313,103
12 KV SPACERS	EA.	6564	$ 15	$ 98,460	$ 5,908	$ 104,368
1000 KVA SUBSTATION W/RECT	EA.	45	$ 50,000	$ 2,250,000	$ 135,000	$ 2,385,000
AUTOMATIC TIE SWITCH	EA.	45	$ 5,000	$ 225,000	$ 13,500	$ 238,500
POWER POLES	EA.	2188	$ 3,000	$ 6,564,000	$ 393,840	$ 6,957,840
POWER DISTRIBUTION SYSTEM MAIN LINE	FT.	437184	$ 100	$ 43,718,400	$ 2,623,104	$ 46,341,504
SCADA	EA.	24	$ 10,000	$ 240,000	$ 14,400	$ 254,400
CIRCUIT BRK. AUTO A.C.	EA.	45	$ 40,000	$ 1,800,000	$ 108,000	$ 1,908,000
CIRCUIT BRK. AUTO D.C.	EA.	45	$ 50,000	$ 2,250,000	$ 135,000	$ 2,385,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					SUBTOTAL	$ 65,730,066
					20% CONT	$ 13,146,013
						$ 78,876,079
		Cost/Mile	$ 1,540,553		Cost Rounded to	$ 78,876,079

MILES	13.25	System Voltage = 750v d.c.
FEET	69960	System Length = 64.48

A.) Base Consist = One Bus
B.) Base Energy required in KWH = 328 KWH
C.) Energy required in KVA = B.x1.38 = 453 KVA
D.) Number of consists required = 84/Hour
E.) Energy required one direction = CxD = 38,052 KVA
F.) Energy required for both directions = 2xE = N/A
G.) Substations required = System Length x 1 Substation per 2 Miles = 32
H.) Substation KVA = F/G = 865 KVA

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	39.75	$ 18,480	$ 734,580	$ 44,075	$ 778,655
12 KV INSULATORS	EA.	1050	$ 45	$ 47,250	$ 2,835	$ 50,085
12 KV SPACERS	EA.	1050	$ 15	$ 15,750	$ 945	$ 16,695
1000 KVA SUBSTATION W/RECT	EA.	7	$ 50,000	$ 350,000	$ 21,000	$ 371,000
AUTOMATIC TIE SWITCH	EA.	7	$ 5,000	$ 35,000	$ 2,100	$ 37,100
POWER POLES	EA.	350	$ 3,000	$ 1,050,000	$ 63,000	$ 1,113,000
POWER DISTRIBUTION SYSTEM MAIN LINE	FT.	69960	$ 100	$ 6,996,000	$ 419,760	$ 7,415,760
SCADA	EA.	4	$ 10,000	$ 40,000	$ 2,400	$ 42,400
CIRCUIT BRK. AUTO A.C.	EA.	7	$ 40,000	$ 280,000	$ 16,800	$ 296,800
CIRCUIT BRK. AUTO D.C.	EA.	7	$ 50,000	$ 350,000	$ 21,000	$ 371,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					Total	$ 10,492,495

MILES	13.25
FEET	69960

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	48.3	$ 18,480	$ 892,584	$ 53,555	$ 946,139
12 KV INSULATORS	EA.	1308	$ 45	$ 58,860	$ 3,532	$ 62,392
12 KV SPACERS	EA.	1308	$ 15	$ 19,620	$ 1,177	$ 20,797
1000 KVA SUBSTATION W/RECT	EA.	9	$ 50,000	$ 450,000	$ 27,000	$ 477,000
AUTOMATIC TIE SWITCH	EA.	9	$ 5,000	$ 45,000	$ 2,700	$ 47,700
POWER POLES	EA.	436	$ 3,000	$ 1,308,000	$ 78,480	$ 1,386,480
POWER DISTRIBUTION SYSTEM MAIN LINE	FT.	87120	$ 100	$ 8,712,000	$ 522,720	$ 9,234,720
SCADA	EA.	4	$ 10,000	$ 40,000	$ 2,400	$ 42,400
CIRCUIT BRK. AUTO A.C.	EA.	9	$ 40,000	$ 360,000	$ 21,600	$ 381,600
CIRCUIT BRK. AUTO D.C.	EA.	9	$ 50,000	$ 450,000	$ 27,000	$ 477,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					Total	$ 13,076,228

MILES	16.1
FEET	87120

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	1.8	$ 18,480	$ 33,264	$ 1,996	$ 35,260
12 KV INSULATORS	EA.	48	$ 45	$ 2,160	$ 130	$ 2,290
12 KV SPACERS	EA.	48	$ 15	$ 720	$ 43	$ 763
1000 KVA SUBSTATION W/RECT	EA.	1	$ 50,000	$ 50,000	$ 3,000	$ 53,000
AUTOMATIC TIE SWITCH	EA.	1	$ 5,000	$ 5,000	$ 300	$ 5,300
POWER POLES	EA.	16	$ 3,000	$ 48,000	$ 2,880	$ 50,880
POWER DISTRIBUTION SYSTEM MAIN LINE	FT.	3168	$ 100	$ 316,800	$ 19,008	$ 335,808
SCADA	EA.	4	$ 10,000	$ 40,000	$ 2,400	$ 42,400
CIRCUIT BRK. AUTO A.C.	EA.	1	$ 40,000	$ 40,000	$ 2,400	$ 42,400
CIRCUIT BRK. AUTO D.C.	EA.	1	$ 50,000	$ 50,000	$ 3,000	$ 53,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					Total	$ 621,101

MILES	0.6
FEET	3168

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	6.9	$ 18,480	$ 127,512	$ 7,651	$ 135,163
12 KV INSULATORS	EA.	183	$ 45	$ 8,235	$ 494	$ 8,729
12 KV SPACERS	EA.	183	$ 15	$ 2,745	$ 165	$ 2,910
1000 KVA SUBSTATION W/RECT	EA.	2	$ 50,000	$ 100,000	$ 6,000	$ 106,000
AUTOMATIC TIE SWITCH	EA.	2	$ 5,000	$ 10,000	$ 600	$ 10,600
POWER POLES	EA.	61	$ 3,000	$ 183,000	$ 10,980	$ 193,980
POWER DISTRIBUTION SYSTEM MAIN LINE	FT.	12144	$ 100	$ 1,214,400	$ 72,864	$ 1,287,264
SCADA	EA.	4	$ 10,000	$ 40,000	$ 2,400	$ 42,400
CIRCUIT BRK. AUTO A.C.	EA.	2	$ 40,000	$ 80,000	$ 4,800	$ 84,800
CIRCUIT BRK. AUTO D.C.	EA.	2	$ 50,000	$ 100,000	$ 6,000	$ 106,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
					Total	$ 1,977,846

MILES	2.3
FEET	12144

ITEM DESCRIPTION	UNIT	UNITS REQ.	UNIT COST	TOT. UNIT COST	LABOR COST	TOTAL COST
12 KV WIRE	MILE	110.7	$ 18,480	$ 2,045,736	$ 122,744	$ 2,168,480
12 KV INSULATORS	EA.	2925	$ 45	$ 131,625	$ 7,898	$ 139,523
12 KV SPACERS	EA.	2925	$ 15	$ 43,875	$ 2,633	$ 46,508
1000 KVA SUBSTATION W/RECT	EA.	19	$ 50,000	$ 950,000	$ 57,000	$ 1,007,000
AUTOMATIC TIE SWITCH	EA.	19	$ 5,000	$ 95,000	$ 5,700	$ 100,700
POWER POLES	EA.	975	$ 3,000	$ 2,925,000	$ 175,500	$ 3,100,500
POWER DISTRIBUTION SYSTEM MAIN LINE	FT.	194832	$ 100	$ 19,483,200	$ 1,168,992	$ 20,652,192
SCADA	EA.	4	$ 10,000	$ 40,000	$ 2,400	$ 42,400
CIRCUIT BRK. AUTO A.C.	EA.	19	$ 40,000	$ 760,000	$ 45,600	$ 805,600
CIRCUIT BRK. AUTO D.C.	EA.	19	$ 50,000	$ 950,000	$ 57,000	$ 1,007,000
				$ -	$ -	$ -
				$ -	$ -	$ -
				$ -	$ -	$ -
		Cost/Mile	$ 1,540,553		Cost Rounded to	$ 29,069,902

MILES	36.9
FEET	194832

Dual Mode Bus Total Facilities Costs

Project Construction Items			
Item Description	Quantity	Per Unit Cost	Cost
Square foot indoor space	788,535.00	$ 105.00	$82,796,175.00
Miscellaneous Equipment and furnishings	Variable	Variable	$1,350,000.00
			$0.00
		Sub total	$84,146,175.00
Mobile Maintenance Equipment			
Guideway double ended truck	2	$ 400,000.00	$800,000.00
Miscellaneous trucks	5	$ 50,000.00	$250,000.00
Toe Trucks	2	$ 100,000.00	$200,000.00
Road Supervision	12	$ 30,000.00	$360,000.00
		Sub total	$1,610,000.00
		Total	$85,756,175.00
Passenger Railcar Fleet	244.00	$ 900,000.00	$219,600,000.00
Automatic Vehicle Location System	244	$ 10,000.00	$2,440,000.00
		Subtotal	$222,040,000.00
		Total	$391,942,350.00

Assumptions

Track length at yards was calculated by taking the aggregate length of the cars required to be able to be stored. 30% was added to the total for non-storage track (only 15% at Vail).

Size of buildings assumed trains will require 35ft width (includes the width of the train and 20 ft.between tracks, per AREMA Standards. Passenger rolling stock does not include paratransit vehicles. The inter urban system is not required to operate ADA complimentary service and the buses are ADA compatible with lifts. However, the feeder bus will be required to offer complimentary service. Those costs

Square foot indoor space represents the sum of three yards: Vail, Frisco, and Denver.

Automatic Vehicle Location System shall include equipment, office space and dispatch costs.

	A	B	C	D
1				
2				
3	**Denver Facility**: Heavy maintenance, cleaning, fueling,			
4	and adminstration.	Quantity	Price	
5	Square Foot Indoor Space	518,400.00	105	$ 54,432,000.00
6	Miscellaneous Equipment and furnishings	1	1000000	$1,000,000.00
7				$0.00
8				$55,432,000.00
9	**Mobile Maintenance Equipment**			
10	Guideway double ended truck	2	$ 400,000.00	$800,000.00
11	Miscellaneous trucks	5	$ 50,000.00	$250,000.00
12	Toe Trucks	2	$ 100,000.00	$200,000.00
13	Road Supervision (mini vans)	12	$ 30,000.00	$360,000.00
14				
15				
16			Total	$57,042,000.00
17	Shop sized to hold 80% of the fleet indoors with a 100% for administrative offices, fueling, and heavy			
18	Indoor space with the length of the Dualmode bus, 60', width 8.5' and 14' lanes			

	A	B	C	D
1				
2				
3	**Frisco Facility** for Inspection, Overhaul, light and heavy maintenance			
4	and cleaning with yard capacity for 40% of the fleet	**Quantity**	**Per Unit Cost**	**Cost**
5	Indoor Square Foot	211,916.25	$ 105.00	$ 22,251,206.25
6	Miscellaneous Equipment and furnishings	1	$ 250,000.00	$ 250,000.00
7				$ -
8			sub total	$ 22,501,206.25
9	**Project Construction Items**			
10	Item Description	**Quantity**	**Per Unit Cost**	**Cost**
11				$ -
12				$ -
13				$ -
14			Total	$ 22,501,206.25
15				
16	An additional 15% was added to the floor space			

	A	B	C	D
1				
2				
3	**Glenwood Facility** for light car maintenance and			
4	cleaning with yard capacity for 10% of the fleet			
5		Quantity	Price	
6	Indoor Square Foot	58,218.75	105	$ 6,112,968.75
7	Miscellaneous Equipment and furnishings	1.00	100000	$ 100,000.00
8				
9			Total	$ 6,212,968.75
10				
11	**Project Construction Items**			
12	Item Description	Quantity	Per Unit Cost	Cost
13				$ -
14			Total	$ 6,212,968.75
15				
16				
17	An additional 15% was added to the floor space			

Station	Ons for peak	Peak Hour	Fare Demand	Round up	Minimum	Total	Location	Total by loc
6th & Laurel	564	141	5	5	0	5	1	
6th & Traver Trail	6	1	0	1	0	1	1	
A-Basin	32	8	0	1	0	1	1	
Arapahoe pnR	7	2	0	1	0	1	1	
Arvada	5	1	0	1	0	1	1	
Cold Springs pnR	542	135	5	5	0	5	1	
Denver Union Sta	3430	858	29	29	0	29	1	
DIA	0	0	0	0	1	1	1	
Jefferson Sta	6333	1583	53	53	0	53	1	
Pena pnR	0	0	0	0	1	1	1	
Westminster NE	6	2	0	1	0	1	1	
Westminster SW	0	0	0	0	1	1	1	100
El Rancho	887	222	7	8	0	8	2	8
Blackhawk	244	61	2	3	0	3	3	
Central City	24	6	0	1	0	1	3	
Empire	362	91	3	4	0	4	3	
US 6 / Gaming	220	55	2	2	0	2	3	10
Idaho Springs	148	37	1	2	0	2	4	
Johnson Park	151	38	1	2	0	2	4	
Keystone	339	85	3	3	0	3	4	
Mineral Sta	6	2	0	1	0	1	4	
Winter Park	528	132	4	5	0	5	4	13
Georgetown	61	15	1	1	0	1	5	
Loveland Ski	77	19	1	1	0	1	5	
Avon	661	165	6	6	0	6	5	
Bell Tower	29	7	0	1	0	1	5	
CO 9 & French	7	2	0	1	0	1	5	
CO 9 & Watson	919	230	8	8	0	8	5	
Copper Circle	0	0	0	0	1	1	5	
Copper Entrance	0	0	0	0	1	1	5	
Frisco TC	1857	464	15	16	0	16	5	
Silverthorne	1747	437	15	15	0	15	5	
Silverthorne	907	227	8	8	0	8	5	59
Vail TC	583	146	5	5	0	5	6	5
Dotsero	44	11	0	1	0	1	7	
Eagle	128	32	1	2	0	2	7	
Eagle & I-70	326	81	3	3	0	3	7	
Edwards	846	211	7	8	0	8	7	
EGE East	175	44	1	2	0	2	7	
EGE West	10	2	0	1	0	1	7	
Glenwood Springs	1	0	0	1	0	1	7	
Gypsum	122	31	1	2	0	2	7	
Gypsum & I-70	4	1	0	1	0	1	7	
W Glenwood Mall	1	0	0	1	0	1	7	
Ward Road	110	27	1	1	0	1	7	
Wolcott	51	13	0	1	0	1	7	24
					total	219		219

Fare Machine
2

Assumptions

20% have purchase tickets prior at Idaho Springs, Frisco, Jefferson, and Vail
10% have purchased tickets prior at stops west of Vail.

Location		Ons/Offs
Jefferson	Route 1	1143.47
Jefferson	Route 2	2460.278
Jefferson	Route 3	2594.767
West Cont	Route 4	4705.464
Jefferson	Route 5	0
West Vail	Route 6	8376.785
West Cont	Route 7	3297.93

2025 Winter Saturday
Dual Mode Bus in Guideway; No IMC
10 cents per mile
3-7.5 minute peak headways
3-12 minute off-peak headways

AM is 6 AM to 10 AM
Noon is 10 AM to 3 PM
PM is 3 PM to 7 PM
Night is 7 PM to 6 AM

Mountain Bus 1W Eastbound: Central City - Westminster

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Central City	24	-	36	-	64	-	57	-	181	-
Blackhawk	234	10	413	6	694	11	648	6	1,988	34
US 6/Gaming	1	42	1	45	1	83	1	46	4	216
El Rancho	41	52	54	65	56	117	49	72	200	307
Jefferson Sta	3	165	3	331	2	488	2	525	9	1,510
Ward Road	-	22	-	45	-	109	-	99	-	276
Arvada	-	5	-	6	-	4	-	4	-	19
Westminster SW	-	-	-	-	-	-	-	-	-	-
Westminster NE	-	6	-	6	-	5	-	3	-	21
Line Totals	303	303	506	506	817	817	756	756	2,382	2,382

Mountain Bus 1W Westbound: Westminster - Central City

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Westminster NE	4	-	6	-	4	-	4	-	18	-
Westminster SW	-	-	-	-	-	-	-	-	-	-
Arvada	2	-	6	-	6	-	6	-	20	-
Ward Road	122	-	63	-	62	-	78	-	325	-
Jefferson Sta	382	1	278	2	242	2	282	3	1,185	8
El Rancho	147	31	90	35	74	46	70	30	381	143
US 6/Gaming	173	1	137	1	103	1	134	1	547	3
Blackhawk	11	741	6	505	11	413	6	503	34	2,162
Central City	-	67	-	44	-	40	-	43	-	195
Line Totals	841	841	587	587	502	502	580	580	2,510	2,510

Mountain Bus 1W, Both Directions

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Central City	24	67	36	44	64	40	57	43	181	195
Blackhawk	244	751	419	511	705	424	654	509	2,022	2,195
US 6/Gaming	174	42	138	46	104	84	134	47	551	219
El Rancho	188	83	144	101	130	163	119	103	581	450
Jefferson Sta	385	166	281	334	244	490	284	528	1,194	1,518
Ward Road	122	22	63	45	62	109	78	99	325	276
Arvada	2	5	6	6	6	4	6	4	20	19
Westminster SW	-	-	-	-	-	-	-	-	-	-
Westminster NE	4	6	6	6	4	5	4	3	18	21
Line Totals	1,143	1,143	1,093	1,093	1,319	1,319	1,336	1,336	4,892	4,892

Mountain Bus 2T Eastbound: Winter Park - Denver Tech Center

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Winter Park	528	-	914	-	1,386	-	754	-	3,582	-
Empire	4	58	7	41	8	57	8	39	27	194
El Rancho	44	4	59	6	57	9	53	7	212	26
Jefferson Sta	6	506	7	922	3	1,380	4	762	20	3,570
Mineral Sta	-	5	-	5	-	3	-	3	-	17
Arapahoe pnR	-	9	-	13	-	5	-	9	-	36
Line Totals	582	582	987	987	1,454	1,454	819	819	3,842	3,842

2025 Winter Saturday

Dual Mode Bus in Guideway; No IMC
10 cents per mile
3-7.5 minute peak headways
3-12 minute off-peak headways

Mountain Bus 2T Westbound: Denver Tech Center - Winter Park

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Arapahoe pnR	3	-	12	-	8	-	14	-	36	-
Mineral Sta	3	-	5	-	5	-	5	-	18	-
Jefferson Sta	1,327	1	767	6	474	4	408	7	2,976	17
El Rancho	279	32	36	41	102	50	31	37	448	161
Empire	268	6	250	5	95	5	133	3	745	19
Winter Park	-	1,839	-	1,018	-	625	-	544	-	4,025
Line Totals	1,879	1,879	1,069	1,069	684	684	590	590	4,223	4,223

Mountain Bus 2T, Both Directions

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Winter Park	528	1,839	914	1,018	1,386	625	754	544	3,582	4,025
Empire	272	64	257	46	102	62	140	42	772	213
El Rancho	322	36	95	47	159	59	84	44	660	186
Jefferson Sta	1,332	507	774	928	478	1,384	412	768	2,996	3,587
Mineral Sta	3	5	5	5	5	3	5	3	18	17
Arapahoe pnR	3	9	12	13	8	5	14	9	36	36
Line Totals	2,460	2,460	2,056	2,056	2,138	2,138	1,410	1,410	8,064	8,064

Mountain Bus 3T Eastbound: Arapahoe Basin - Denver Tech Center

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
A-Basin	32	-	157	-	377	-	187	-	752	-
Keystone	338	0	729	1	1,546	1	735	1	3,348	3
Silverthorne	45	139	55	175	73	202	59	162	233	678
Loveland Ski	22	14	54	7	278	5	63	5	419	31
Georgetown	15	5	34	8	41	10	41	7	131	30
Idaho Springs	37	5	86	8	108	11	105	8	337	31
El Rancho	44	5	59	9	57	16	53	11	212	41
Jefferson Sta	6	358	7	954	3	2,232	4	1,042	20	4,585
Mineral Sta	-	5	-	6	-	4	-	3	-	18
Arapahoe pnR	-	9	-	14	-	5	-	9	-	37
Line Totals	540	540	1,181	1,181	2,483	2,483	1,248	1,248	5,453	5,453

Mountain Bus 3T Westbound: Denver Tech Center - Arapahoe Basin

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Arapahoe pnR	3	-	12	-	8	-	14	-	37	-
Mineral Sta	3	-	6	-	5	-	5	-	19	-
Jefferson Sta	1,919	1	641	5	414	3	401	6	3,375	15
El Rancho	76	32	43	41	16	50	28	37	163	159
Idaho Springs	37	78	43	58	35	60	19	39	134	235
Georgetown	8	33	7	24	6	22	6	16	27	96
Loveland Ski	2	271	7	70	13	36	7	44	29	421
Silverthorne	545	60	422	43	226	40	290	32	1,483	175
Keystone	1	1,680	2	799	2	455	1	507	6	3,441
A-Basin	-	439	-	142	-	59	-	88	-	729
Line Totals	2,595	2,595	1,183	1,183	725	725	769	769	5,272	5,272

2025 Winter Saturday
Dual Mode Bus in Guideway; No IMC
10 cents per mile

3-7.5 minute peak headways
3-12 minute off-peak headways

Mountain Bus 3T, Both Directions

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
A-Basin	32	439	157	142	377	59	187	88	752	729
Keystone	339	1,680	731	800	1,547	456	736	508	3,354	3,444
Silverthorne	590	198	477	218	299	242	349	194	1,716	853
Loveland Ski	25	285	61	78	291	40	70	49	447	452
Georgetown	23	39	42	32	47	32	47	24	158	125
Idaho Springs	75	83	129	66	144	71	124	47	471	266
El Rancho	120	37	102	50	73	65	81	48	375	200
Jefferson Sta	1,925	359	648	959	417	2,235	405	1,048	3,395	4,600
Mineral Sta	3	5	6	6	5	4	5	3	19	18
Arapahoe pnR	3	9	12	14	8	5	14	9	37	37
Line Totals	3,135	3,135	2,364	2,364	3,208	3,208	2,017	2,017	10,724	10,724

Mountain Bus 4W Eastbound: Breckenridge - Westminster

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Bell Tower	29	-	164	-	108	-	156	-	458	
CO 9 & French	7	-	16	-	22	-	20	-	65	-
CO 9 & Watson	919	-	1,099	-	2,304	-	1,018	-	5,339	-
Frisco TC	248	451	271	370	401	629	268	367	1,188	1,817
Silverthorne	40	310	89	505	63	984	104	550	296	2,349
Loveland Ski	21	21	127	15	276	10	154	11	578	58
El Rancho	41	30	54	17	56	16	49	16	200	79
Jefferson Sta	3	487	3	905	2	1,585	2	821	9	3,797
Ward Road	-	1	-	1	-	0	-	0	-	2
Arvada	-	5	-	5	-	3	-	3	-	16
Westminster SW	-	-	-	-	-	-	-	-	-	-
Westminster NE	-	6	-	5	-	3	-	2		16
Line Totals	1,309	1,309	1,822	1,822	3,232	3,232	1,771	1,771	8,133	8,133

Mountain Bus 4W Westbound: Westminster - Breckenridge

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Westminster NE	3	-	4	-	4	-	3	-	14	
Westminster SW	-	-	-	-	-	-	-	-	-	-
Arvada	2	-	5	-	5	-	5	-	17	-
Ward Road	0	-	0	-	0	-	0	-	1	-
Jefferson Sta	1,520	1	508	2	496	2	279	2	2,804	7
El Rancho	16	31	11	35	10	46	8	30	45	142
Loveland Ski	4	270	12	68	19	34	10	43	45	415
Silverthorne	867	49	537	34	345	32	406	25	2,155	139
Frisco TC	985	428	689	319	550	282	509	215	2,732	1,244
CO 9 & Watson	-	2,514	-	1,209	-	985	-	837	-	5,545
CO 9 & French	-	30	-	23	-	13	-	16	-	82
Bell Tower	-	75	-	76	-	35	-	52		238
Line Totals	3,397	3,397	1,765	1,765	1,429	1,429	1,221	1,221	7,812	7,812

2025 Winter Saturday
Dual Mode Bus in Guideway; No IMC
10 cents per mile
3-7.5 minute peak headways
3-12 minute off-peak headways

Mountain Bus 4W, Both Directions

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Bell Tower	29	75	164	76	108	35	156	52	458	238
CO 9 & French	7	30	16	23	22	13	20	16	65	82
CO 9 & Watson	919	2,514	1,099	1,209	2,304	985	1,018	837	5,339	5,545
Frisco TC	1,233	878	959	689	951	912	776	582	3,919	3,061
Silverthorne	907	358	625	539	408	1,016	510	574	2,451	2,488
Loveland Ski	25	292	139	83	295	45	164	54	623	473
El Rancho	57	60	64	52	66	62	57	46	244	220
Jefferson Sta	1,523	487	511	907	497	1,586	281	824	2,813	3,804
Ward Road	0	1	0	1	0	0	0	0	1	2
Arvada	2	5	5	5	5	3	5	3	17	16
Westminster SW	-	-	-	-	-	-	-	-	-	-
Westminster NE	3	6	4	5	4	3	3	2	14	16
Line Totals	4,705	4,705	3,587	3,587	4,661	4,661	2,991	2,991	15,945	15,945

Mountain Bus 5D Eastbound: Vail - Denver International Airport

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Vail TC									-	
Copper Entrance									-	-
Copper Circle									-	-
Copper Entrance	-	-	-	-	-	-	-	-	-	-
Frisco TC									-	-
El Rancho									-	-
Jefferson Sta									-	-
Stapleton TC	-	-	-	-	-	-	-	-	-	-
Pena pnR	-	-	-	-	-	-	-	-	-	-
DIA										-
Line Totals	-	-	-	-	-	-	-	-	-	-

Mountain Bus 5D Westbound: Denver International Airport - Vail

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
DIA									-	
Pena pnR	-	-	-	-	-	-	-	-	-	-
Stapleton TC	-	-	-	-	-	-	-	-	-	-
Jefferson Sta									-	-
El Rancho									-	-
Frisco TC									-	-
Copper Entrance									-	-
Copper Circle									-	-
Copper Entrance	-	-	-	-	-	-	-	-	-	-
Vail TC										-
Line Totals	-	-	-	-	-	-	-	-	-	-

2025 Winter Saturday
Dual Mode Bus in Guideway; No IMC
10 cents per mile
3-7.5 minute peak headways
3-12 minute off-peak headways

Mountain Bus 5D, Both Directions

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Vail TC	-	-	-	-	-	-	-	-	-	-
Copper Entrance	-	-	-	-	-	-	-	-	-	-
Copper Circle	-	-	-	-	-	-	-	-	-	-
Copper Entrance	-	-	-	-	-	-	-	-	-	-
Frisco TC	-	-	-	-	-	-	-	-	-	-
El Rancho	-	-	-	-	-	-	-	-	-	-

Jefferson Sta	-	-	-	-	-	-	-	-	-	-
Stapleton TC	-	-	-	-	-	-	-	-	-	-
Pena pnR	-	-	-	-	-	-	-	-	-	-
DIA	-	-	-	-	-	-	-	-	-	-
Line Totals	-	-	-	-	-	-	-	-	-	-

Note: - indicates no stop assumed at this location; line is retained for spreadsheet structure
- indicates no stop was coded at this location during this run

Mountain Bus 6U Eastbound: West Glenwood Springs - Denver Union Station

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
W Glenwood Mall	-	-	-	-	-	-	-	-	-	
Johnson Park	151	-	111	-	137	-	103	-	502	-
6th & Traver Trail	6	-	18	-	21	-	23	-	67	-
6th & Laurel	564	-	572	-	672	-	335	-	2,145	-
Glenwood Springs	1	-	2	4	2	-	2	4	7	8
Dotsero	6	2	8	5	7	7	7	5	28	18
Gypsum & I-70	2	0	2	1	2	2	2	1	9	4
Gypsum	50	11	56	32	38	80	55	40	200	163
EGE West	10	0	21	1	8	0	10	1	50	2
EGE East	125	46	103	62	97	70	66	52	392	230
Eagle	62	44	31	37	37	76	20	40	150	196
Eagle & I-70	241	43	210	73	99	126	87	79	636	321
Wolcott	36	11	49	13	32	15	23	8	140	47
Edwards	734	167	609	117	512	196	360	117	2,215	597
Avon	420	270	340	226	273	271	179	208	1,211	975
Vail TC	549	193	517	190	511	147	291	150	1,869	680
Frisco TC	74	687	254	411	425	531	279	356	1,032	1,984
El Rancho	83	39	138	33	110	48	133	27	464	148
Jefferson Sta	230	673	532	151	770	633	510	75	2,042	1,531
Cold Springs pnR	1	113	3	339	3	240	4	266	11	958
Denver Union Sta	-	1,048	-	1,881	-	1,315	-	1,062		5,306
Line Totals	3,347	3,347	3,575	3,575	3,757	3,757	2,489	2,489	13,168	13,168

2025 Winter Saturday
Dual Mode Bus in Guideway; No IMC
10 cents per mile
3-7.5 minute peak headways
3-12 minute off-peak headways

Mountain Bus 6U Westbound: Denver Union Station - West Glenwood Springs

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Denver Union Sta	2,173	-	1,962	-	1,136	-	981	-	6,251	
Cold Springs pnR	282	0	216	0	158	0	146	0	802	0
Jefferson Sta	784	230	528	443	547	89	230	300	2,089	1,062
El Rancho	18	386	10	235	14	209	6	195	48	1,025
Frisco TC	722	1,038	556	507	787	231	455	287	2,521	2,063
Vail TC	181	775	219	530	196	623	206	300	802	2,228
Avon	241	383	187	443	209	358	142	245	780	1,428
Edwards	206	681	116	642	177	651	113	391	612	2,365
Wolcott	21	33	14	44	13	24	8	17	56	118
Eagle & I-70	121	181	67	230	48	242	56	125	294	779
Eagle	80	20	30	30	31	49	23	29	163	129
EGE East	70	74	77	97	47	85	40	70	235	327
EGE West	1	17	4	25	4	14	4	11	13	67
Gypsum	86	30	33	42	16	53	24	41	159	167
Gypsum & I-70	2	2	1	2	1	2	1	2	4	8
Dotsero	43	6	16	8	27	7	11	6	97	27

Glenwood Springs	-	2	-	3	-	2	-	2	-	9
6th & Laurel	-	987	-	626	-	611	-	315	-	2,538
6th & Traver Trail	-	22	-	20	-	10	-	14	-	66
Johnson Park	-	162	-	109	-	150	-	96	-	517
W Glenwood Mall	-	-	-	-	-	-	-	-		-
Line Totals	5,030	5,030	4,035	4,035	3,412	3,412	2,448	2,448	14,925	14,925

Mountain Bus 6U, Both Directions

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
W Glenwood Mall	-	-	-	-	-	-	-	-	-	-
Johnson Park	151	162	111	109	137	150	103	96	502	517
6th & Traver Trail	6	22	18	20	21	10	23	14	67	66
6th & Laurel	564	987	572	626	672	611	335	315	2,145	2,538
Glenwood Springs	1	2	2	7	2	2	2	6	7	17
Dotsero	49	8	23	12	34	14	18	11	124	45
Gypsum & I-70	4	2	3	3	3	4	3	3	13	13
Gypsum	136	41	89	74	54	133	79	81	359	330
EGE West	11	17	25	26	12	14	15	12	62	69
EGE East	195	120	180	159	145	155	107	122	626	557
Eagle	142	64	61	67	67	125	43	69	313	324
Eagle & I-70	362	224	277	303	147	369	143	204	929	1,100
Wolcott	57	43	63	57	46	39	31	25	196	164
Edwards	940	849	725	759	689	847	473	508	2,827	2,962
Avon	661	653	527	669	482	629	321	453	1,992	2,403
Vail TC	729	969	736	721	708	770	497	449	2,670	2,908
Frisco TC	797	1,724	810	918	1,212	762	734	643	3,553	4,047
El Rancho	101	425	148	268	124	258	139	222	512	1,173
Jefferson Sta	1,014	903	1,059	594	1,317	722	740	375	4,131	2,594
Cold Springs pnR	283	113	219	339	161	240	149	266	812	959
Denver Union Sta	2,173	1,048	1,962	1,881	1,136	1,315	981	1,062	6,251	5,306
Line Totals	8,377	8,377	7,611	7,610	7,169	7,169	4,936	4,937	28,092	28,093

2025 Winter Saturday
Dual Mode Bus in Guideway; No IMC
10 cents per mile
3-7.5 minute peak headways
3-12 minute off-peak headways

Mountain Bus 7U Eastbound: Frisco - Denver Union Station Local

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Frisco TC	291	-	452	-	650	-	462	-	1,854	
Silverthorne TC	58	194	111	174	90	193	126	160	385	721
Loveland Ski	24	18	132	9	282	5	158	6	596	39
Georgetown	26	6	70	10	54	12	81	10	231	37
Empire	17	18	23	20	19	32	22	21	81	91
Idaho Springs	73	10	170	16	133	19	200	15	576	60
US 6 / Gaming	1	63	1	43	1	52	1	38	4	196
El Rancho	83	5	138	9	110	15	133	11	464	39
Jefferson Sta	230	111	532	65	770	488	510	74	2,042	739
Cold Springs pnR	1	69	3	287	3	257	4	332	12	945
Denver Union Sta	-	309	-	1,001	-	1,039	-	1,030		3,379
Line Totals	804	804	1,634	1,634	2,111	2,111	1,698	1,698	6,246	6,246

Mountain Bus 7U Westbound: Denver Union Station - Frisco Local

Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Denver Union Sta	1,257	-	1,448	-	365	-	917	-	3,987	
Cold Springs pnR	258	0	227	0	122	0	174	0	780	0

Jefferson Sta	625	3	264	27	211	10	174	33	1,274	73
El Rancho	15	93	10	185	8	136	7	157	40	571
US 6 / Gaming	44	85	43	92	64	51	39	97	189	325
Idaho Springs	17	127	16	248	15	123	13	169	62	666
Empire	73	266	50	267	62	100	43	143	227	776
Georgetown	12	56	11	98	9	43	8	67	40	264
Loveland Ski	3	424	9	178	17	56	9	112	39	769
Silverthorne TC	192	383	197	452	174	109	154	291	717	1,236
Frisco TC	-	1,056	-	729	-	421	-	469	-	2,675
Line Totals	2,494	2,494	2,275	2,275	1,049	1,049	1,538	1,538	7,355	7,355

Mountain Bus 7U, Both Directions

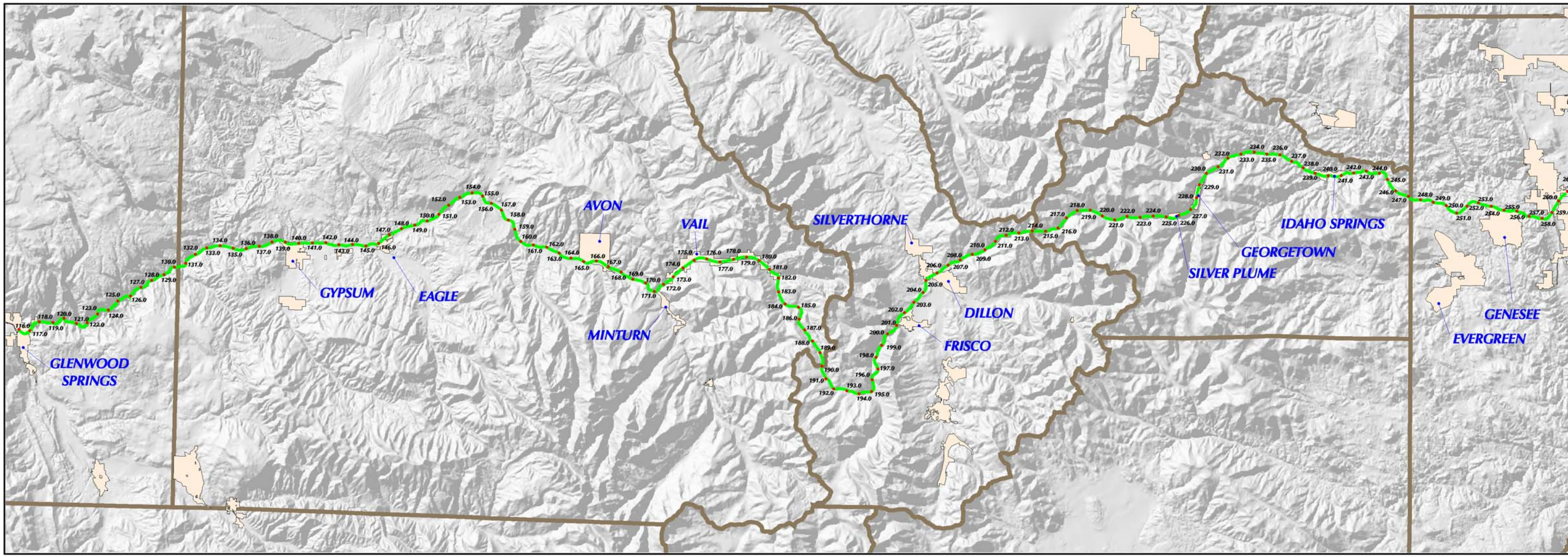
Station	AM Ons	AM Offs	Noon Ons	Noon Offs	PM Ons	PM Offs	Night Ons	Night Offs	Daily Ons	Daily Offs
Frisco TC	291	1,056	452	729	650	421	462	469	1,854	2,675
Silverthorne TC	250	577	309	626	264	302	280	451	1,102	1,956
Loveland Ski	27	442	142	187	299	61	167	118	635	808
Georgetown	38	62	81	108	63	55	90	77	272	302
Empire	90	284	73	287	80	132	65	164	308	867
Idaho Springs	90	137	187	263	148	142	213	184	638	726
US 6 / Gaming	45	149	44	135	65	103	40	135	193	521
El Rancho	98	97	148	194	118	151	140	168	504	610
Jefferson Sta	855	115	795	91	982	498	684	108	3,316	812
Cold Springs pnR	259	69	230	287	125	257	178	332	792	945
Denver Union Sta	1,257	309	1,448	1,001	365	1,039	917	1,030	3,987	3,379
Line Totals	3,298	3,298	3,908	3,909	3,159	3,160	3,235	3,235	13,601	13,601

Transfers at Jefferson Station

AM Peak Period		Noon Period		PM Peak Period		Night Period		Daily	
EB Ons	WB Offs	EB Ons	WB Offs	EB Ons	WB Offs	EB Ons	WB Offs	EB Ons	WB Offs
478	237	1,082	485	1,550	109	1,031	352	4,142	1,184
	237		485		109		352		1,184

Appendix F
Colorado Department of Transportation
I-70 Mountain Corridor PEIS Level 2 Screening
Alternatives Comparison
March 2001

This page intentionally left blank.



D R A F T

I-70 Mountain Corridor PEIS
Level 2 Screening
Alternatives Comparison

March 21, 2001

TABLE OF CONTENTS

1 - STEPS OF LEVEL 2 SCREENING

Steps in Level 2 Screening

Background

This document provides an explanation of the Level 2 Screening Process and initial findings. This effort follows the initial level of screening, where alternatives were screened if they did not provide any potential to meaningfully reduce congestion of improve mobility in the I-70 Mountain Corridor. Criteria for Level 2 Screening have been developed in response to the comments from Public Scoping and direction from the Federal Highway Administration (FHWA), the Colorado Department of Transportation (CDOT), the Environmental Protection Agency (EPA), the U. S. Army Corps of Engineers (COE), the Technical Advisory Committee (TAC), and the Mountain Corridor Advisory Committee (MCAC).

Alternatives have been organized in response to the I-70 Mountain Corridor Major Investment Study (MIS) Vision. “Families” of alternatives include Fixed Guideway Transit (FGT), Rubber Tire Transit (RTT), Highway and Interchange Elements, Transportation System Management (TSM), Aviation, and Alternate Routes. The purpose of “screening” is to select options within the Families of alternatives that best meet the purpose and need for the project. Need–related criteria address factors related to congestion, capacity and mobility. Criteria related to project purposes include safety, implementation (cost, technology, contractibility, and energy requirements), environmental sensitivity and community values.

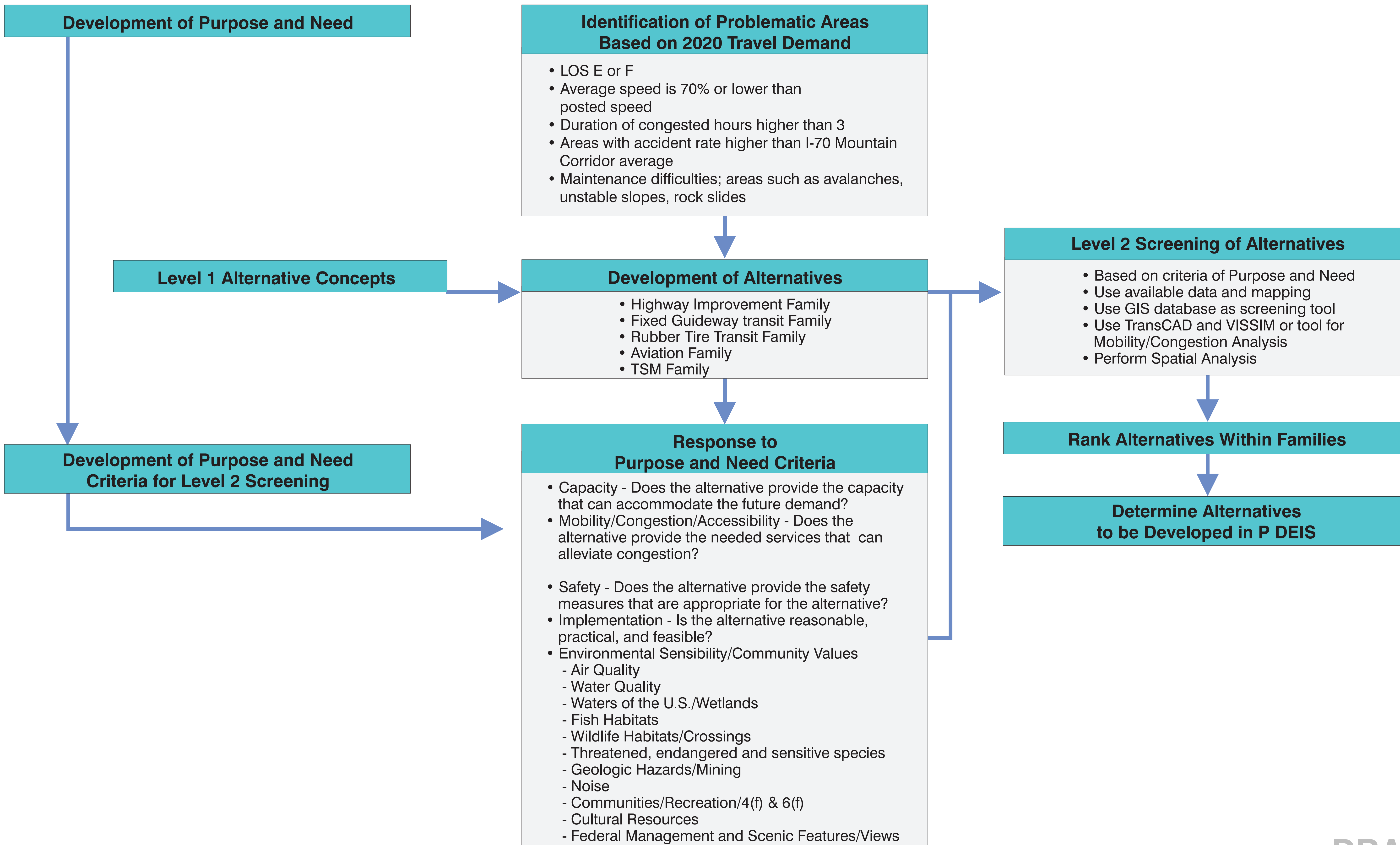
With the exception of Alternate Routes, each of the Families of alternatives will be carried into the Draft PEIS. Alternatives in the Draft PEIS will be organized into “packages” of transportation modes that will include options that represent each of the Families of alternatives. Environmental studies of the intermodal packages of alternatives will include impact assessments of direct, indirect and cumulative impacts, as well as mitigation planning.

Document Organization

This document provides initial findings for each of the alternatives under study, and is intented to facilitate discussions for the TAC and MCAC meetings on March 19 and 21. The process is described on the following diagram. This document is organized into the following sections, (please refer to the table of contents) including:

- Screening Criteria
- FGT Alternatives
- RTT Alternatives
- Highway Alternatives
- TSM Alternatives
- Aviation
- Summary of Environmental Screening Analysis

I-70 PEIS Steps and Flow Chart of Level 2 Screening



2 - SCREENING CRITERIA

	Criteria	Assumptions	Highest	Highest to Intermediate	Intermediate	Intermediate to Lowest	Lowest
NEED	**System Capacity**	System capacity is based on conceptual ridership plans. The range is from an inability to provide seats for all passengers in peak direction during peak hours in opening year to an ability to provide seats for all peak hour passengers in peak direction forecast for year 20.	Significantly exceeds year 2020 demand	Somewhat exceeds year 2020 demand	Accommodates year 2020 demand.	Provides seats for opening year demand but not year 2020 demand.	Does not provide seats for all passengers in peak direction during peak hours in opening year demand.
	System Attractiveness	The relative attributes of the system technology to attract ridership based on the amenities and ride quality, including curvature, noise, food service, baggage handling, and susceptibility to weather conditions.	Vehicles in a guideway have higher ride quality, due to lower curvature, and quiet electric motors. Vehicles with food service, not as susceptible to weather conditions and full baggage handling.				Low ride quality is based on vehicles on the roadway in mixed traffic, greater curvature in the route, and high interior noise from power type and operations. Low amenities include vehicles with no food service, trip highly susceptible to weather and no baggage handling.
	Average Speed	Average Speed in mph including stops/dwell for 10 stops - time based on Vail to C-470 or Golden trip times.	> 60 mph	50 to 60 mph	40 to 50 mph	30 to 40 mph	<30 mph
	Connectivity	Connectivity in number of transfers required between modes. The "ideal" is origin to destination with no transfer between transit vehicles at either of the Mountain Corridor journey.	No transfer required at either end (no transfer).		Transfer required at one end (1 transfer)		Transfers required at both ends (2 or more connections)
	Feeder/Distributor Requirements	Feeder/Distributor Requirements in percent change in vehicle miles from that presently used for local transit services in the Corridor.	Feeder systems in existence or no feeder system needed. Minimal change in local transit services required in the corridor. Utilizes these existing feeder systems as their network.		Feeder systems in existence. Moderate change in local transit services required in the corridor.		New feeder systems required. Significant change in local transit services required in the corridor.
SAFETY	**Safety System**	System Safety - Measures relative safety of the transit alternative considering the relative potential for crashes.	Heavy weight (FRA compliant) rail vehicles on new alignment	Middleweight rail vehicles on new alignment	Use of buses with prof. drivers only on guided transitway. Lightest weight rail vehicles on new alignment.	Use of buses with professional drivers only on transitway.	Mixed traffic, including vans (with lightweight construction).
IMPLEMENTATION	**Initial Infrastructure Cost**	Including associated highway improvements over a 50 year period.	<$10M/mile	$10-15M/mile	$15-20M/mile	$20-25M/mile	>$25M/mile
	Technology Availability	Criteria range from technologies that are currently available to operate within the corridor to technologies that are currently in the developmental or research stage. The range in between covers any modifications required to existing technologies for operation in the corridor. An additional factor relates to the percent grade that given technologies are capable of operating within.	System is able to operate in the corridor without modifications.		Technology exists but requires modifications.		System is in the research and development stage.
	Fuel Availability	Identifies whether linehaul mode uses petroleum-based fuel (with its currently available supply and established production and distribution system), or has a heavy use of electricity, (which is presently dependent on relatively limited production and generation capabilities and the potential difficulty/expense in providing needed additional capacity.)	Uses existing facilities	Uses existing facilities with some modifications	Uses some existing facilities and some new infrastructure	Uses mostly new infrastructure	Uses all new infrastructure.
	Fuel Limitations	Federal Policy dictate that transit systems minimize the use of non-renewable fuel sources. This criteria measure whether the proposed system is capable of using non-renewable fuels.	Uses multiple, renewable fuel resources	Uses renewable fuel resources,	Uses a combination of non-renewable and renewable fuel resources	Uses mostly non-renewable fuel resources,	Uses only non-renewable fuel resources (fossil fuels).
	Energy Consumption	Relative rating based on system power requirements. Diesel fuel is assumed at $1.60/gal. Electrical energy is assumed at $0.10/kWH.	<$0.01/seat-mile	$0.01-0.05/seat-mile	$0.05-0.10/seat-mile	$0.10-0.15/seat-mile	>$0.15/seat-mile

	Criteria	Assumptions	Highest	Highest to Intermediate	Intermediate	Intermediate to Lowest	Lowest
NEED	**System Capacity**	Measured as the ratio between the traffic volume as projected by TransCAD Model and the capacity of highway as the result of proposed action at various sections of I-70. The capacity of highway is determined by the grade, width of lane and shoulders, horizontal and vertical curvatures, and other roadway features as specified in the Highway Capacity Manual (HCM).	LOS A (0.29 and below) LOS B (0.29 - 0.43)	LOS C (0.44 - 0.65)	LOS D (0.66 - 0.84)	LOS E (0.85 - 1.00)	LOS F (Above 1.00)
NEED	**Speed**	Speed in mph is calculated using the software VISSIM. VISSIM can determine the average speed of vehicles based on the travel demand from forecast model and the roadway features.	100% or above free flow speed	85 - 99% of free flow speed	68 - 84% of free flow speed	50 - 68% of free flow speed	50% or less than free flow speed
NEED	**Duration of Congested Hours**	Duration of Congested Hours is calculated as the length of time at a section of I-70 where the LOS of that section is continuously E or F.	0 hours of continuous LOS E or F	0 - 1 hour of continuous LOS E or F	1 - 2 hours of continuous LOS E or F	2 - 4 hours of continuous LOS E or F	Above 4 hours of continuous LOS E or F
SAFTEY	**Safety System**	Safety criteria relate to the evaluation of potential improvements in safety which might result from changes in the highway cross-section and potential changes in the alignment of I-70. Safety improvement results in an estimate of accident reduction rates attributed to widening the highway from four to six lanes. Further accident reduction rates would result from providing wider shoulders and various median treatments.	Reduction of accident 40% and higher	Reduction of accident 25 - 39%	Reduction of accident 20 - 25%	Reduction of accident 10 - 19%	Reduction of accident 0 - 9%
IMPLEMENTATION	**Initial Infrastructure Costs**	Cost is based upon an initial study of the estimated capital construction cost for the alternative (average $million/mile basis, including lane widening, tunnel capacity improvements & structured lanes). The environmental mitigation cost is not included in this estimate.	Less than $15 million/mile	$15 - 20 million/mile	$20 - 25 million/mile	$25 - 30 million/mile	Above $30 million/mile Costs for alternative - 160 million/mile
IMPLEMENTATION	**Constructability**	Measures relate to the difficulty of constructing the alternatives, based on professional judgment and past construction experience. Constructibility measures include the amount of construction detours required, length of construction duration, need for special construction equipment, disposal of waste materials, acquisition of construction materials and labor, obtaining special construction material (availability) from manufacturers, special construction procedures prohibited by adverse weather conditions, construction workers' physical condition due to a high altitude work site, and many other construction related issues.	Least difficult		Moderately difficult		Most difficult

RESOURCES		CONFLICT CRITERIA[1]	ASSUMPTIONS	APPLICABLE FEDERAL, STATE REGULATIONS[2]	MIS & RELATED ISSUES FROM PUBLIC SCOPING & AGENCY COMMENTS
Air Quality		Potential for conflict is based on the change in COx, NOx, or PM10 in tons/day relative to current (baseline) conditions. The relative change in mobile emissions and particulate matter for each highway alternative, will be determined through change in average daily traffic relative to the baseline calculations.	1. The relative change in tons/day of COx, NOx, and PM10 is directly related to the average daily traffic. The evaluation for highway alternatives will be to examine the change in traffic volumes for each alternative and use this number to determine mobile emissions and particulate matter. These values will be compared to the baseline conditions by calculating COx, NOx, and PM10 using traffic volumes from the year 2000. 2. Calculations will use traffic counts from 2000 at the Twin Tunnels and model projections fro the highway segments between Idaho Springs and Empire. 3. The difference between the no action alternative for 2020 and the action alternatives for 2020 is most useful when compared to the year 2000 baseline. 4. The percentage of SUV, automobiles and trucks is consistent throughout this segment of highway. 5. The air quality quantitative analysis will be refined in the Draft PEIS and will consider additional factors as well as evaluate impacts due to multi-modal combinations of alternatives.	NAAQS are currently not exceeded in the study area (except Jefferson County) therefore most of the area is an attainment area. There is not sufficient air quality monitoring the 5 counties along I-70 to provide a baseline for analysis (there are no monitoring stations in Clear Creek County and incomplete monitoring data from stations further west). The team is developing baseline mobile emissions based on the travel demand model and is working closely with the CDPHE and the EPA to create a customized approach that considers topography, weather, and travel characteristics for air quality modeling during the Draft PEIS.	Identified by EPA and in the Clear Creek County Survey.
Geological Hazards	Rockfall	Potential for conflict is based on adverse impacts on existing rockfall hazards. An adverse impact would result if increased potential for rockfall hazard to effect safety, service, and mobility of the transportation facility.	1. Rock fall hazard delineated from aerial photo interpretation and published data. 2. Cursory field observations performed to verify presence/absence. 3. Mitigation methods may provide only partial protection.	———	Identified in the Clear Creek County Survey and by the Colorado Geological Survey.
	Debris / Mudflow	Potential for conflict is based on adverse impacts on existing debris/mudflow hazards. An adverse impact would result if increased potential for existing debris/mudflow hazard affected safety, service, and mobility of the transportation facility. Decease in depositional zone at base of debris fan leads to increased potential for sedimentation of waterways/wetlands.	1. Debris/mudflow hazard delineated from aerial photo interpretation and published data. 2. Cursory field observations performed to verify presence/absence. 3. Mitigation methods may provide only partial protection.	———	Identified in the Clear Creek County Survey and by the Colorado Geological Survey.
	Landslide	Potential for conflict is based on adverse impacts on existing landslide hazards. An adverse impact would result if increased potential for existing landslide affected safety, service, and mobility of the transportation facility. Disturbance near toe/base of existing landslide will increase potential for future and continued movement.	1. Debris/mudflow hazard delineated from aerial photo interpretation and published data. 2. Cursory field observations performed to verify presence/absence. 3. Mitigation methods may provide only partial protection.	———	Identified in the Clear Creek County Survey and by the Colorado Geological Survey.
	Avalanche	Potential for conflict is based on adverse impact on existing avalanche hazards. An adverse impact would result if increased potential for existing avalanche affected safety, service, and mobility of the transportation facility. Decease in depositional zone at base of avalanche zone leads to increased potential for conflict.	1. Avalanche hazard delineated from aerial photo interpretation and published data. 2. Cursory field observations performed to verify presence/absence. 3. Mitigation methods may provide only partially effective. 4. Many avalanche hazards cannot be mitigated, and potential impacts may include loss of forested areas and substantial increase in erosion.	———	Identified in the Clear Creek County Survey and by the Colorado Geological Survey.
Water Quality	Mine Waste	Potential for conflict is based on disturbance of existing mine waste. Disturbance to contaminated mine waste must be handled in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980, Superfund Amendments and Reauthorization Act of 1986, Resource Conservation and Recovery Act of 1976, and subsequent amendments in 1984. These documents specify requirements for hazardous materials treatment, storage, transportation, cleanup, industry disclosure, and liability.	1. Mine waste delineated from aerial photo interpretation and published data. 2. Some of the mine waste sites in the Idaho Springs area have been classified as Superfund sites. Precise impacts to these sites and other mine waste sites will not be performed in Level 2 screening. 3. No field observations performed to verify presence/absence. 4. Ranking based on presence/absence. If transportation alternative impacts identified mine waste site, mitigation will be required in accordance with the above referenced documents. 5. Amount of material, type of waste product, and cost of cleanup will not be performed under Level 2 screening.	Comprehensive Environmental Response, Compensation and Liability Act of 1980, Superfund Amendments and Reauthorization Act of 1986, Resource Conservation and Recovery Act of 1976, and subsequent amendments in 1984 provide the guidance for hazardous materials treatment, storage, transportation, cleanup, industry disclosure, and liability.	Identified in the Clear Creek County Survey and by the EPA & Colorado Division of Geology.
	Mineralized Rock	Potential for conflict is based on increase of acidic groundwater flow in mineralized rock areas. An adverse impact would result if disturbance to mineralized rock occurs. Rock excavations may increase fracture flow and transport of organic and inorganic compounds. Low-pH water in these areas is created through chemical reaction of sulfide minerals with water and air. For example, when pyrite is exposed to air and water, it reacts with the oxygen and water to form ferrous sulfate and sulfuric acid. These reactions decrease the pH (creating acidic water) and increase hardness, the concentrations of iron, sulfate, and total dissolved solids in water. Surface or groundwater with a low pH can then leach out metals from the surrounding bedrock, thereby contaminating the water with metals. The concentration and type of metal in the drainage is a function of the pH of the drainage and the type of metals present in the host rocks. The principal metal contaminants in Clear Creek are zinc and manganese. Other contaminants that are present include iron, aluminum, copper, cadmium, gold, silver, lead, molybdenum, and uranium.	1. Mineralized rock zones delineated from aerial photo interpretation and published data, specifically observing mining activity in the area. 2. Field observations performed to verify presence/absence of staining on existing cuts.	Colorado Department of Public Health and Environment, Water Quality Control Commission, C.R.S. 1973, 25-8-101, as amended. Classifications and Numeric Standards for: South Platte River Basin – Region 3, Clear Creek Basin, Stream Segments 1, 2, 11, 12. Upper Colorado River Basin – Region 12. Blue River Basin, Stream Segments 3, 14. Eagle River Basin, Stream Segments 1, 8, 9.	Identified in the Clear Creek County Survey and by the EPA .
	Winter Maintenance	Potential for conflict is based on the relative usage of sand and magnesium chloride applications adjacent to open waters. Alternatives comparison measure the relative distance (miles of highway) where application of sand and magnesium chloride could negatively impact streams and rivers adjacent to the alternative alignment.	1. Excessive road sand or salt is detrimental to water quality when transported or deposited in streams. 2. The highway width is positively correlated (proportionately) to the volume of sand or salt applied for winter maintenance. 3. Sand/salt application rates and the associated potential for conflict are positively correlated with elevation (i.e., application rates increase with elevation). 4. The "potential for conflict" is directly proportional to the width of highway - the wider the highway, the higher the potential for conflict. 5. The reference or "baseline" is the existing width of I-70.	Colorado Department of Public Health and Environment, Water Quality Control Commission, C.R.S. 1973, 25-8-101, as amended. Classifications and Numeric Standards for: South Platte River Basin – Region 3, Clear Creek Basin, Stream Segments 1, 2, 11, 12. Upper Colorado River Basin – Region 12. Blue River Basin, Stream Segments 3, 14. Eagle River Basin, Stream Segments 1, 8, 9.	Identified in the Clear Creek County Survey and by the EPA & CDPHE.
	Stormwater Runoff	Potential for conflict is based on the relative increase in impermeable surface areas. Alternatives comparison measure the relative increase in amount (approximate area) of impermeable surface area directly associated with the widening of highway alternatives. The increase in surface water runoff resulting from the increase in impermeable surface area could negatively impact streams and rivers adjacent to the alternative alignment.	1. Excessive stormwater runoff transports particulates and various contaminants (byproducts of automobile operations along the highway) that are detrimental to stream water quality. 2. The highway width is positively correlated (proportionately) to the volume of stormwater runoff. 3. The "potential for conflict" is, therefore, directly proportional to the width of the highway 4. The reference or "baseline" is the existing width of I-70.	Section 402(p) of the Clean Water Act. Clarifies that storm water discharges associated with industrial activity to waters of the United States must be authorized by an NPDES permit, to include storm water discharges associated with construction activity (40 CFR 122.26). Colorado Department of Public Health and Environment, Water Quality Control Commission, C.R.S. 1973, 25-8-101, as amended. Classifications and Numeric Standards for: South Platte River Basin – Region 3, Clear Creek Basin, Stream Segments 1, 2, 11, 12. Upper Colorado River Basin – Region 12. Blue River Basin, Stream Segments 3, 14. Eagle River Basin, Stream Segments 1, 8, 9.	Identified in the Clear Creek County Survey and the MIS - The impact of construction of the vision elements is a concern identified throughout the planning process. This includes the impact of the vision due to increased runoff of sediments, deicing chemicals, metals, oil and grease, etc. into proximate streams (ES-10) Identified by the EPA .

RESOURCES		Greatest Potential for Conflict / Critical Environmental & Hazard Issues	Range between Greatest to Intermediate Potential for Conflict	Intermediate Potential for Conflict	Range between Intermediate to Least Potential for Conflict	Least Potential for Conflict
Graphic Legend						
Air Quality		The analysis will provide estimates of mobile emissions and particulate matter associated with project alternatives. These estimates will be based on year 2000 and 2020 traffic volumes for the no action and the highway alternatives, as well as emissions associated with FGT power sources				
Geological Hazards	Rock Fall	Evidence of recent activity/ highly fractured bedrock/ rock face at steep angle/ talus below slope/ no catchment beside highway/rockfall rating "4"/ long-term loss of service to highway/ impedance of full roadway/ driver must stop/ immediate mitigation needed/ no mitigation previously done		Somewhat recent activity/ highly fractured bedrock/ little or no talus on slope below/ rock face at moderate to steep angle/ limited catchment area/ rockfall rating "2"/ moderate loss of service to highway/impedance to less than half of the roadway/ driver must slow down/ long-term mitigation needed/ periodic maintenance required/ limited or partial mitigation may have been done in the past		No evidence of recent activity/ rock is not highly weathered/ good catchment area for debris/ rockfall rating "0" or "1"/ little or no loss of service to highway/ impedance of shoulder or less/ no mitigation necessary/ one-time maintenance needed/ extensive mitigation has been done which is mostly effective
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		84 to 161 acres		46 to 84 acres		< 46 acres
	Debris / Mud Flow	Known recent activity/ usually less than 500 feet from the highway/ mud cracks on surface/ young or no vegetation/ usually no buildings present/ long-term loss of service to highway/ impedance of full roadway/ driver must stop/ immediate mitigation needed/ no mitigation previously done		Somewhat recent activity/ usually less than 500 feet from the highway/ deposit visible with thick colluvium on surface/ young vegetation/minor engineering structures / moderate loss of service to highway/ impedance to less than half of the roadway/ driver must slow down/ long-term mitigation needed/ periodic maintenance required/ limited or partial mitigation may have been done in the past.		No evidence of recent activity/ most north-facing slopes with long recurrence intervals (50-100yrs)/ usually greater than 500 feet from highway/ little or no loss of service to highway/ impedance of shoulder or less/ no mitigation necessary/ one-time maintenance needed/ extensive mitigation has been done which is mostly effective
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		50 to 72 acres		19 to 54 acres		< 19 acres
	Landslide	Evidence of recent activity/ usually less than 500 feet from the highway/ head scarps, slumps, and hummocky surface/ young vegetation/ tilted fences or utilities/ long-term loss of service to highway/ impedance of full roadway/ driver must stop/ immediate mitigation needed/ no mitigation previously done		Somewhat recent activity/ usually less than 500 feet from the highway/ no visible scarps or slumps, surface is hummocky/ intermediate vegetation/ utilities and fences stand straight/moderate loss of service to highway/ impedance to less than half of the roadway/ driver must slow down/ long-term mitigation needed/ periodic maintenance required/ limited or partial mitigation may have been done in the past		No evidence of recent activity/ usually greater than 500 feet from highway/ no fresh head scarps, surface is hummocky/ vegetation is mature/ utilities and fences stand straight/ little or no loss of service to highway/ impedance of shoulder or less/ no mitigation necessary/ one-time maintenance needed/ extensive mitigation has been done which is mostly effective
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		> 1 acres				< 1 acres
	Avalanche	Evidence of recent activity/ usually less than 500 feet from the highway/ well defined, deep chute/ young vegetation/ limited or no runout zone beside highway/ long-term loss of service to highway/ impedance of full roadway/ driver must stop/ immediate mitigation needed/ no mitigation previously done		Somewhat recent activity/ usually less than 500 feet from the highway/ chute is not active every year/ runout zone may or may not reach highway/ moderate loss of service to highway/ impedance to less than half of the roadway/ driver must slow down/ long-term mitigation needed/ periodic maintenance required/limited or partial mitigation may have been done in the past		No evidence of recent activity/ usually greater than 500 feet from highway/ sufficient runout zone, but suspended debris may reach the highway/ little or no loss of service to highway/ impedance of shoulder or less/ no mitigation necessary/one-time maintenance needed/ extensive mitigation has been done which is mostly effective
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		> 6 acres		2 to 6 acres		< 2 acres
Water Quality	Mine Waste	Disturbance in existing mine waste / Extensive observed mining activity		Disturbance in existing mine waste / Some observed mining activity		No observed mine waste deposits / Little or no mining activity
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		Mine Waste Encountered		No significant change in exposure to mine water, no disturbance of know mine waste material		Mine water may be avoided
	Mineralized Rock	Disturbance in mineralized zones / Extensive observed mining activity		Disturbance in mineralized zones / Some observed mining activity		No observed mineralized zones / Little or no mining activity
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		Large rock cuts through mineralized zones		No significant change in exposure to mineralized rock		Mineralized rock may be avoided
	Winter Maintenance	Increase in winter sanding or magnesium chloride use		Increase in winter sanding or magnesium chloride use in watershed area		No increase in winter sanding or magnesium chloride use
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		50 % Increase		20% Increase		3 to 7% Increase
	Stormwater Runoff	Greatest increase in impermeable surface		Intermediate increase in impermeable surface		Least increase in impermeable surface
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		50 % Increase		20% Increase		3 to 7% Increase

RESOURCES		CONFLICT CRITERIA[1]	ASSUMPTIONS	APPLICABLE FEDERAL, STATE REGULATIONS[2]	MIS & RELATED ISSUES FROM PUBLIC SCOPING & AGENCY COMMENTS
Wetlands		Potential for conflict is based on displacement of Waters of the U.S. and wetlands (vegetated wetlands, and fens-seeps-springs). Alternatives comparison measure the approximate amount (acreage) of open and flowing waters, vegetated wetlands, and fens-seeps-springs that have potential to be directly affected by construction of the alternatives.	1. Impacts occur when new roadway facilities extend into Waters of the U.S. and wetlands. Roadway facilities include cut and fill for expansion of existing roads, and construction (cut and fill) of roadbeds in a new right-of-way. Alternative footprints that extend out from the existing roadbed and those where new roadbeds are required are used to calculate areas. 2. All wetlands will be included in the analysis irregardless of jurisdiction of Section 404 of the Clean Water Act. The COE suggested that instead of Waters of the U.S., this category should specify open and flowing water. However, intermittent streams are currently included in this category. 3. Fens-seeps-springs is recognized as a critical wetland type, but this category will not be weighted in the first determination of conflict, although alternatives that have potential to affect fens-seeps-springs will be marked. 4. Alternatives that have potential to impact fens-seeps-springs, or complexes of vegetated wetlands will be evaluated to avoid or reduce impacts.	Section 404 of the Clean Water Act, regulates waters of the U.S. including wetlands; the team is working closely with the COE to ensure that the appropriate level of detail is achieved in order to identify the least damaging, practicable alternative [(404 (b)(1)] in terms of impacts to aquatic resources. Particular attention is given to the displacement of fens, which are a USFWS resource category 1 and an irreplaceable resource without mitigation potential. In addition, Executive Orders 11990 (protection of Wetlands) and 11988 (management of floodplains), relate to screening criteria.	Identified in the Clear Creek County Survey and the MIS - Construction of the vision will be located within 150 feet of 24 miles of riparian habitat, much of which includes wetlands. Additionally, numerous bridges and culverts will need to be replaced over watercourses. Consequently, there is significant concern regarding wetland impacts. (ES-11) Identified by the COE & EPA.
Fishery Resources		Potential for conflict is based on relative potential for impact to Species of Special Concern, Gold Medal Streams, and high value fisheries resources (as defined by the Colorado Division of Wildlife). Alternatives comparison measure relative amount (miles of stream) of fisheries resources with potential for negative impacts resulting from the implementation of alternatives.	1. Impact will occur to the fishery resource if the alignment (including catch points and toe of slope) encroaches within 100 feet of the fishery resource. 2. The Colorado Division of Wildlife has not officially designated stream reaches as "high value fisheries", however, discussions with CDOW personnel have resulted in the identification of reaches considered by these individuals as valued fisheries. 3. As described by CDOW personnel "high value fisheries" are considered resources with any of the following attributes: support public recreation and the local economy, support abundant and diverse fish populations, support naturally reproducing trout populations. 4. The relative extent of potential fisheries resource impacts or loss will be calculated using existing Geographic Information System (GIS) data and identification of valued fisheries resources provided by CDOW Fisheries Biologists. 5. Although mitigation measures may be implemented to reduce or eliminate the potential for impacts to the fisheries resources, for screening purposes, these measures have not been considered.	———	Identified in the Clear Creek County Survey and by the USFWS, CDOW, & EPA.
Wildlife	Range	Potential for conflict is based on area of selected big game range intersected by transportation alternatives. Selected big game include mule deer, elk, and bighorn sheep populations along the I-70 Corridor. Range refers to winter, summer, and production areas for these species as defined and delineated by the Colorado Division of Wildlife WRIS and intersected by alternatives. Area intersected will be in acres.	1. Use of this criteria in Level 2 screening refers to the additional (or net difference) area of big game range intersected by transportation modes under consideration. 2. Determination of big game range area intersected will be based on a GIS overlay analysis of transportation alternatives with Colorado Division of Wildlife WRIS data. No field studies will be conducted. 3. Determination of big game range area intersected may change based on subsequent and more refined analyses. 4. Criteria index was calculated by dividing the number of conflict categories (5) into the greatest acreage of biodiversity area intersected by any single alternative.	———	Identified in the Clear Creek County Survey and by the USFWS, CDOW, & EPA.
	Biological Diversity	Potential for conflict is based on area of designated high biodiversity areas intersected by transportation alternatives. High biodiversity areas are geographic areas exhibiting relatively high biological diversity as defined and delineated by the Colorado Natural Heritage Program (CNHP).	1. Use of this criteria in Level 2 screening refers to the additional (or net difference) biodiversity area intersected by transportation modes under consideration. 2. Determination of biodiversity area intersected will be based on a GIS overlay analysis of transportation alternatives with CNHP-designated biodiversity areas. No field studies will be conducted. 3. Determination of biodiversity area may change based on subsequent and more refined analyses. 4. Criteria index was calculated by dividing the number of conflict categories (5) into the greatest acreage of biodiversity area intersected by any single alternative.	———	Identified in the Clear Creek County Survey and by the USFWS, CDOW, & EPA.
	Crossings	Potential for conflict is based on additional miles of structural barrier in designated wildlife crossing areas along the I-70 corridor. Barriers include structural, operational, and behavioral impediments to wildlife trying to cross the I-70 corridor. Only structural barriers are included in this screening criteria. Structural barriers include concrete Jersey median barriers, headlight reflectors mounted on concrete median barriers, retaining walls, fences, and road or rail surface. Designated wildlife crossing areas are based on animal vehicle collision data and information from CDOW, CDOT, USFS, BLM, and USFWS.	1. Use of this criteria in Level 2 screening refers to the additional (or net difference) structural barrier (in linear miles) due to transportation modes under consideration. 2. Determination of additional barrier will be based on a GIS overlay analysis of transportation alternatives with wildlife crossing areas designated by the Colorado Division of Wildlife (CDOW). No field studies will be conducted. 3. Determination of additional barrier effect may change based on subsequent and more refined analyses. 4. Criteria index was calculated by dividing the greatest mileage intersected (by any single alternative) by the number 5 (the number of conflict categories). Where wildlife crossing areas are designated on both sides of I-70, only one side of the highway was used in the calculation to avoid duplicate counting.	———	Identified in the Clear Creek County Survey and the MIS - Methods to mitigate vehicle/animal accidents will need to be investigated. Concerns are especially pronounced in Clear Creek County where bighorn sheep frequent the I-70 right-of-way, and near Dowd Junction, where accidents with migrating elk on I-70 are an ongoing problem (ES-10). Identified by the USFWS, CDOW, & EPA
T&E Species		Potential for conflict for Boreal Toad is based on proximity to or loss of confirmed breeding sites. Potential for conflict for lynx is based on additional miles of structural barrier along I-70 intersecting areas of potential lynx habitat. Barriers include structural, operational, and behavioral impediments to wildlife crossing the I-70 corridor. Only structural barriers are included in this criteria. Structural barriers include concrete Jersey median barriers, headlight reflectors mounted on concrete median barriers, retaining walls, fence, and road or rail surface. Potential lynx habitat will be identified with data/input from CDOW, USFS, BLM, CDOT, and USFWS. Proximity to confirmed boreal toad breeding sites will be measured in feet from the outer edge of the proposed disturbance footprint associated with each alternative. Potential conflict for Colorado River and Greenback Cutthroat Trout is based on proximity to water bodies identified by CDOW as known or potentially inhabited by these species.	1. Use of this criteria in Level 2 screening refers to the additional (or net difference) structural barrier (in linear miles) intersecting potential lynx habitat and boreal toad breeding habitat lost due to transportation modes under consideration. 2. Determination of additional barrier and boreal toad habitat lost will be based on a GIS overlay analysis of transportation alternatives. No field studies will be conducted. 3. Determination of additional barrier distance and boreal toad habitat intersected may change based on subsequent and more refined analyses. 4. Criteria index for lynx was calculated by dividing 5 (the number of conflict categories) into the greatest mileage of additional structural barrier (for any single alternative) intersecting potential lynx habitat. Criteria index for boreal toads was calculated by dividing 5 (number of conflict categories) into the greatest distance measured from the outer edge of the alternative's proposed disturbance footprint.	Section 7 of the Endangered Species Act. Loss of individuals may affect species viability.	Identified in the Clear Creek County Survey and the MIS - Elements of the vision cross through habitats of T&E species near the Eisenhower Tunnel and over Vail Pass. The effect of building and operating vision elements on these species will need to be addressed. (ES-10) Identified by the USFWS.

RESOURCES			Greatest Potential for Conflict / Critical Environmental & Hazard Issues	Range between Greatest to Intermediate Potential for Conflict	Intermediate Potential for Conflict	Range between Intermediate to Least Potential for Conflict	Least Potential for Conflict
Graphic Legend							
Wetlands	Open and Flowing Waters		Greatest quantity of displacement of waters of the U.S. including wetlands (Quantity does not distinguish functionality, wetland type, or jurisdiction)		Intermediate quantity of displacement of waters of the U.S. including wetlands		Least quantity of displacement of waters of the U.S. including wetlands
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 7 acres	5 to 7 acres	3 to 5 acres	1 to 3 acres	< 1 acres
	Vegetated Wetlands		Greatest quantity of displacement of vegetated wetlands (Quantity does not distinguish functionality, wetland type, or jurisdiction)		Intermediate quantity of displacement of vegetated wetlands		Least quantity of displacement of vegetated wetlands
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 10 acres	7 to 10 acres	4 to 7 acres	1 to 4 acres	< 1 acre
	Fen/Seep/Spring		Greatest quantity of displacement of fen, seep or spring		Intermediate quantity of displacement of fen, seep or spring		Least quantity of displacement of fen, seep or spring
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 0.5 acre		0.1 to 0.5 acre		0 acre
Fishery Resources	Gold Medal Fisheries		Greatest length of gold medal fishery water encroached		Intermediate length of gold medal fishery water encroached		Least length of gold medal fishery water encroached
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 0.6 mile		0.1 to 0.5 mile		< 0.1 mile
	High Value Fisheries		Greatest length of high value fishery water encroached		Intermediate length of high value fishery water encroached		Least length of high value fishery water encroached
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 2.0 miles	1.5 to 1.9 miles	1.0 to 1.4 miles	0.5 to 0.9 mile	0 to 0.4 mile
Wildlife	Highway & RTT	Range, Biological Diversity, & Crossing	Alternative creates a structural barrier to wildlife movement across I-70 and/or results in a significantly wider roadway section up to twice the width of I-70. Greatest quantity of displacement of range and biological diversity areas	Alternative creates a partial barrier to wildlife movement, operational impediment, and/or results in a substantially wider road up to 50%	Alternative creates a partial barrier to wildlife movement and results in increased road width up to 25%. Moderate quantity of displacement of range and biological diversity areas	Localized highway alignment resulting in habitat fragmentation	Minimal change to roadway section. Least quantity of displacement of range and biological diversity areas
	FGT Alternatives	Range: Deer & Elk Wintering Concentrations	Greatest quantity of displacement of elk winter concentrations areas		Moderate quantity of displacement of elk winter concentration areas		Least quantity of displacement of elk winter concentration areas
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
						> 27 acres	< 27 acres
		Range: Big Horn Sheep Summer Range	Greatest quantity of displacement of designated summer range		Moderate quantity of displacement of designated summer range		Least quantity of displacement of designated summer range
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 360 acres	271 to 360 acres	181 to 270 acres	90 to 180 acres	< 90 acres
		Range: Big Horn Sheep Lambing Area	Greatest quantity of displacement of designated lambing range		Moderate quantity of displacement of designated lambing range		Least quantity of displacement of designated lambing range
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
						> 1 acre	< 1 acre
		Biological Diversity	Greatest quantity of CNHP-designated biological diversity area intersected.		Intermediate quantity of CNHP-designated biological diversity area intersected.		Least quantity of CNHP-designated biological diversity area intersected.
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 110 acres	82-109 acres	55-81 acres	27-54 acres	< 27 acres
		Crossings	Greatest additional linear miles of structural barrier intersecting designated wildlife crossings areas.		Intermediate additional linear miles of structural barrier intersecting designated wildlife crossings areas.		Least additional linear miles of structural barrier intersecting designated wildlife crossings areas.
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 37 miles	28-36 miles	19-27 miles	9-18 miles	< 9 miles
T&E Species	Lynx Habitat		Greatest additional linear miles of structural barrier intersecting potential lynx crossings		Intermediate additional linear miles of structural barrier intersecting potential lynx crossings		Least additional linear miles of structural barrier intersecting potential lynx crossings
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			> 8 miles of lynx crossing	6-8 miles of lynx crossing	4-6 miles of lynx crossing	2-4 miles of lynx crossing	< 2 miles of lynx crossing
	Boreal Toad Habitat		Greatest loss of boreal toad breeding habitat.		Intermediate encroachment upon boreal toad breeding habitat.		Least encroachment upon boreal toad breeding habitat.
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
			< 82 feet to toad breeding habitat	82-164 feet to toad breeding habitat	165-246 feet to toad breeding habitat	247-328 feet to toad breeding habitat	> 328 feet to toad breeding habitat
	Colorado and Greenback Cutthroat Trout		Disruption of streams with Colorado and Greenback Cutthroat Trout.				No disruption of streams with Colorado and Greenback Cutthroat Trout.
			Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*

RESOURCES	CONFLICT CRITERIA[1]	ASSUMPTIONS	APPLICABLE FEDERAL, STATE REGULATIONS[2]	MIS & RELATED ISSUES FROM PUBLIC SCOPING & AGENCY COMMENTS
Land Use / Recreation	Potential for encroachment, disruption, or fragmentation of communities and recreation use areas.	1. Land use inventories are based on 2000 aerial photography, and published sources that identify existing recreation uses. 2. Future land use planning by Federal, State, and Local jurisdictions is currently under review and will be addressed in the Draft PEIS.	Section 6(f) of the Land and Water Conservation Fund Act. Section 4(f) of the Transportation Act of 1966.	Identified in the Clear Creek County Survey, EPA, & NPS.
Federal Management and Scenic Features / Views	Potential for conflict is based on most restrictive USFS visual and recreation management prescriptions, and foreground and middleground views from sensitive receptors.	1. Communities, historic, and recreation sites are considered to be most sensitive to visual changes. 2. The appearance of features in the landscape varies with the viewing distance and project type. The lands seen from existing viewers in the study area were divided into three distance zones: foreground - from 0 to ½ mile, middleground - ½ to 4 miles, background – beyond 4 miles. The visual screening focuses on changes to local viewsheds within foreground distance zones. 3. The visual screening focuses on the most restrictive visual management prescriptions on Forest Service lands, including Retention VQO, and High and Very High Scenic Integrity.	USFS Management Visual and Recreation Management Prescriptions.	Identified in the Clear Creek County Survey and the MIS - The amount of rock cuts and retaining wall needed for the TSM build elements will need to be addressed, as will the visual impact of the FGT guideway. (ES-11) Identified by the USFS.
Cultural Resources (Historic and Archaeological)	Potential for conflict is based on disturbance of significant cultural resources including National Historic Landmarks and/or Historic Districts and sites listed on, or eligible for, the National Historic Register.	1. Screening was conducted to determine Historic Districts, Landmarks and properties crossed, as well as those within 300 feet of either side of each alternative. This 300 foot buffer zone was included to identify the potential for impacting the setting and feeling of properties, which are National Historic Register criteria.	Section 106 of Historic Preservation Act, FHWA Section 4(f).	Identified in the Clear Creek County Survey and the MIS - The vision will pass through an historic district in Idaho Springs and an historic landmark district in Georgetown and Silver Plume. This will complicate approvals for construction through these areas. (ES-11) Identified by SHPO.
Noise	Potential for conflict is based on the increases in peak-hour in Leq noise level, 24-hour noise level, and number of receptors impacted, as well as potential for noise mitigation.	1. Regulatory agencies (CDOT and FHWA) and communities in the corridor are target audiences for the noise analysis. 2. CDOT/FHWA regulate highway noise based on the peak-hour noise level. 3. It is assumed that the peak-hour comparison would address all of the citizen's issues. Most of the alternatives will be very similar during the peak-hour but may exhibit more significant differences in 24-hour noise levels. Also, looking forward to the PEIS when alternatives will have both rail and highway elements, FTA regulates noise on a 24-hour basis. 4. The number of receptors impacted (i.e. within the 66 dBA contour) provides regulators with a metric to judge the impact of an alternative Corridor wide. 5. The potential for mitigation is very important because one alternative may be louder than the other with no mitigation but be quieter with mitigation. For example, a bypass route and a non-bypass route through Clear Creek County would have the same noise levels at 200 feet but obviously would produce much different levels in town.	FHWA, FTA, and FRA regulate highway, light rail, and heavy rail noise, respectively. The policies of these agencies mandate that noise impacts be mitigated when feasible. FHWA defines noise impact as noise levels exceeding standards (e.g., 66 dBA for residences) and when design-year noise levels exceed existing levels by 10 dBA or more. FTA and FRA impact criteria define impact standards based on existing noise levels.	Identified in the Clear Creek County Survey and the MIS - Approximately 2,600 dwellings are located within 500 feet of I-70, and noise impacts are a concern. After a transit technology is defined, an evaluation and mitigation of noise impacts will be required. (ES-11) Identified by EPA.
Environmental Justice	Potential for conflict is based on disproportionate effects to low income and minority populations.	1. Criteria for low income based on EPA and FHWA criteria.	Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations."	Identified in the Clear Creek County Survey and by EPA

[1] In order to distinguish between alternatives, potential levels of conflict range from greatest to least based on these criteria

[2] This column is not intended to provide a comprehensive listing of laws, ordinances, regulations, or standards, rather it highlights key regulatory factors that are considered instrumental considerations in the Level 2 Screening process

RESOURCES		Greatest Potential for Conflict / Critical Environmental & Hazard Issues	Range between Greatest to Intermediate Potential for Conflict	Intermediate Potential for Conflict	Range between Intermediate to Least Potential for Conflict	Least Potential for Conflict
Graphic Legend						
Land Use / Recreation	Communities	Disruption of or fragmentation of a community		Proximity to community or development		No community encroachment
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		> 5 miles		1 to 5 miles		< 1 mile
	Recreation 4(f)/6(f) Properties	Disturbance known of 4(f) / 6(f) property (see viewshed analysis below)		Proximity to known 4(f)/6(f) properties (see viewshed analysis below)		No 4(f)/6(f)\ encroachment (see viewshed analysis below)
Federal Management and Scenic Features / Views	Scenery Management	Most restrictive USFS Visual and Recreation management prescriptions.		Moderate restrictive USFS Visual and Recreation management prescriptions.		Least restrictive USFS Visual and Recreation management prescriptions.
	Community Viewsheds	Elevated structures within foreground views from communities, recreation sites and historic landmarks, districts and sites listed or eligible for the NRHP.		Highway widening within foreground views from communities, recreation sites and historic landmarks, districts and sites listed or eligible for the NRHP.		Highway widening within middleground views from communities, recreation sites and historic landmarks, districts and sites listed or eligible for the NRHP.
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		> 5 miles		1 to 5 miles		< 1 mile
	Recreation Site Viewsheds	Elevated structures within foreground views from communities, recreation sites and historic landmarks, districts and sites listed or eligible for the NRHP.		Highway widening within foreground views from communities, recreation sites and historic landmarks, districts and sites listed or eligible for the NRHP.		Highway widening within middleground views from communities, recreation sites and historic landmarks, districts and sites listed or eligible for the NRHP.
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		> 5 miles		1 to 5 miles		< 1 mile
Cultural Resources (Historic and Archaeological)		Cross national historic district or landmark, or crosses many historic sites		Adjacent to national historic district or landmark, or crosses several historic sites		No known historic landmarks, districts, or sites are crossed or are in the immediate vicinity
		Resource Quantifications	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*	*Resource Quantifications*
		5 to 10 historic site crossed or a historic district is encountered		1 to 4 historic site crossed or alternative is adjacent to a historic district		No identified historic sites crossed, no historic districts or landmarks encountered or adjacent
Noise		Much greater than the existing number of receptors impacted / a 24 hour noise increase of 10 dB of more, and a peak-hour noise increase of 10 dB or more	Greater than existing number of receptors impacted / a 24 hour increase of 7-9 dB and a peak hour level increase of 7-9 dB	Same as existing number of receptors impacted / a 24 hour noise increase of 5 to 7 dB, and a peak-hour noise increase of 5 to 7 dB	Fewer than existing number of receptors impacted / a 24 hour increase of 3-4 dB and a peak-hour increase of 3-4 dB	Far fewer than existing number of receptors impacted / a 24 hour noise increase of 0 to 2 dB, and a peak-hour noise increase of 0 to 2 dB
Environmental Justice		Low-income and minority populations will generally be identified and a public outreach program will be conducted				

ENVIRONMENTAL SENSITIVTY	NAME	FIRM	HIGHEST DEGREE AND YEARS OF EXPERIEINCE	ROLE IN LEVEL 2 ANALYSIS
Air Quality (Support from Jim DeLio – Colorado department of Public Health and Environment and Jeff Houck – EPA)	Amy Baerenklau	JFSA	M.S. in Environmental Science, 4 years	Coordinated studies with the Colorado Department of Environmental Health and the Environmental Protection Agency
Water Quality	Mike Crouse	Clear Creek Consultants	B.S. in Aquatics Biology, 17 years	Conducted water quality analysis
Wetlands	Dr. Loren Hettinger Pat Murphy	JFSA Ecotone	Ph.D., Plant Ecology, 22 years M.A. in Vegetation Ecology, 22 years	Conducted wetland analysis
Wildlife Habitats and Crossings **Threatened, Endangered and Sensitive Species**	Robert Henke	SAIC	B.S. Forestry, Fisheries & Wildlife Management M.S. Wildlife Biology, 19 years	Conducted wildlife habitats and crossings analysis
Fish Habitats	Bob Quinlan	JFSA	B.S. in Aquatic Biology, 20 years	Conducted fish habitat assessment
Geologic Hazards/Mining	Rick Andrews	Yeh & Associates	M.S. in Geology, 17 years	Conducted geologic hazards and mining analysis
COMMUNITY VALUES				
Noise	Mike Hankard	Hankard Environmental	B.S. Electric Engineering with Acoustic Specialty, 11 years	Conducted noise analysis
Land Use/Recreation/4(f)/6(f) **Federal Management and Scenic Features/Views**	Tim Tetherow Teresa O'Neil	JFSA	M.S. in Landscape Architecture, 28 years B.S. in Landscape Architecture, 10 years	Conducted land use/recreation/4(f)/6(f) analysis
Cultural Resources	Dr. Steve Mehls	Western Historical Studies	Ph.D. in History of U.S. Western Movement, 22 years	Conducted cultural resources analysis

Environmental and Community Values Analysis

Step 1) Identify Issues

- Scoping
- I-70 MIS
- Agency Consultation
- TAC/MCAC
- Best Professional Judgement

EXAMPLE - Wildlife Crossing

Step 2) Develop Criteria

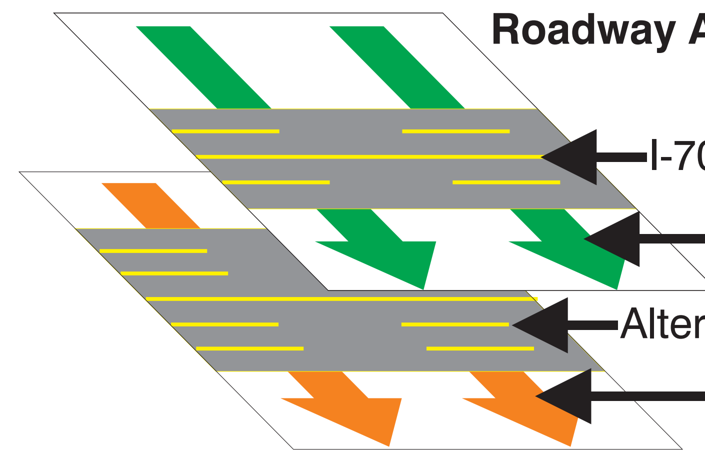
Analysis of Alternatives for Barrier Effect

- Structured Lanes, Tunneled Lanes, Cantilever Lanes → Greatest potential for conflict (5)
- 6-Lane Full Width, Reversible Lanes → Greatest to intermediate potential for conflict (4)
- 6 - Lane Reduced Width, 6 - Lane Variable Width, Moveable Median → Intermediate potential for conflict (3)
- Parallel Route → Intermediate to least potential for conflict (2)
- Tunnel → Least potential for conflict (1)

Step 3) Conduct GIS Overlay Analysis

- General Wildlife Movement Corridors
- Elk and Deer Crossings
- Potential Lynx Movement Corridor
- Increased Barrier Effect from Alternatives

Step 4) Quantify Potential for Conflict



Step 5) Analyze Level of Conflict

- Wildlife

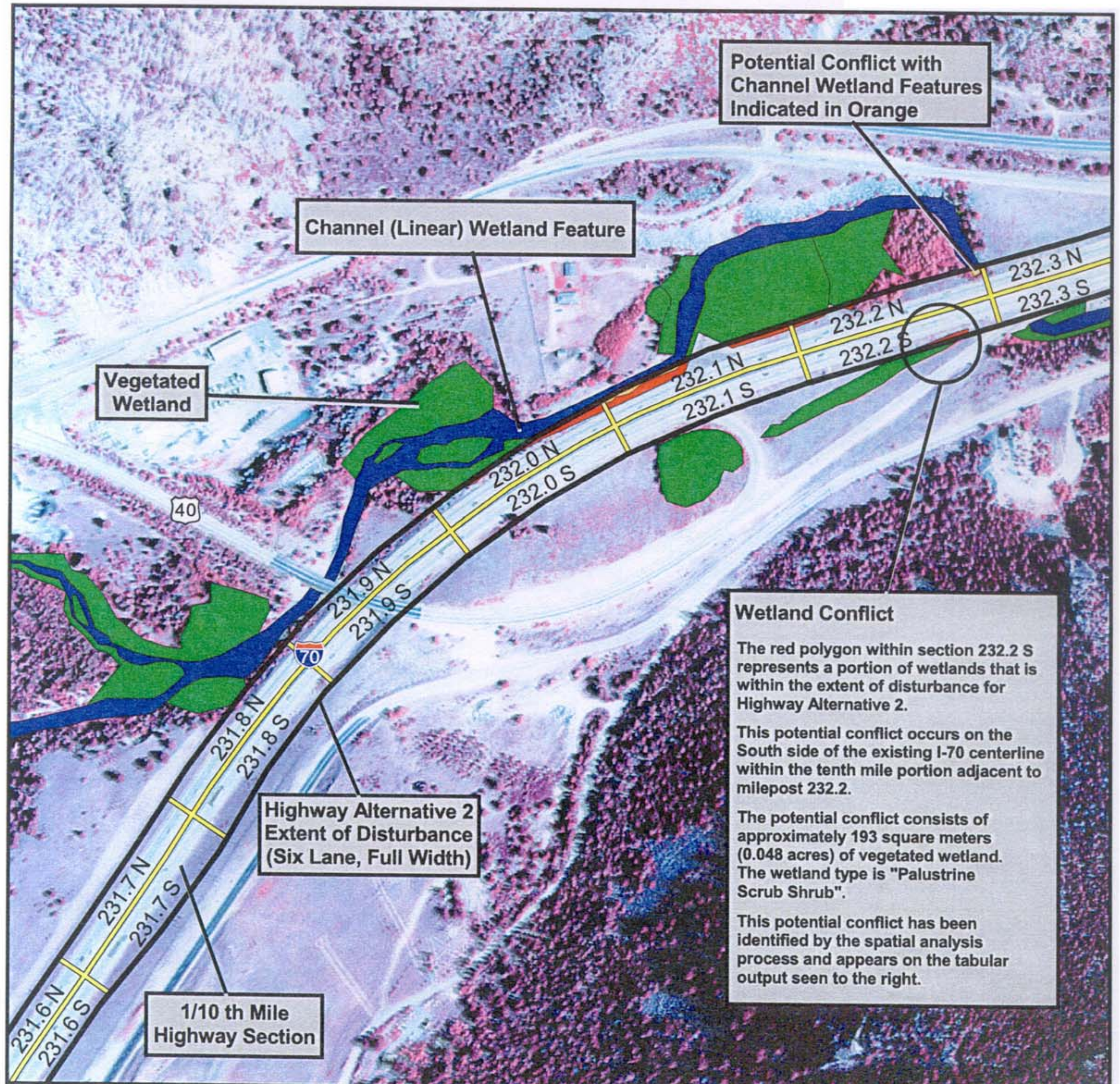
  Alternative 1 =

- Threatened, Endangered, and Sensitive Species

  Alternative 1 =

I-70 / U.S. 40 Interchange Area

Color Infrared Aerial Imagery, General Wetlands Mapping and Potential Wetland Conflicts



DRAFT
03/20/20

Tabular Data Output From Spatial Analysis Process

SECTION	CLASS	TYPE	AREA (square meters)	ACRES
231.6 N			0.000	0.000
231.6 S			0.000	0.000
231.7 N			0.000	0.000
231.7 S			0.000	0.000
231.8 N	PSS	Wet Veg	5.131	0.001
231.8 N			0.000	0.000
231.8 S			0.000	0.000
231.9 N			0.000	0.000
231.9 S			0.000	0.000
232 N	PFO	Wet Veg	551.207	0.136
232 N			0.000	0.000
232 S			0.000	0.000
232.1 N	PFO	Wet Veg	780.096	0.193
232.1 N			0.000	0.000
232.1 S			0.000	0.000
232.2 N	PFO	Wet Veg	117.385	0.029
232.2 N	PSS	Wet Veg	42.138	0.010
232.2 N			0.000	0.000
232.2 S	PSS	Wet Veg	193.180	0.048
232.2 S			0.000	0.000
232.3 N			0.000	0.000
232.3 S			0.000	0.000

This entry in the tabular output represents the Palustrine Scrub Shrub feature indicated as a potential conflict in the figure to the left.

KEY

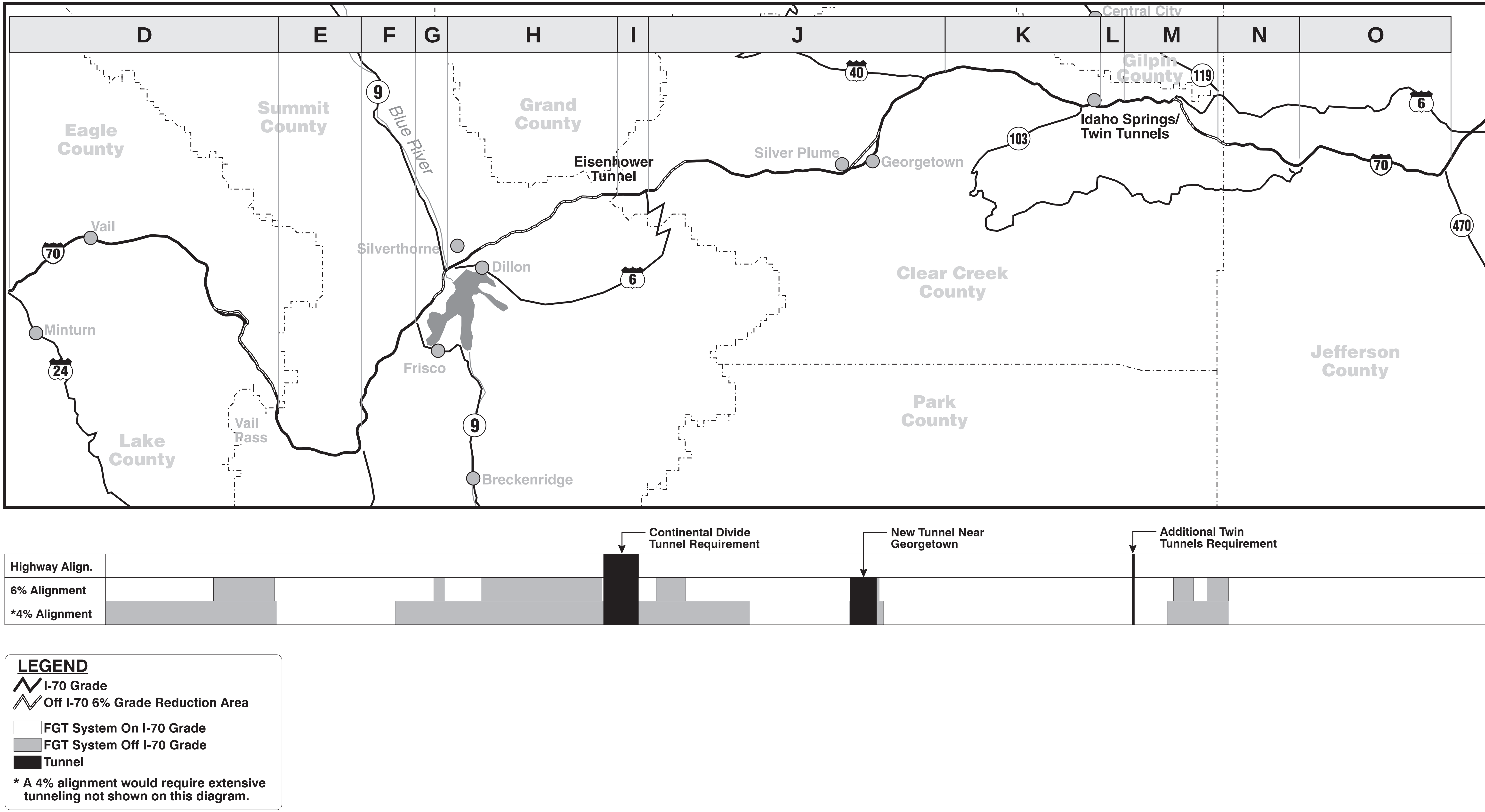
PSS - Palustrine Scrub Shrub
PFO - Palustrine Forested

Wet Veg - Vegetated Wetlands

Disturbance Area Assumptions For Highway, Fixed Guideway Transit and Rubber Tire Transit Alternatives				
	Roadway Template Width (feet)	**Variable Construction Width (feet)**	**Construction Disturbance Buffer (feet)**	**Potential Total Area of Disturbance**
Highway Alternatives				
6-lanes/ Full Width Barrier Separated	122'	30' max on either side	15' max on either side	167’
6-lanes/ Full width Open Median	148'	30' max on either side	15' max on either side	193’
6-lanes/ Reduced Width	98'	30' max on either side	15' max on either side	143’
Flex Lanes	90'	30' max on either side	15' max on either side	135’
Parallel Route	44'	15' max on either side	15' max on either side	89’
Structured Lanes Full Width	60'	30' max on either side	15' max on either side	105’
Structured Lanes Reduced Width	48'	30' max on either side	15' max on either side	93’
Tunneled Lanes	48'	30' max on either side	15' max on either side	93’
Cantilever Wall	96'	30' max on either side	15' max on either side	141’
Moveable Lanes	90'	30' max on either side	15' max on either side	135’
Reversible Lanes	116'	30' max on either side	15' max on either side	161’
Fixed Guideway Transit Alternatives				
Highway Alignment Alternatives along I-70	60' beyond edge of pavement of I-70 (30' / up to 30’ for construction)	–	–	60’
6% Grade Alignment:				
On I-70 Grade (up to 6 %)	60' beyond edge of pavement of I-70	–	–	60’
Grade Reduction Area (over 6 %)	120' beyond edge of pavement of I-70	–	–	120’
CIFGA Monorail Alternative	60' beyond edge of pavement where on north side of I-70 45' beyond edge of pavement where on south side of I-70	–	–	60’ where on north side 45’ where on south side
Rubber Tire Transit Alternatives				
HOV	122' (same as 6-lane full highway alternative)	30' max on either side	15' max on either side	167’
Guideway (C-470 to Eisenhower Tunnel)	98' (same as 6-lane reduced highway alternative)	30' max on either side	15' max on either side	143’
Transitway (C-470 to Vail)	60' beyond edge of pavement of I-70	–	–	60’
Bus in Mixed Traffic	No Change from Existing Roadway Template	–	–	–

*** Existing I-70 width between C470 and Vail ranges from approximately 78’ to 175’ width median**

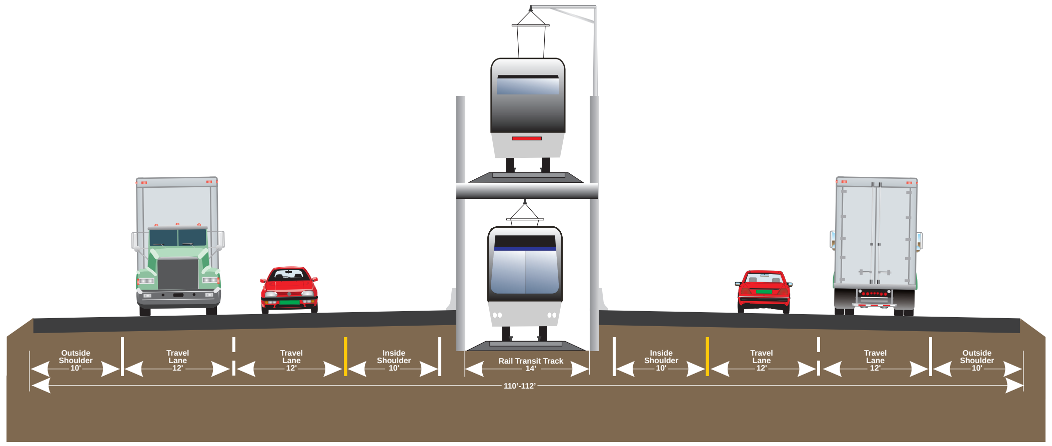
3 - FGT ALTERNATIVES



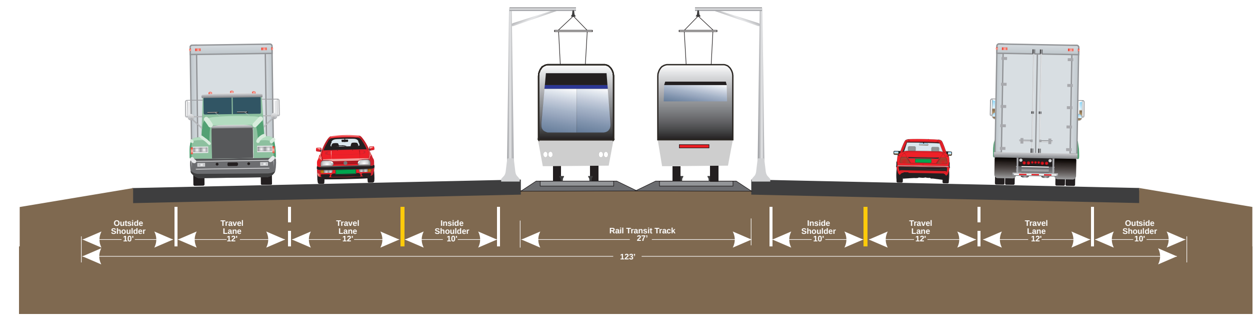
DRAFT

I-70 Mountain Corridor PEIS
Fixed Guideway Transit Alternatives

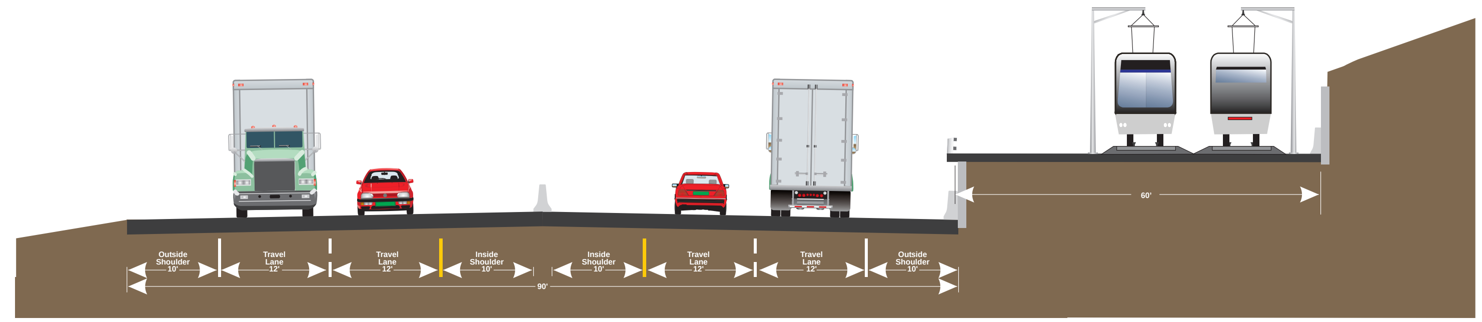
03/20/01



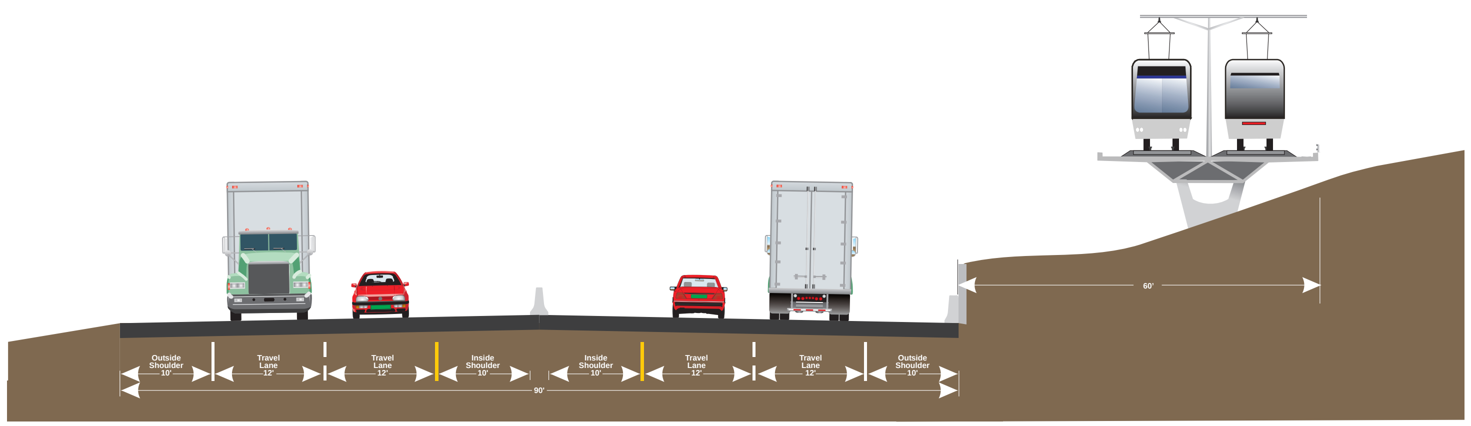
RAIL TRANSIT (TIGHT MEDIAN)



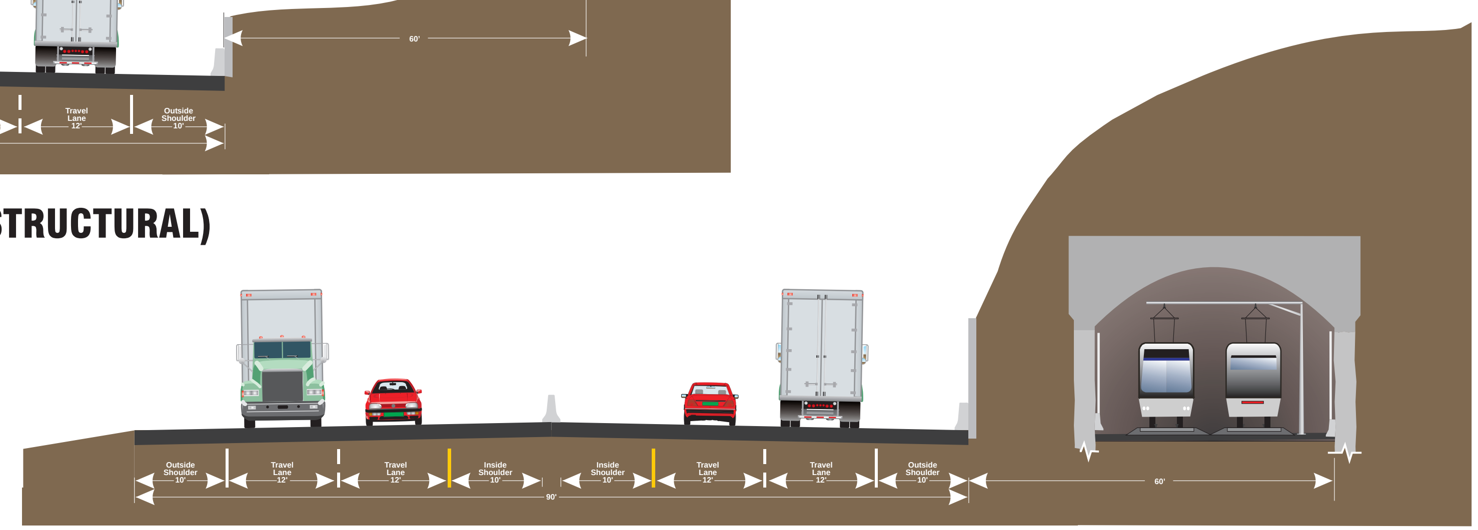
RAIL TRANSIT (WIDE MEDIAN)



RAIL TRANSIT (BENCH)



RAIL TRANSIT (STRUCTURAL)



RAIL TRANSIT (TUNNEL)

DRAFT

Fixed Guideway Transit Alternatives

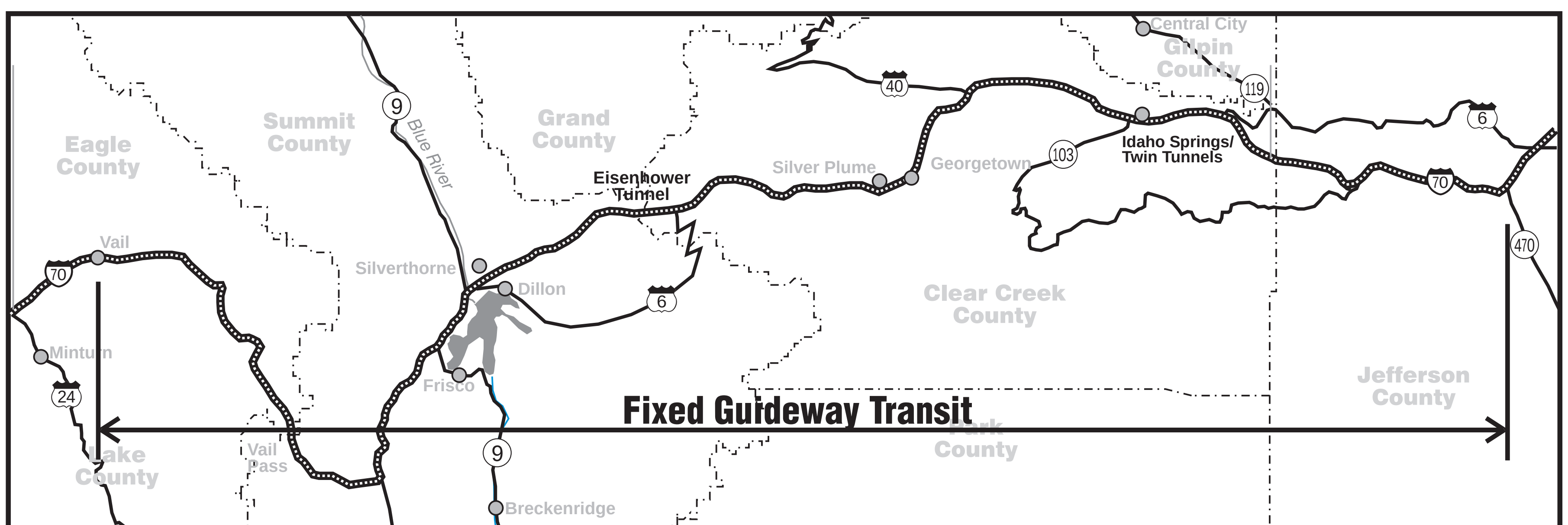
03/20/01

Fixed Guideway Transit Alternative

Highway Alignment

Diesel Power

Technology	Track	Need: System Capacity (Peak Hour) Actual	Need: System Capacity (Peak Hour) Rating	Need: System Attractiveness	Need: Average Speed Actual	Need: Average Speed Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs	Implementation: Technology Available	Implementation: Fuel Avail.	Implementation: Fuel Limit	Implementation: Energy Consumption
LRT	Single	1416	Lowest/Worst	Best to Intermediate	46.1	Intermediate	Highest/Best	Intermediate	Intermediate	Highest/Best	Worst to Intermediate	Highest/Best	Lowest/Worst	Best to Intermediate
LRT	Double	2832	Worst to Intermediate	Best to Intermediate	46.1	Intermediate	Highest/Best	Intermediate	Intermediate	Intermediate	Worst to Intermediate	Highest/Best	Lowest/Worst	Best to Intermediate
PRR - Winter Park	Single	1400	Lowest/Worst	Highest/Best	23.2	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Highest/Best	Highest/Best	Highest/Best	Lowest/Worst	Worst to Intermediate
PRR - Glenwood Springs	Single	1400	Lowest/Worst	Highest/Best	28.7	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Highest/Best	Highest/Best	Highest/Best	Lowest/Worst	Lowest/Worst



Fixed Guideway Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Legend for Technology:

LRT - Light Rail Transit; HRT - Heavy Rail Transit; PRR- Passenger Rail Road; MUP - Multiple Unit Passanger Rail Road; AGS - Advanced Guideway System

Highest/Best	Best to Intermediate	Intermediate	Worst to Intermediate	Lowest/Worst

Environmental Sensitivity

Air Quality*

Please Refer to Energy Requirements

Water Quality*

Item	Level of Conflict
Mine Tailings/Waste Rock	Greatest Potential for Conflict
Mineralized Rock	Greatest Potential for Conflict
Winter Maintenance	Least Potential for Conflict
Stormwater Runoff	Least Potential for Conflict
Summary	Greatest Potential for Conflict

Waters of the U.S./Wetlands*

Item	Level of Conflict
Open and Flowing Waters	Intermediate - Least Potential for Conflict
Vegetated Wetlands	Intermediate - Least Potential for Conflict
Fen/Seep/Spring	Intermediate Potential for Conflict
Summary	Intermediate - Least Potential for Conflict

Fish Habitats

Item	Level of Conflict
High Value Fishery	Greatest Potential for Conflict
Gold Medal Fisheries	Intermediate Potential for Conflict
Summary	Greatest Potential for Conflict

Wildlife Habitats and Crossings

Item	Level of Conflict
Deer Range	Under Study
Elk Winter Concentration	Intermediate - Least Potential for Conflict
Big Horn Sheep Range	Greatest - Intermediate Potential for Conflict
Big Horn Sheep Lambing Area	Least Potential for Conflict
Biodiversity Area	Greatest Potential for Conflict
General Wildlife Crossing	Greatest Potential for Conflict
Summary	Intermediate Potential for Conflict

Threatened, Endangered, and Sensitive Species*

Item	Level of Conflict
Potential Lynx Movement Corridor	Greatest Potential for Conflict
Boreal Toad	Intermediate - Least Potential for Conflict
Colorado Cutthroat Trout	Intermediate - Least Potential for Conflict
Greenback Cutthroat Trout	Least Potential for Conflict
Summary	Greatest Potential for Conflict

Geologic Hazards/Mining

Item	Level of Conflict
Rockfall	Greatest Potential for Conflict
Debris/Mud Flow	Greatest Potential for Conflict
Landslide	Greatest Potential for Conflict
Avalanche	Greatest Potential for Conflict
Summary	Greatest Potential for Conflict

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Item	Level of Conflict
Noise Increase	Greatest Potential for Conflict
Summary	Greatest Potential for Conflict

Community/Recreation/4(f) and 6(f)*

Item	Level of Conflict
Community Areas	Greatest Potential for Conflict
Recreation (4(f)/6(f))	Intermediate Potential for Conflict
Hike and Bike Trails	Under Study
Summary	Greatest - Intermediate Potential for Conflict

Cultural Resources/4(f)*

Item	Level of Conflict
Historic Districts	Greatest Potential for Conflict
Historic Sites & Trails	Intermediate - Least Potential for Conflict
Archaeological Sites	Least Potential for Conflict
Summary	Greatest Potential for Conflict

Federal Management and Scenic Features/Views*

Item	Elevated	On Grade
USFS/Visual Quality Objectives/Retention*	Under Study	Under Study
USFS/ROS/Roaded Natural*	Under Study	Under Study
Visually Sensitive Areas		
Community Setting/Foreground Views	Greatest Potential for Conflict	Intermediate Potential for Conflict
Recreation Sites/Foreground Views	Greatest Potential for Conflict	Intermediate Potential for Conflict
Historic Sites, Districts & Landmarks/Foreground Views	Greatest Potential for Conflict	Intermediate Potential for Conflict
Summary	Greatest Potential for Conflict	Intermediate Potential for Conflict

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

- Greatest Potential for Conflict
- Greatest - Intermediate Potential for Conflict
- Intermediate Potential for Conflict
- Intermediate - Least Potential for Conflict
- Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

Fixed Guideway Transit Alternative

Highway Alignment
Diesel Power

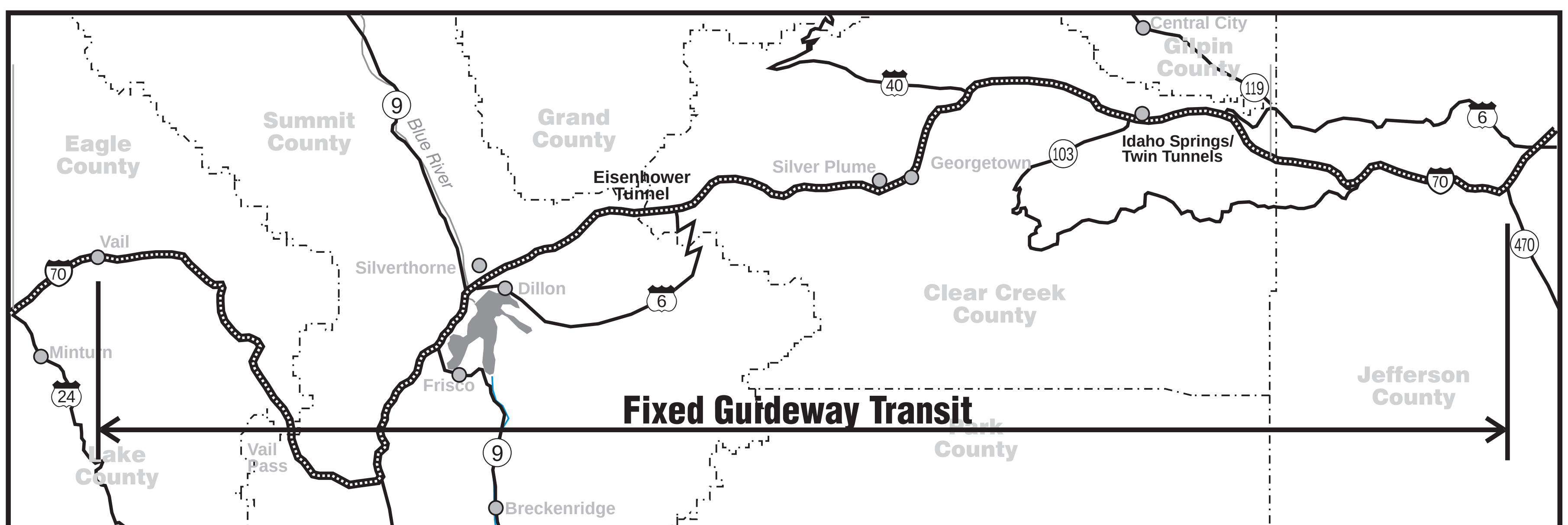
DRAFT

03/20/01

Fixed Guideway Transit Alternative

Highway Alignment
Electric Power

Technology	Track	Need: System Capacity (Peak Hour) – Actual	Need: System Capacity (Peak Hour) – Rating	Need: System Attractiveness	Need: Average Speed – Actual	Need: Average Speed – Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs	Implementation: Technology Available	Implementation: Fuel – Avail.	Implementation: Fuel – Limit	Implementation: Energy Consumption
LRT	Single	1320	Lowest/Worst	Best to Intermediate	48.6	Intermediate	Best to Intermediate	Intermediate	Intermediate	Best to Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Best to Intermediate
LRT	Double	2640	Intermediate	Best to Intermediate	48.6	Intermediate	Best to Intermediate	Intermediate	Intermediate	Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Best to Intermediate
AGS - Supported	Double	4200	Intermediate	Best to Intermediate	63	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Best to Intermediate
AGS - Suspended	Double	4200	Intermediate	Best to Intermediate	63	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Best to Intermediate
AGS - Side Hanging	Unit	4200	Intermediate	Best to Intermediate	63	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Best to Intermediate



Fixed Guideway Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Legend for Technology:

LRT - Light Rail Transit; HRT - Heavy Rail Transit; PRR- Passenger Rail Road; MUP - Multiple Unit Passanger Rail Road; AGS - Advanced Guideway System

Highest/Best | Best to Intermediate | Intermediate | Worst to Intermediate | Lowest/Worst

03/20/01

Environmental Sensitivity

Air Quality*

Please Refer to Energy Requirements

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Deer Range

Under Study

Elk Winter Concentration

Big Horn Sheep Range

Big Horn Sheep Lambing Area

Biodiversity Area

General Wildlife Crossing

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*

Noise Increase

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Elevated On Grade

Recreation Sites/Foreground Views

Elevated On Grade

Historic Sites, Districts & Landmarks/Foreground Views

Elevated On Grade

Summary

Elevated On Grade

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict

Greatest - Intermediate Potential for Conflict

Intermediate Potential for Conflict

Intermediate - Least Potential for Conflict

Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

Fixed Guideway Transit Alternative

Highway Alignment Electric Power

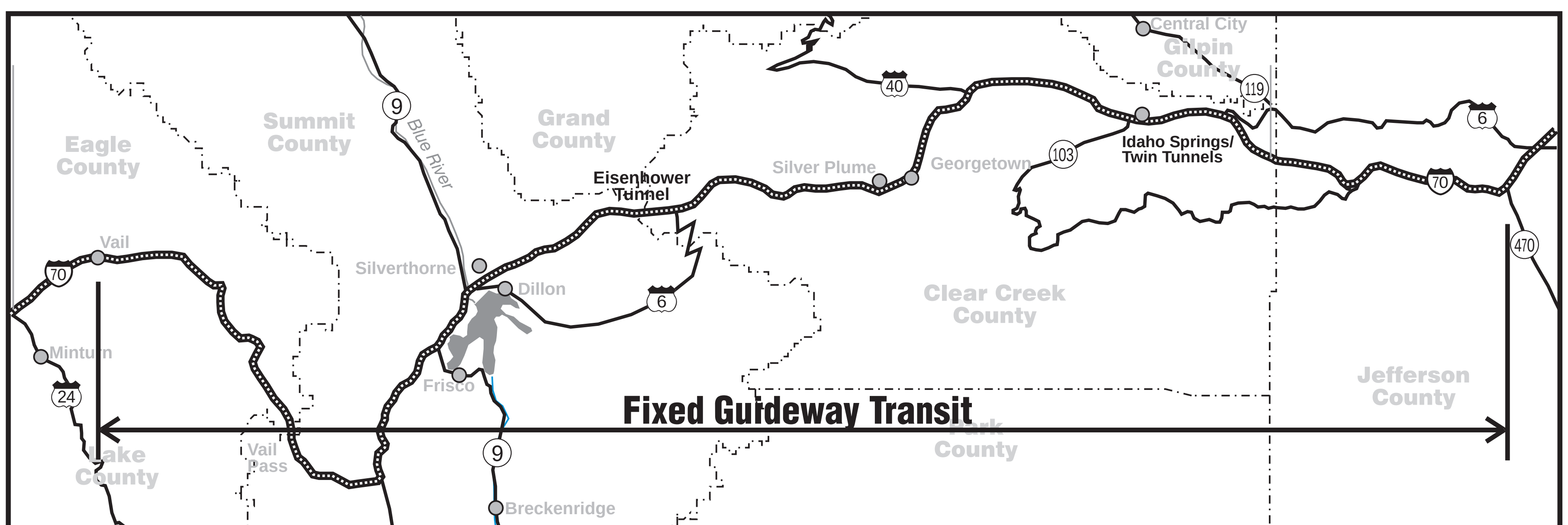
DRAFT

03/20/01

Fixed Guideway Transit Alternative

6% Alignment
Diesel Power

		Need							Safety	Implementation				
		System Capacity (Peak Hour)		System Attractiveness	Average Speed		Connectivity	Feeder/Distribution Requirements	System Safety	Costs	Technology Available	Fuel		Energy Consumption
Technology	**Track**	Actual	Rating		Actual	Rating						Avail.	Limit	
LRT	Single	1416			45.8									
LRT	Double	2832			45.8									
HRT	Single	4320			33.3									
HRT	Double	8640			33.3									
PRR in Corridor	Single	--												
PRR in Corridor	Double	--												



Fixed Guideway Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Legend for Technology:

LRT - Light Rail Transit; HRT - Heavy Rail Transit; PRR- Passenger Rail Road;
MUP - Multiple Unit Passanger Rail Road; AGS - Advanced Guideway System

Highest/Best	Best to Intermediate	Intermediate	Worst to Intermediate	Lowest/Worst

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*

Please Refer to Energy Requirements

Water Quality*

- Mine Tailings/Waste Rock
- Mineralized Rock
- Winter Maintenance
- Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

- Open and Flowing Waters
- Vegetated Wetlands
- Fen/Seep/Spring

Summary

Fish Habitats

- High Value Fishery
- Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

- Deer Range (Under Study)
- Elk Winter Concentration
- Big Horn Sheep Range
- Big Horn Sheep Lambing Area
- Biodiversity Area
- General Wildlife Crossing

Summary

Threatened, Endangered, and Sensitive Species*

- Potential Lynx Movement Corridor
- Boreal Toad
- Colorado Cutthroat Trout
- Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

- Rockfall
- Debris/Mud Flow
- Landslide
- Avalanche

Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*

- Noise Increase

Summary

Community/Recreation/ 4(f) and 6(f)*

- Community Areas
- Recreation (4(f)/6(f))
- Hike and Bike Trails (Under Study)

Summary

Cultural Resources/4(f)*

- Historic Districts
- Historic Sites & Trails
- Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

- USFS/Visual Quality Objectives/Retention* (Under Study)
- USFS/ROS/Roaded Natural* (Under Study)

Visually Sensitive Areas

- Community Setting/Foreground Views
- Recreation Sites/Foreground Views
- Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

- Greatest Potential for Conflict
- Greatest - Intermediate Potential for Conflict
- Intermediate Potential for Conflict
- Intermediate - Least Potential for Conflict
- Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

Fixed Guideway Transit Alternative

6% Alignment
Diesel Power

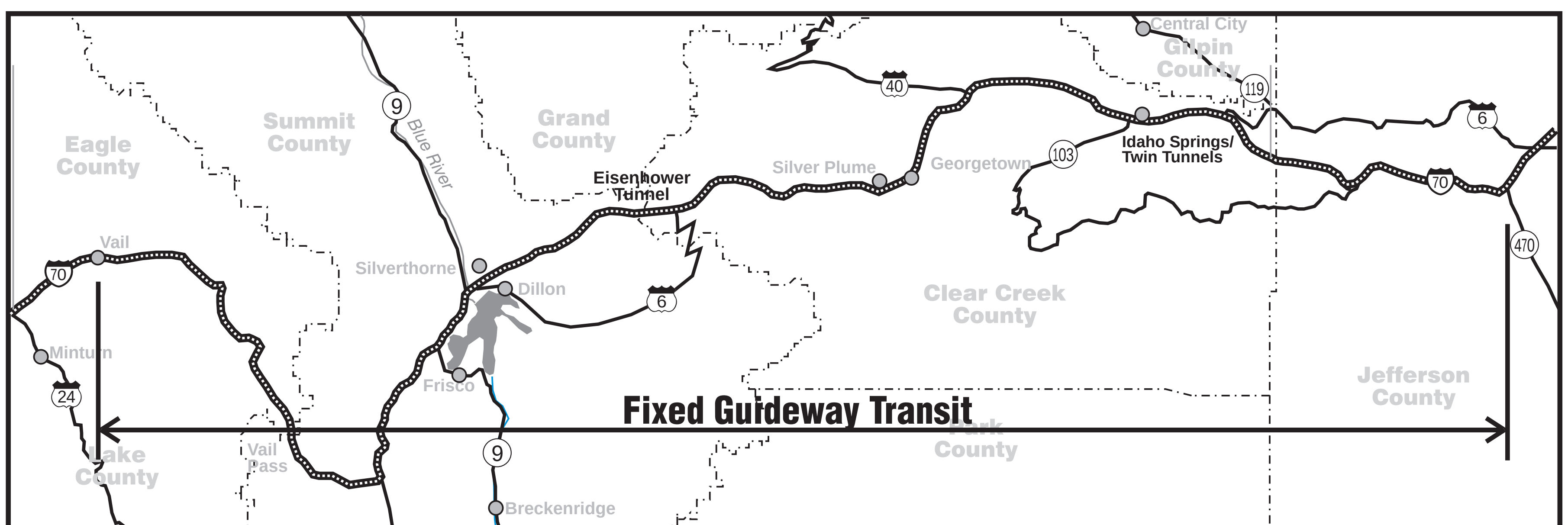
DRAFT

03/20/01

Fixed Guideway Transit Alternative

6% Alignment
Electric Power

Technology	Track	Need: System Capacity (Peak Hour) – Actual	Need: System Capacity (Peak Hour) – Rating	Need: System Attractiveness	Need: Average Speed – Actual	Need: Average Speed – Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs	Implementation: Technology Available	Implementation: Fuel – Avail.	Implementation: Fuel – Limit	Implementation: Energy Consumption
LRT	Single	1320	Lowest/Worst	Best to Intermediate	48.4	Intermediate	Best to Intermediate	Intermediate	Intermediate	Best to Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Best to Intermediate
LRT	Double	2640	Worst to Intermediate	Best to Intermediate	48.4	Intermediate	Best to Intermediate	Intermediate	Intermediate	Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Best to Intermediate
HRT	Single	4200	Intermediate	Highest/Best	44.6	Intermediate	Best to Intermediate	Intermediate	Best to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Highest/Best	Worst to Intermediate
HRT	Double	4200	Intermediate	Highest/Best	44.6	Intermediate	Best to Intermediate	Intermediate	Best to Intermediate	Worst to Intermediate	Best to Intermediate	Lowest/Worst	Highest/Best	Worst to Intermediate
PRR in Corridor	Single	--												
PRR in Corridor	Double	--												
AGS - Supported	Double	4200	Intermediate	Best to Intermediate	64.5	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Intermediate
AGS - Suspended	Double	4200	Intermediate	Best to Intermediate	64.5	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Intermediate
AGS - Side Hanging	Unit	4200	Intermediate	Best to Intermediate	64.5	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Intermediate
MUP	Single	4380	Intermediate	Highest/Best	42.8	Intermediate	Worst to Intermediate	Intermediate	Highest/Best	Intermediate	Worst to Intermediate	Lowest/Worst	Highest/Best	Intermediate
MUP	Double	8760	Highest/Best	Highest/Best	42.8	Intermediate	Worst to Intermediate	Intermediate	Highest/Best	Intermediate	Worst to Intermediate	Lowest/Worst	Highest/Best	Intermediate



Fixed Guideway Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Legend for Technology:
LRT - Light Rail Transit; HRT - Heavy Rail Transit; PRR- Passenger Rail Road;
MUP - Multiple Unit Passanger Rail Road; AGS - Advanced Guideway System

Highest/Best | Best to Intermediate | Intermediate | Worst to Intermediate | Lowest/Worst

Environmental Sensitivity

Air Quality*

Please Refer to Energy Requirements

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Deer Range

Under Study

Elk Winter Concentration

Big Horn Sheep Range

Big Horn Sheep Lambing Area

Biodiversity Area

General Wildlife Crossing

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Noise Increase

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict

Greatest - Intermediate Potential for Conflict

Intermediate Potential for Conflict

Intermediate - Least Potential for Conflict

Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

Fixed Guideway Transit Alternative

6% Alignment
Electric Power

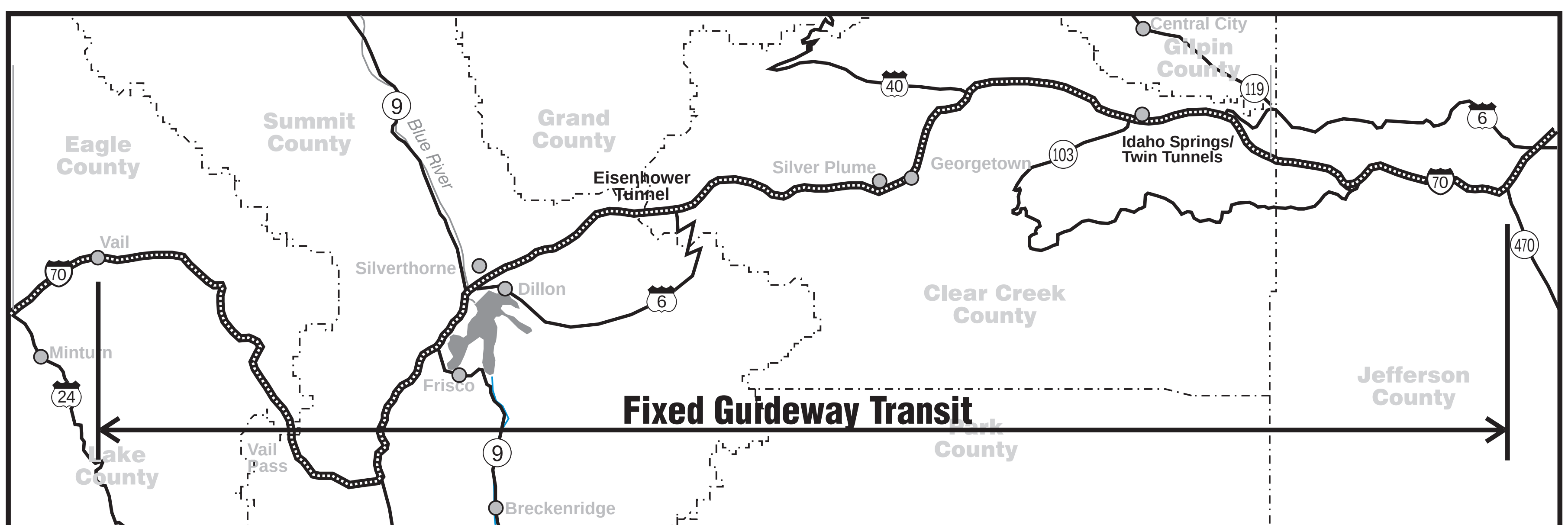
DRAFT

03/20/01

Fixed Guideway Transit Alternative

4% Alignment
Diesel Power

Technology	Track	Need: System Capacity (Peak Hour) – Actual	Need: System Capacity (Peak Hour) – Rating	Need: System Attractiveness	Need: Average Speed – Actual	Need: Average Speed – Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs	Implementation: Technology Available	Implementation: Fuel – Avail.	Implementation: Fuel – Limit	Implementation: Energy Consumption
LRT	Single	1416	Lowest/Worst	Best to Intermediate	48.7	Intermediate	Highest/Best	Intermediate	Intermediate	Intermediate	Highest/Best	Highest/Best	Lowest/Worst	Best to Intermediate
LRT	Double	2832	Worst to Intermediate	Best to Intermediate	48.7	Intermediate	Highest/Best	Intermediate	Intermediate	Lowest/Worst	Highest/Best	Highest/Best	Lowest/Worst	Best to Intermediate
HRT	Single	4320	Intermediate	Highest/Best	36.4	Worst to Intermediate	Highest/Best	Intermediate	Best to Intermediate	Lowest/Worst	Highest/Best	Highest/Best	Lowest/Worst	Worst to Intermediate
HRT	Double	8640	Highest/Best	Highest/Best	36.4	Worst to Intermediate	Highest/Best	Intermediate	Best to Intermediate	Lowest/Worst	Highest/Best	Highest/Best	Lowest/Worst	Worst to Intermediate
PRR in Corridor	Single	--												
PRR in Corridor	Double	--												



Fixed Guideway Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Legend for Technology:

LRT - Light Rail Transit; HRT - Heavy Rail Transit; PRR- Passenger Rail Road; MUP - Multiple Unit Passanger Rail Road; AGS - Advanced Guideway System

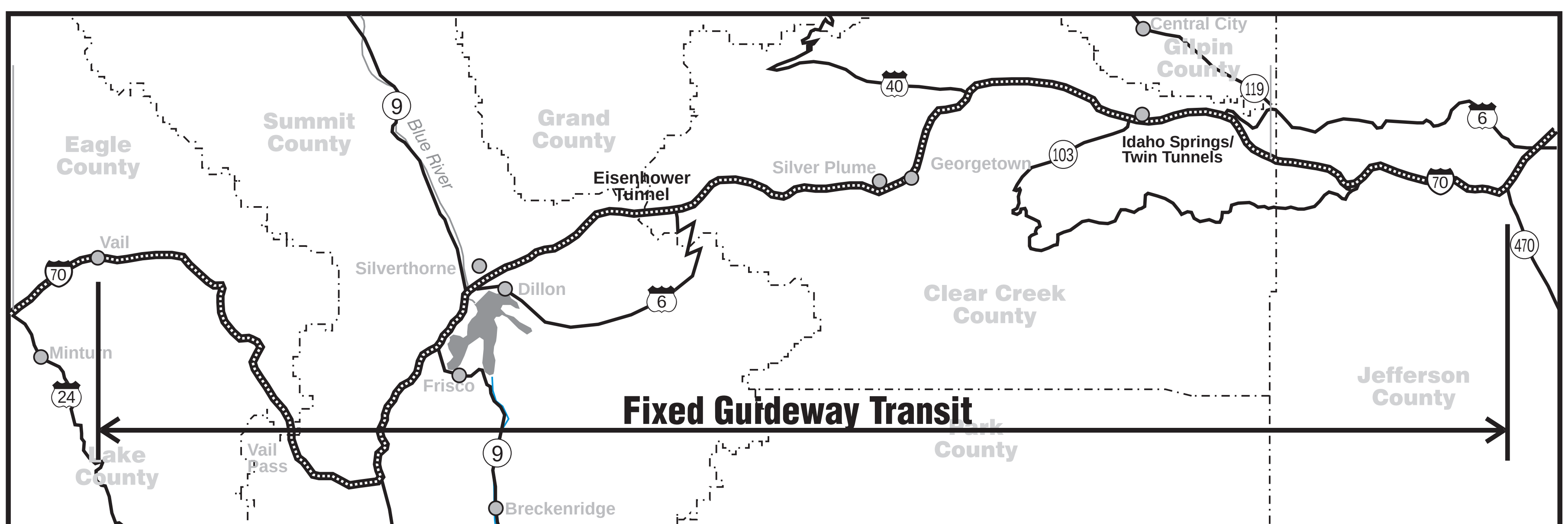
Highest/Best | Best to Intermediate | Intermediate | Worst to Intermediate | Lowest/Worst

03/20/01

Fixed Guideway Transit Alternative

4% Alignment
Electric Power

Technology	Track	Need: System Capacity (Peak Hour) Actual	Need: System Capacity (Peak Hour) Rating	Need: System Attractiveness	Need: Average Speed Actual	Need: Average Speed Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs	Implementation: Technology Available	Implementation: Fuel Avail.	Implementation: Fuel Limit	Implementation: Energy Consumption
LRT	Single	1320	Lowest/Worst	Best to Intermediate	50.2	Best to Intermediate	Best to Intermediate	Intermediate	Intermediate	Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Best to Intermediate
LRT	Double	2640	Worst to Intermediate	Best to Intermediate	50.2	Best to Intermediate	Best to Intermediate	Intermediate	Intermediate	Lowest/Worst	Highest/Best	Lowest/Worst	Highest/Best	Best to Intermediate
HRT	Single	4200	Intermediate	Highest/Best	47.2	Intermediate	Best to Intermediate	Intermediate	Best to Intermediate	Worst to Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Worst to Intermediate
HRT	Double	4200	Intermediate	Highest/Best	47.2	Intermediate	Best to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Highest/Best	Lowest/Worst	Highest/Best	Worst to Intermediate
PRR in Corridor	Single	--												
PRR in Corridor	Double	--												
AGS - Supported	Double	4200	Intermediate	Best to Intermediate	68.3	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Best to Intermediate
AGS - Suspended	Double	4200	Intermediate	Best to Intermediate	68.3	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Best to Intermediate
AGS - Side Hanging	Unit	4200	Intermediate	Best to Intermediate	68.3	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Lowest/Worst	Lowest/Worst	Highest/Best	Best to Intermediate
MUP	Single	4380	Intermediate	Highest/Best	45.7	Intermediate	Worst to Intermediate	Intermediate	Highest/Best	Worst to Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Intermediate
MUP	Double	8760	Highest/Best	Highest/Best	45.7	Intermediate	Worst to Intermediate	Intermediate	Highest/Best	Lowest/Worst	Highest/Best	Lowest/Worst	Highest/Best	Intermediate



Fixed Guideway Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

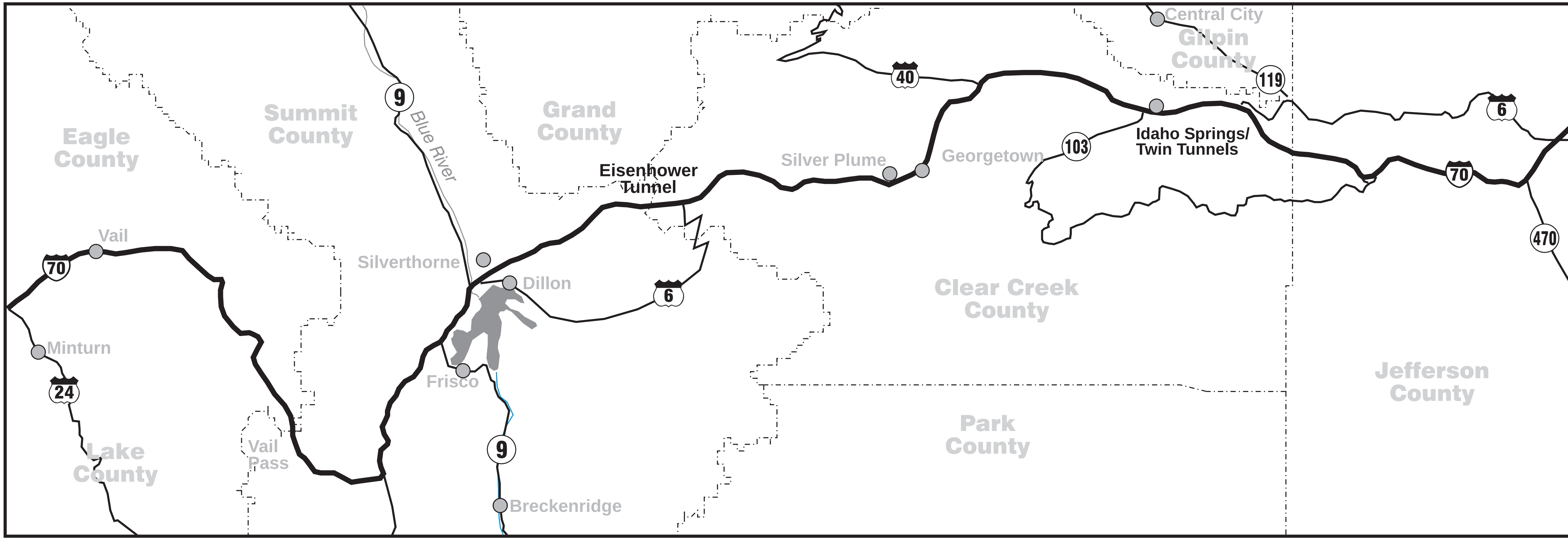
Implementation -

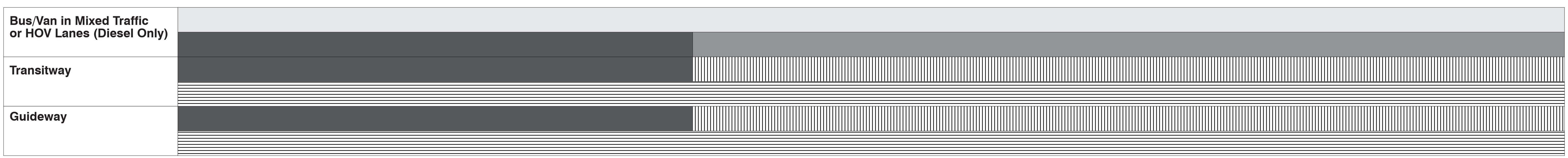
Legend for Technology:
LRT - Light Rail Transit; HRT - Heavy Rail Transit; PRR- Passenger Rail Road; MUP - Multiple Unit Passanger Rail Road; AGS - Advanced Guideway System

Highest/Best | Best to Intermediate | Intermediate | Worst to Intermediate | Lowest/Worst

03/20/01

4 - RTT ALTERNATIVES





LEGEND

- Bus/Van in Mixed Traffic or HOV Lanes (Diesel Only)
- Mixed Traffic
- All HOV Options
- Diesel and Dual Power Options
- Electric Power Option

DRAFT

I-70 Mountain Corridor PEIS
Rubber Tire Transit Alternatives

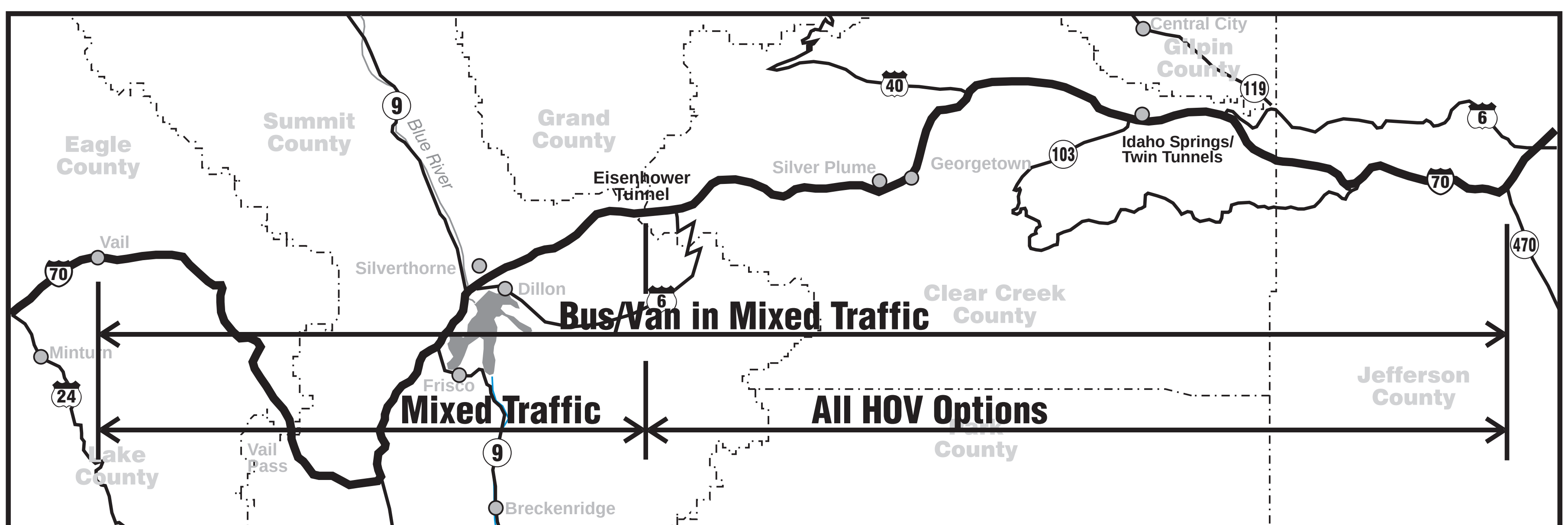
03/20/01

RTT Sections To Be Provided

Rubber Tire Transit Alternative

Bus/Van in Mixed Traffic or HOV Lanes (Diesel Only)

Type of HOV	Direction	Need: Practical Capacity (Peak Hour) Rating	Need: System Attractiveness	Need: Average Speed Actual MPH	Need: Average Speed Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs CAP.	Implementation: Technology Available	Implementation: Fuel Usage	Implementation: Energy Consumption
Bus/Van in Mixed Traffic	Both	Highest/Best	Lowest/Worst	36	Lowest/Worst	Highest/Best	Highest/Best	Lowest/Worst	Highest/Best	Highest/Best	Highest/Best	Highest/Best
Marked Lane	Peak	Highest/Best	Lowest/Worst	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Best to Intermediate	Best to Intermediate	Highest/Best	Highest/Best
Marked Lane	Both	Highest/Best	Lowest/Worst	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Best to Intermediate	Best to Intermediate	Highest/Best	Highest/Best
Separated Lane	Peak	Highest/Best	Worst to Intermediate	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best	Highest/Best
Separated Lane	Both	Highest/Best	Worst to Intermediate	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Worst to Intermediate	Best to Intermediate	Highest/Best	Highest/Best



Rubber Tire Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

Note: Cost estimates for all RTT options were developed on conceptual operating plans.

Note: All RTT Options Are Assumed to Operate in the Current Highway Alignment.

03/20/01

Environmental Sensitivity

Air Quality*

Please Refer to
Energy Requirements

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Deer Range

Under Study

Elk Winter Concentration

Big Horn Sheep Range

Big Horn Sheep Lambing Area

Biodiversity Area

General Wildlife Crossing

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*

Diesel Dual Electric

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict	Greatest - Intermediate Potential for Conflict	Intermediate Potential for Conflict	Intermediate - Least Potential for Conflict	Least Potential for Conflict

* Applicable Federal Regulations
(Refer to Table x)

Rubber Tire Transit Alternative

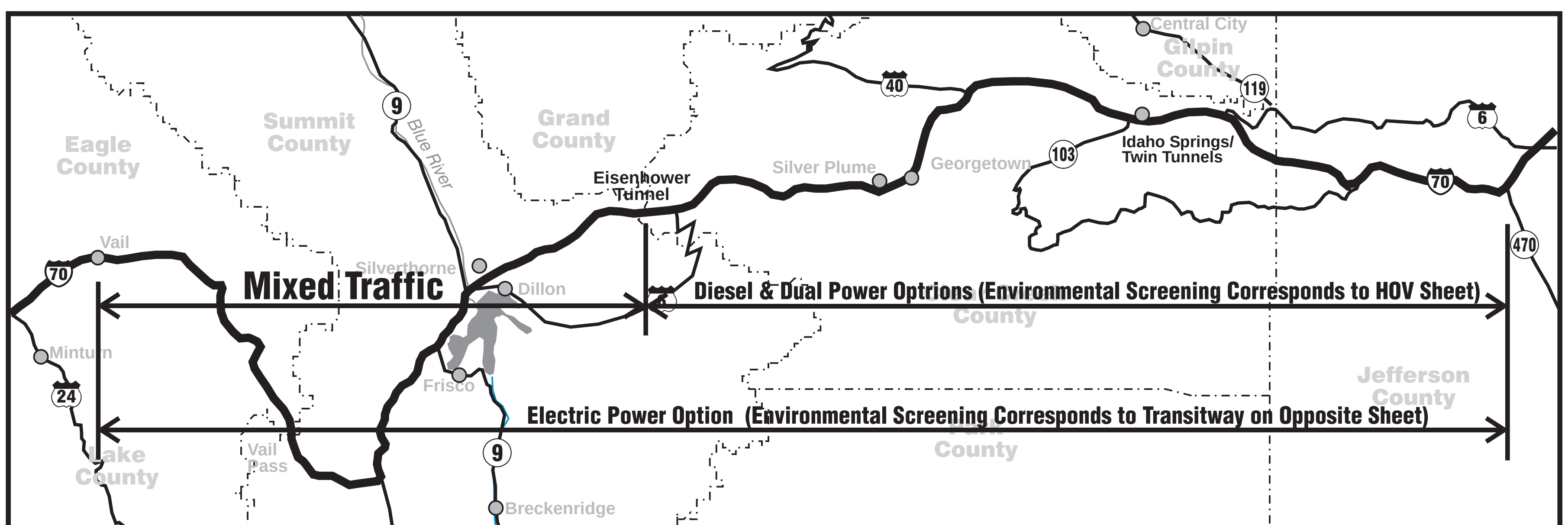
DRAFT

HOV Lanes

03/20/01

Rubber Tire Transit Alternative
Transitway

Type of Power	Direction	Need: Practical Capacity (Peak Hour) Rating	Need: System Attractiveness	Need: Average Speed Actual MPH	Need: Average Speed Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs CAP.	Implementation: Technology Available	Implementation: Fuel Usage	Implementation: Energy Consumption
Diesel Power												
	Peak	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Intermediate	Best to Intermediate	Highest/Best	Highest/Best
	Both	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Intermediate	Best to Intermediate	Highest/Best	Highest/Best
DualPower (Diesel/Elec)												
	Peak	Highest/Best	Worst to Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Worst to Intermediate	Worst to Intermediate	Intermediate	Highest/Best
	Both	Highest/Best	Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Worst to Intermediate	Worst to Intermediate	Intermediate	Highest/Best
Electric Power												
	Both	Highest/Best	Intermediate	60	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Worst to Intermediate	Lowest/Worst	Best to Intermediate



Rubber Tire Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best
(solid black)	(crosshatch)	(diagonal hatch)	(dotted)	(blank)

Note: Cost estimates for all RTT options were developed on conceptual operating plans.

Note: All RTT Options Are Assumed to Operate in the Current Highway Alignment.

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*	Water Quality*	Waters of the U.S./Wetlands*	Fish Habitats	Wildlife Habitats and Crossings	Threatened, Endangered, and Sensitive Species*	Geologic Hazards/Mining
Please Refer to Energy Requirements	Mine Tailings/Waste Rock	Open and Flowing Waters	High Value Fishery	Deer Range (Under Study)	Potential Lynx Movement Corridor	Rockfall
	Mineralized Rock	Vegetated Wetlands	Gold Medal Fisheries	Elk Winter Concentration	Boreal Toad	Debris/Mud Flow
	Winter Maintenance	Fen/Seep/Spring		Big Horn Sheep Range	Colorado Cutthroat Trout	Landslide
	Stormwater Runoff			Big Horn Sheep Lambing Area	Greenback Cutthroat Trout	Avalanche
				Biodiversity Area		
				General Wildlife Crossing		
	Summary	Summary	Summary	Summary	Summary	Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*	Community/Recreation/ 4(f) and 6(f)*	Cultural Resources/4(f)*	Federal Management and Scenic Features/Views*
Diesel / Dual / Electric	Community Areas	Historic Districts	USFS/Visual Quality Objectives/Retention* (Under Study)
	Recreation (4(f)/6(f))	Historic Sites & Trails	USFS/ROS/Roaded Natural* (Under Study)
	Hike and Bike Trails (Under Study)	Archaeological Sites	Visually Sensitive Areas
			Community Setting/Foreground Views
			Recreation Sites/Foreground Views
			Historic Sites, Districts & Landmarks/Foreground Views
Summary	Summary	Summary	Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict | Greatest - Intermediate Potential for Conflict | Intermediate Potential for Conflict | Intermediate - Least Potential for Conflict | Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

Rubber Tire Transit Alternative

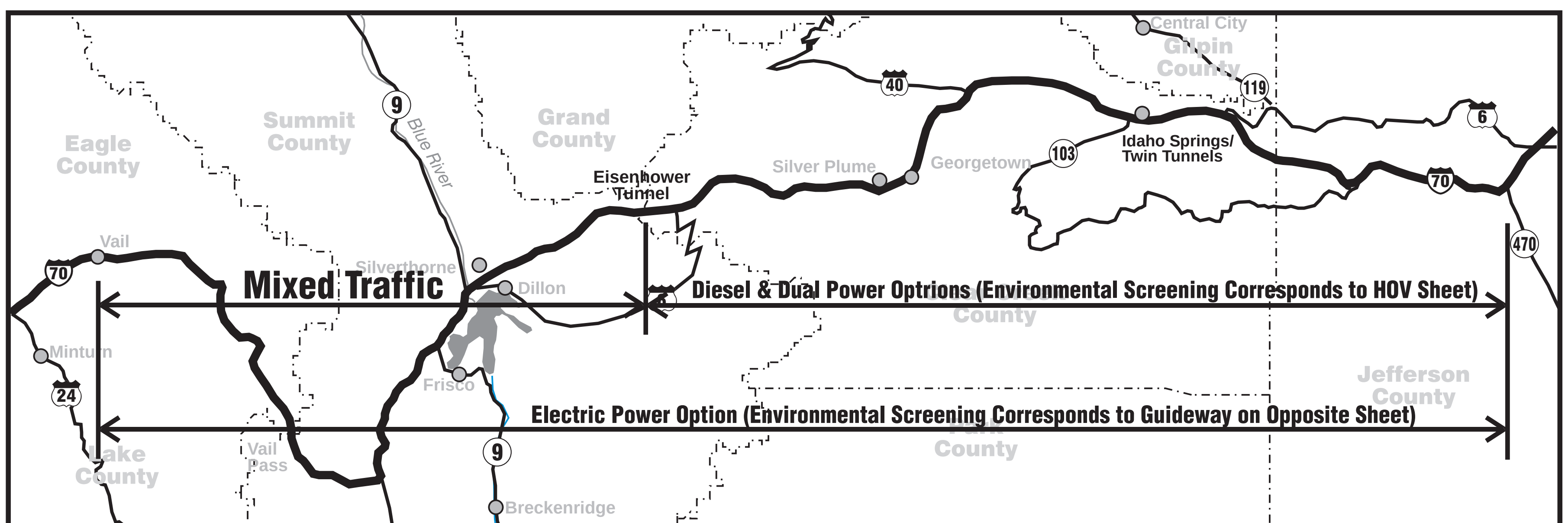
DRAFT

Transit Way

03/20/01

Rubber Tire Transit Alternative
Guideway (Guided Transitway)

Type of Power	Direction	Need: Practical Capacity (Peak Hour) – Rating	Need: System Attractiveness	Need: Average Speed – Actual MPH	Need: Average Speed – Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs – CAP.	Implementation: Technology Available	Implementation: Fuel Usage	Implementation: Energy Consumption
Diesel Power												
	Peak	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Best to Intermediate	Best to Intermediate	Intermediate	Highest/Best	Highest/Best
	Both	Highest/Best	Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Best to Intermediate	Best to Intermediate	Intermediate	Highest/Best	Highest/Best
	BRT Station	Highest/Best	Intermediate	54	Best to Intermediate	Highest/Best	Intermediate	Best to Intermediate	Intermediate	Intermediate	Highest/Best	Highest/Best
Dual Power (Diesel/Elec)												
	Peak	Highest/Best	Best to Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Highest/Best	Intermediate	Lowest/Worst	Intermediate	Highest/Best
	Both	Highest/Best	Best to Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Highest/Best	Worst to Intermediate	Lowest/Worst	Intermediate	Highest/Best
	BRT Station	Highest/Best	Best to Intermediate	64	Highest/Best	Highest/Best	Intermediate	Highest/Best	Worst to Intermediate	Lowest/Worst	Intermediate	Highest/Best
Electric Power												
	Both	Highest/Best	Highest/Best	60	Best to Intermediate	Worst to Intermediate	Intermediate	Highest/Best	Lowest/Worst	Lowest/Worst	Lowest/Worst	Best to Intermediate
	BRT Station	Highest/Best	Highest/Best	64	Highest/Best	Worst to Intermediate	Intermediate	Highest/Best	Lowest/Worst	Lowest/Worst	Lowest/Worst	Best to Intermediate



Rubber Tire Transit Alternative I-70 Context

Technical Summary:

Need -

Safety -

Implementation -

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

BRT - Bus Rapid Transit

Note: Cost estimates for all RTT options were developed on conceptual operating plans.

Note: All RTT Options Are Assumed to Operate in the Current Highway Alignment.

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*

Please Refer to
Energy Requirements

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Deer Range

Under Study

Elk Winter Concentration

Big Horn Sheep Range

Big Horn Sheep Lambing Area

Biodiversity Area

General Wildlife Crossing

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*

Diesel Dual Electric

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict

Greatest - Intermediate Potential for Conflict

Intermediate Potential for Conflict

Intermediate - Least Potential for Conflict

Least Potential for Conflict

* Applicable Federal Regulations
(Refer to Table x)

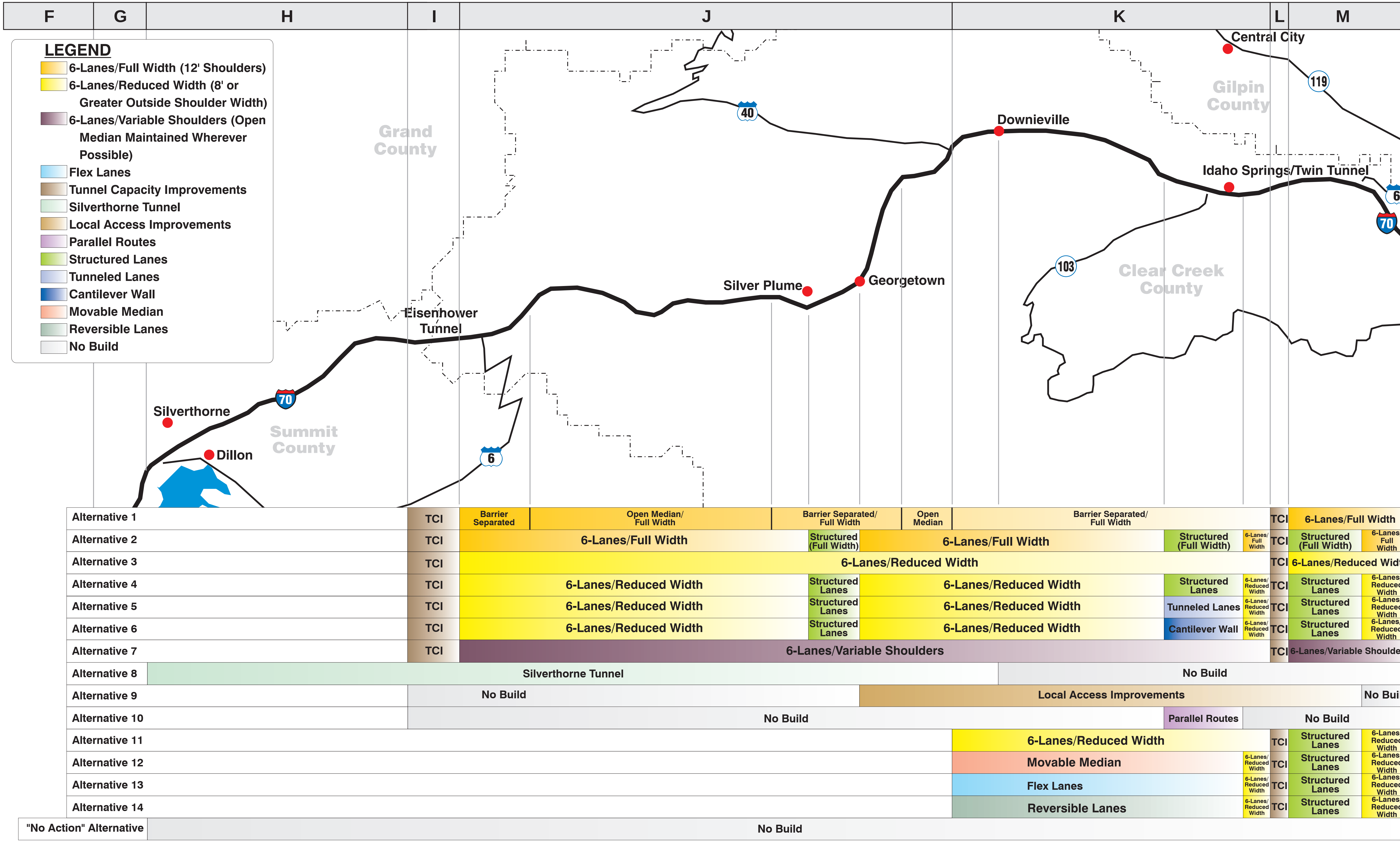
Rubber Tire Transit Alternative

DRAFT

Guideway

03/20/01

5 – HIGHWAY ALTERNATIVES



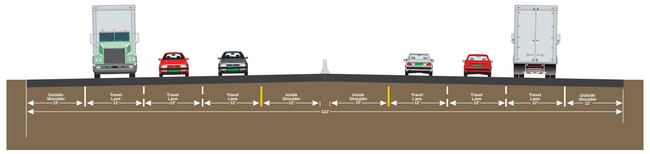
Note 1: Alternatives respond to 2020 conditions.
Note 2: Future alternatives may be a mix of various alternatives shown above.

DRAFT

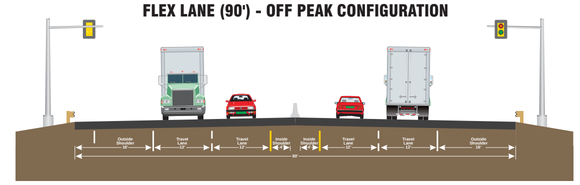
I-70 Mountain Corridor PEIS Primary Highway Alternatives

03/18/01

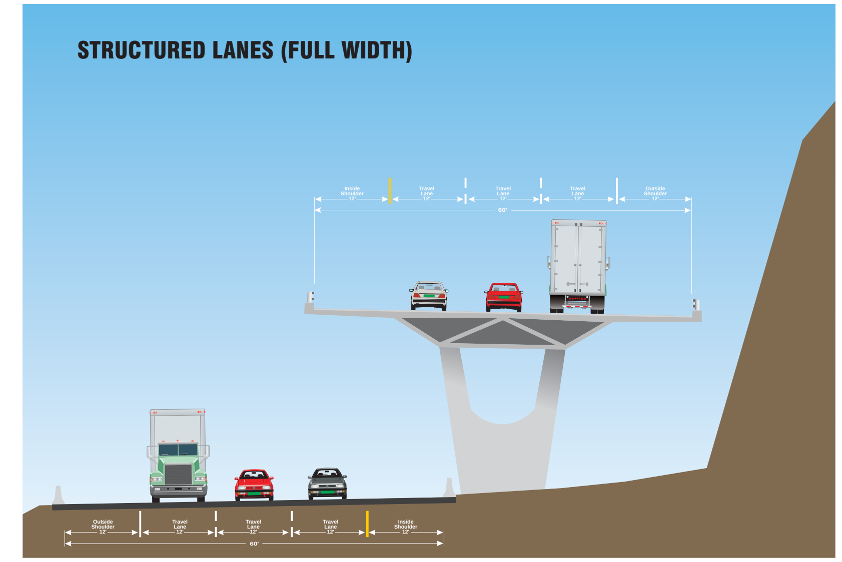
6 LANE FULL WIDTH (BARRIER) (122')



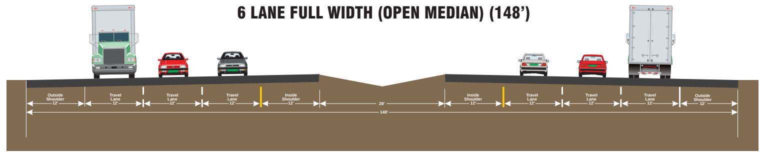
FLEX LANE (90') - OFF PEAK CONFIGURATION



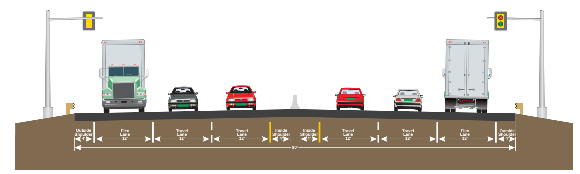
STRUCTURED LANES (FULL WIDTH)



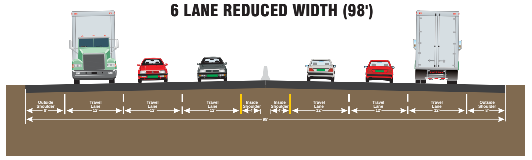
6 LANE FULL WIDTH (OPEN MEDIAN) (148')



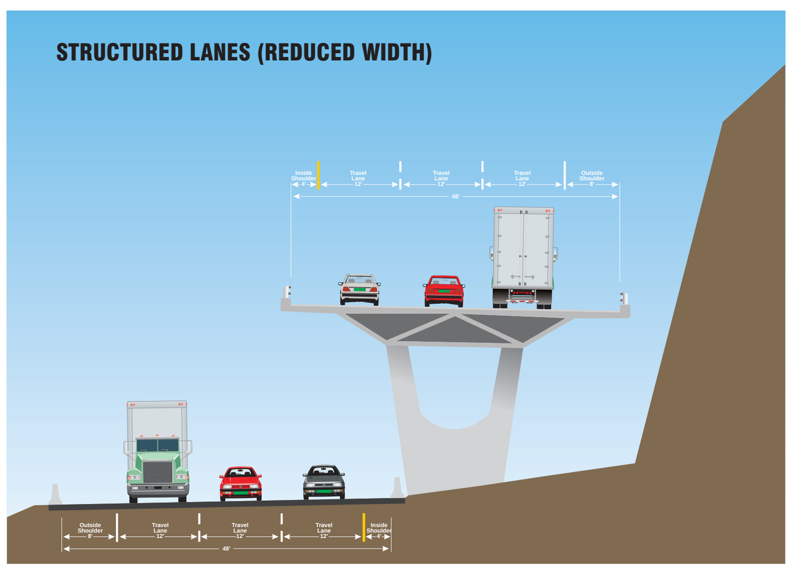
FLEX LANE (90') - PEAK CONFIGURATION



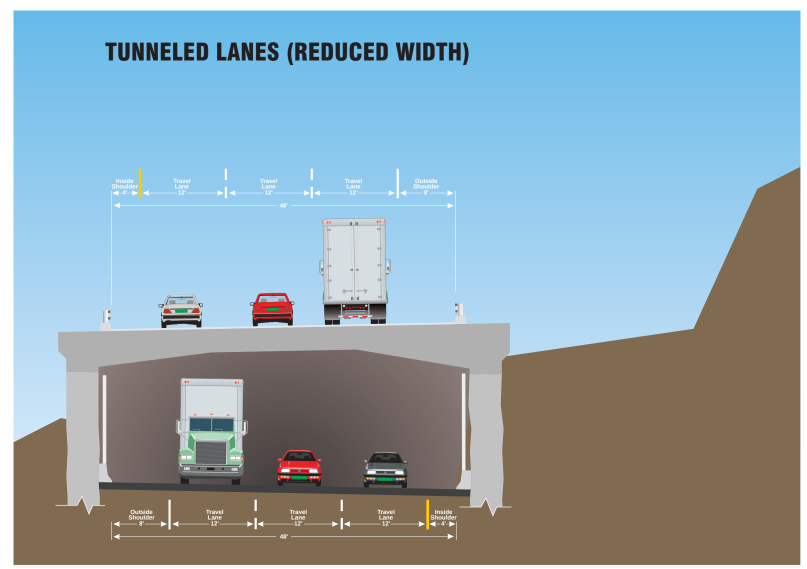
6 LANE REDUCED WIDTH (98')



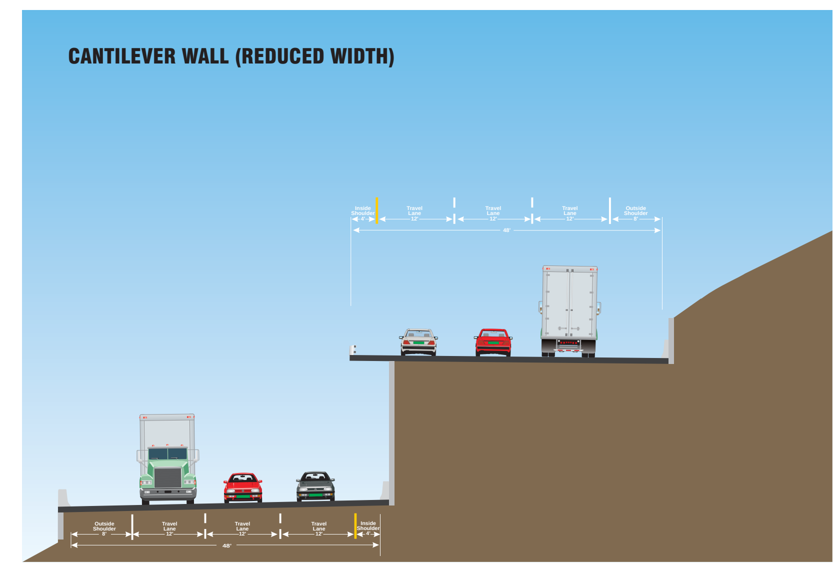
STRUCTURED LANES (REDUCED WIDTH)



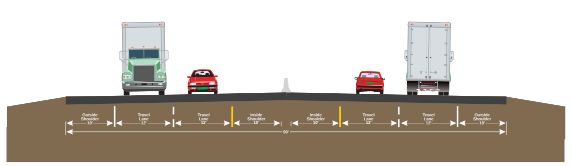
TUNNELED LANES (REDUCED WIDTH)



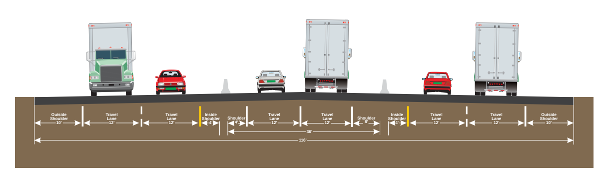
CANTILEVER WALL (REDUCED WIDTH)



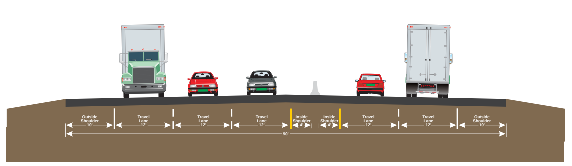
MOVEABLE MEDIAN (90') - OFF PEAK CONFIGURATION



REVERSIBLE LANE (116')



MOVEABLE MEDIAN (90') - PEAK CONFIGURATION



Highway Alternative Sections

DRAFT

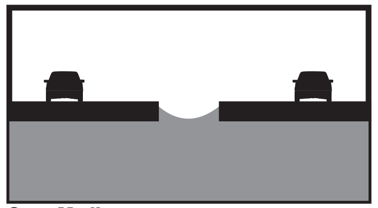
03/20/01

Highway Alternative 1

6-Lane/Full Width

Tunnel Capacity Improvements (TCI)
(Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)

Barrier Separated



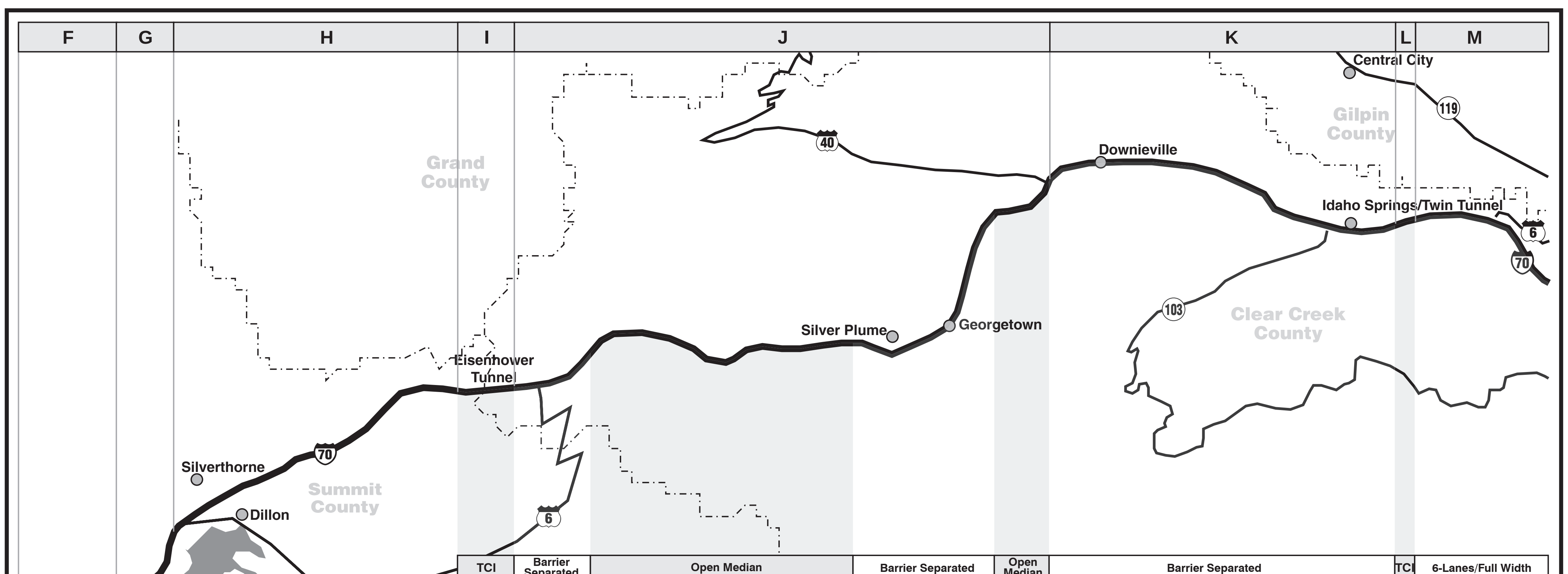
Open Median

Description of Highway Alternatives

This Alternative is a hybrid of the various Full-width alternatives (open and barrier medians). The selection of median treatment was based on the available platform width where an existing barrier is present, a barrier section is proposed; where an open median is present, an open median is proposed.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 1	0.56 LOS C	0.83 LOS D	65	61	0	0			

Technical Summary:



Alternative 1 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Summary

Community/Recreation/ 4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict | Greatest - Intermediate Potential for Conflict | Intermediate Potential for Conflict | Intermediate - Least Potential for Conflict | Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

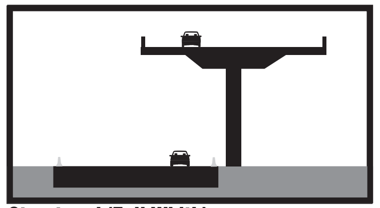
Highway Alternative 1

03/20/01

Highway Alternative 2

6-Lane/Full Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)



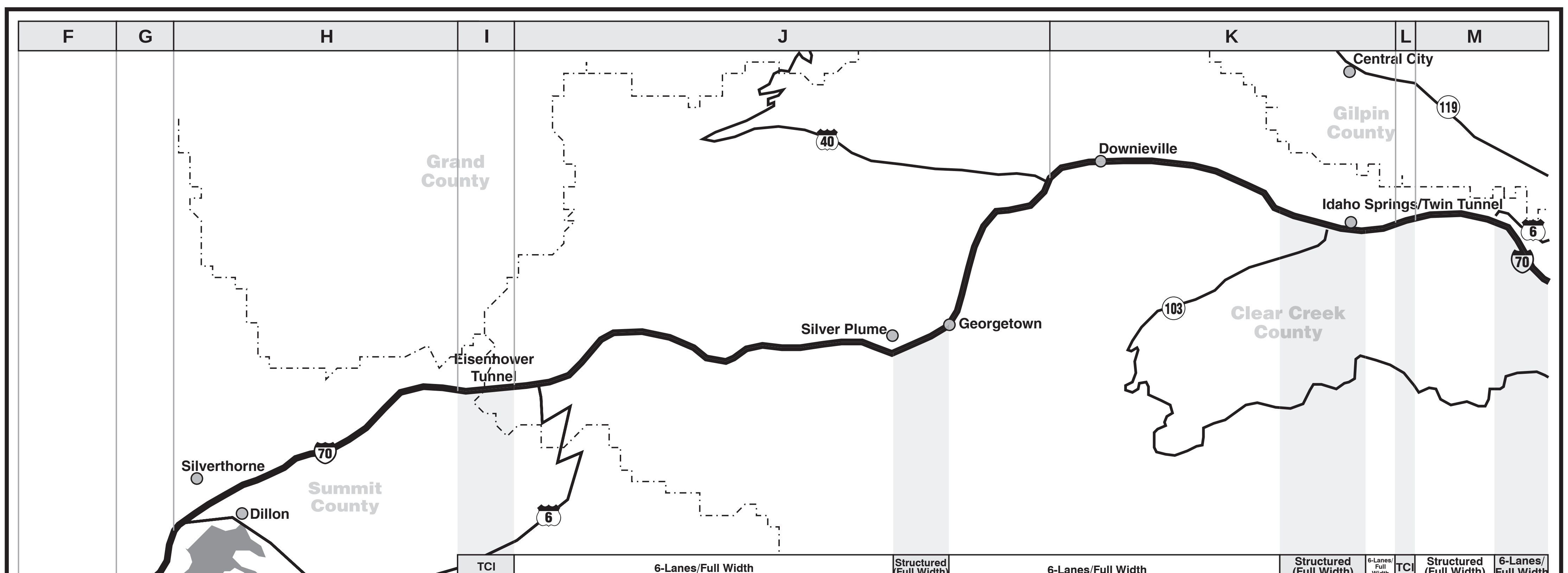
Structured (Full Width)

Description of Highway Alternatives

This Alternative is a Full-width section. It is included as a baseline to which all other narrower sections will be compared. Structured Lanes are included in three sensitive locations to minimize impacts.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 2	0.56 LOS C	0.83 LOS D	65	61	0	0			

Technical Summary:



Alternative 2 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

03/20/01

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- · Air Quality
- · Water Quality
- · Wetlands
- · Wildlife Habitats and Crossings
- · Threatened, Endangered & Sensitive Species
- · Fish Habitats
- · Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | George-town | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Summary

Community/Recreation/ 4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- · Noise
- · Land Use/Recreation/4(f) and 6(f)
- · Cultural Resources/4(f)
- · Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict | Greatest - Intermediate Potential for Conflict | Intermediate Potential for Conflict | Intermediate - Least Potential for Conflict | Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

Highway Alternative 2

03/20/01

Highway Alternative 3

6-Lane/Reduced Width

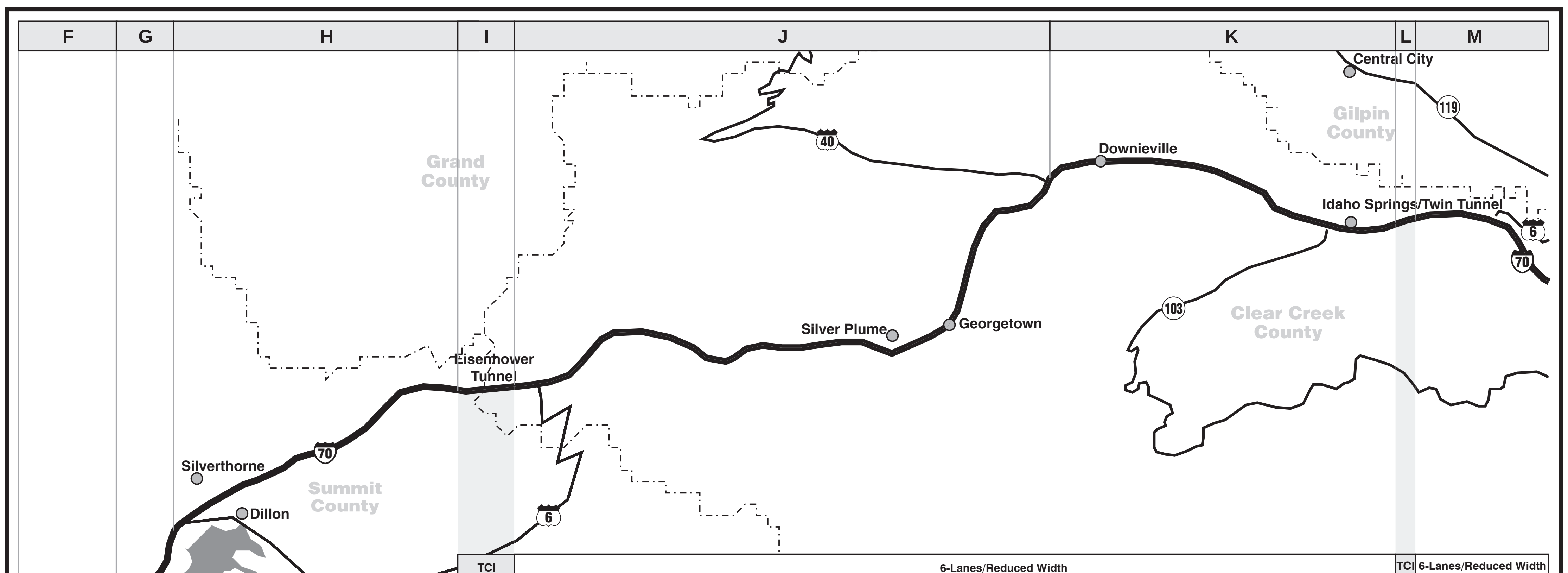
Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 3	0.56 LOS C	0.83 LOS D	65	61	0	0			

Description of Highway Alternatives

This Alternative is an option to Alternative 2, in which a reduced-width section is used to reduce impacts along the entire Corridor.

Technical Summary:



Alternative 3 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

Environmental Sensitivity

Air Quality*
Total Emissions
Under Study
% Change Between Alternatives and Current Conditions
Total Particulates and Dust
Under Study
% Change Between Alternatives and Current Conditions

Water Quality*
Mine Tailings/Waste Rock
Mineralized Rock
Winter Maintenance
Stormwater Runoff
Summary

Waters of the U.S./Wetlands*
Open and Flowing Waters
Vegetated Wetlands
Fen/Seep/Spring
Summary

Fish Habitats
High Value Fishery
Gold Medal Fisheries
Summary

Wildlife Habitats and Crossings
Elk and Big Horn Sheep Range
Crossings
Biodiversity Area
Deer
Under Study
Summary

Threatened, Endangered, and Sensitive Species*
Potential Lynx Movement Corridor
Boreal Toad
Colorado Cutthroat Trout
Greenback Cutthroat Trout
Summary

Geologic Hazards/Mining
Rockfall
Debris/Mud Flow
Landslide
Avalanche
Summary

Summary - Environmental Sensitivity
- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*
Peak Hour Increase
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail
24-Hour Increase
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail
Number of Receptors
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail
Potential for Mitigation
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail
Summary

Community/Recreation/ 4(f) and 6(f)*
Community Areas
Recreation (4(f)/6(f))
Hike and Bike Trails
Under Study
Summary

Cultural Resources/4(f)*
Historic Districts
Historic Sites & Trails
Archaeological Sites
Summary

Federal Management and Scenic Features/Views*
USFS/Visual Quality Objectives/Retention*
Under Study
USFS/ROS/Roaded Natural*
Under Study
Visually Sensitive Areas
Community Setting/Foreground Views
Recreation Sites/Foreground Views
Historic Sites, Districts & Landmarks/Foreground Views
Summary

Summary - Community Values
- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict
Greatest Potential for Conflict | Greatest - Intermediate Potential for Conflict | Intermediate Potential for Conflict | Intermediate - Least Potential for Conflict | Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

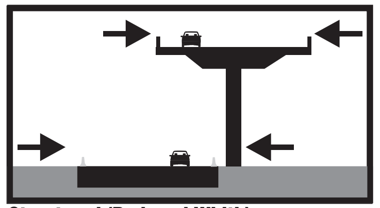
Highway Alternative 3

03/20/01

Highway Alternative 4

6-Lane/Reduced Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)



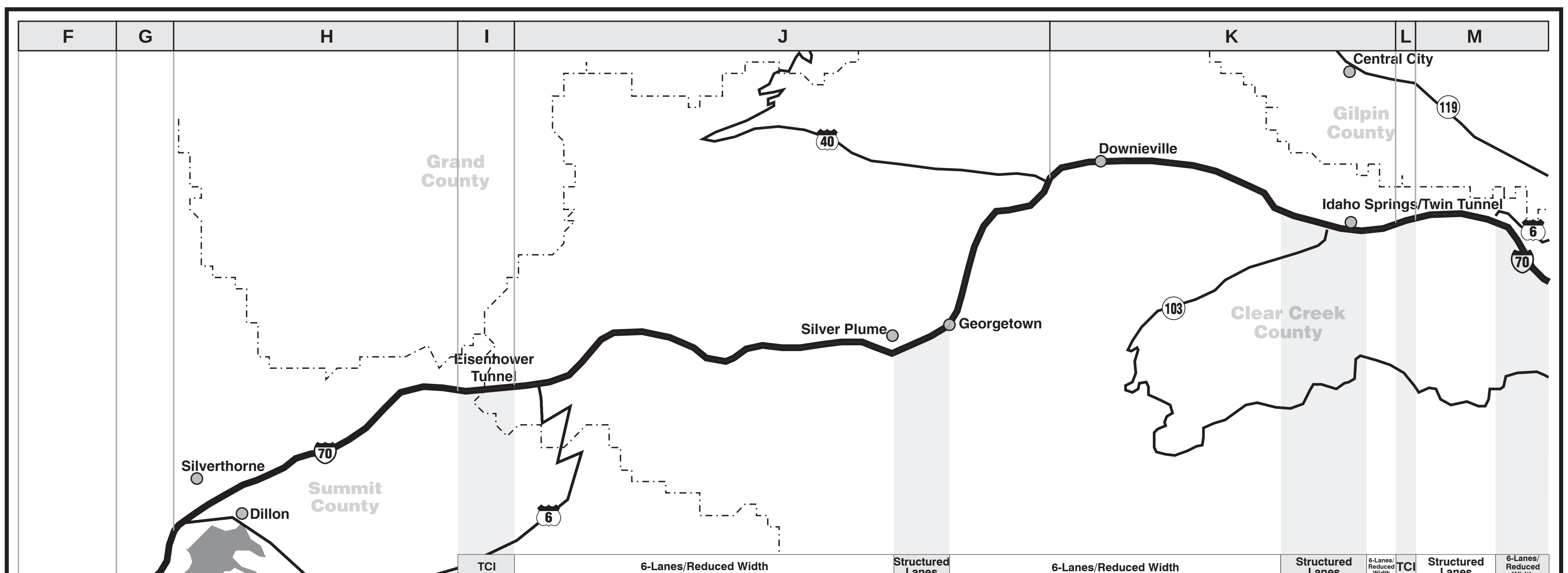
Structured (Reduced Width)

Description of Highway Alternatives

Same as Alternative 2, but with Reduced-width Structured Lanes at three sensitive locations.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 4	0.56 LOS C	0.83 LOS D	65	61	0	0			

Technical Summary:



Alternative 4 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict | Greatest - Intermediate Potential for Conflict | Intermediate Potential for Conflict | Intermediate - Least Potential for Conflict | Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

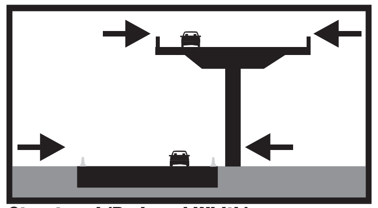
Highway Alternative 4

03/20/01

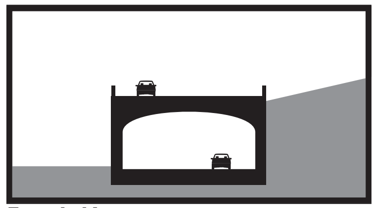
Highway Alternative 5

6-Lane/Reduced Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)



Structured (Reduced Width)



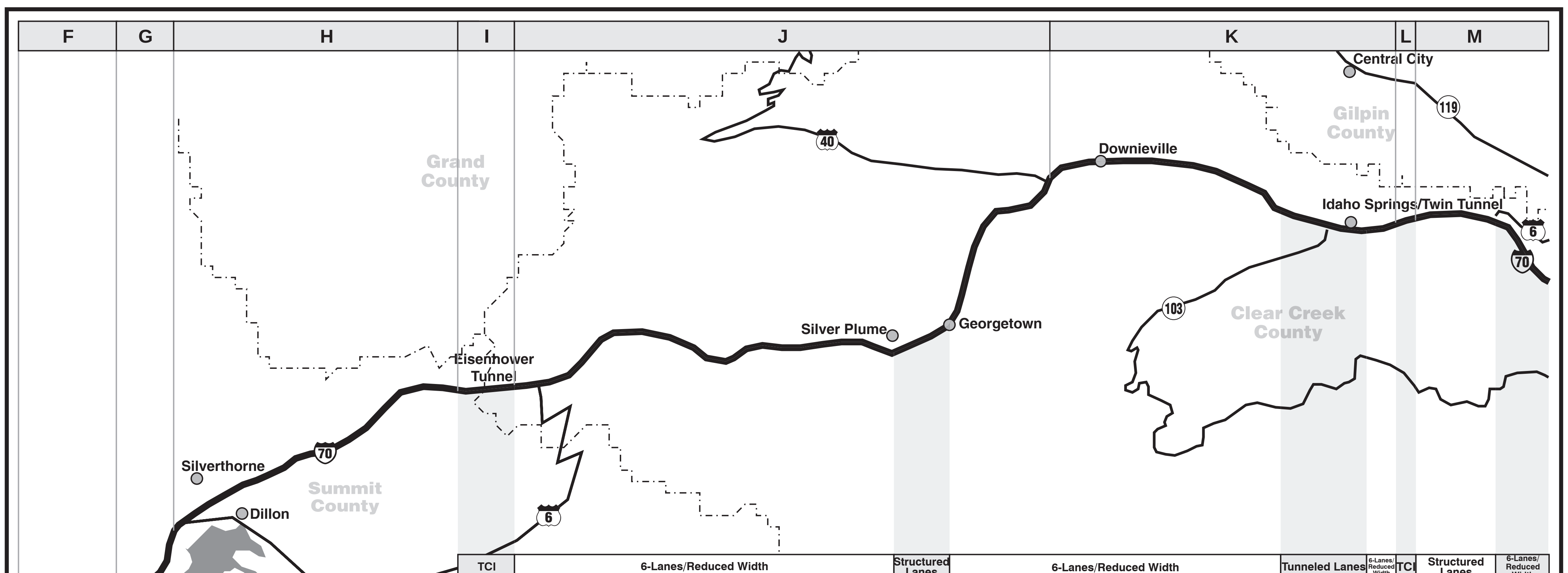
Tunneled Lanes

Description of Highway Alternatives

Same as Alternative 4, but with Tunneled Lanes through Idaho Springs.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 5	0.56 LOS C	0.83 LOS D	65	61	0	0			

Technical Summary:



Alternative 5 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Summary

Community/Recreation/ 4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

- Greatest Potential for Conflict
- Greatest - Intermediate Potential for Conflict
- Intermediate Potential for Conflict
- Intermediate - Least Potential for Conflict
- Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

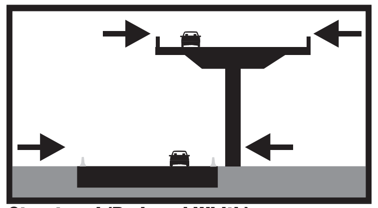
Highway Alternative 5

03/20/01

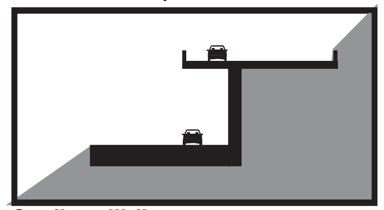
Highway Alternative 6

6-Lane/Reduced Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)



Structured (Reduced Width)



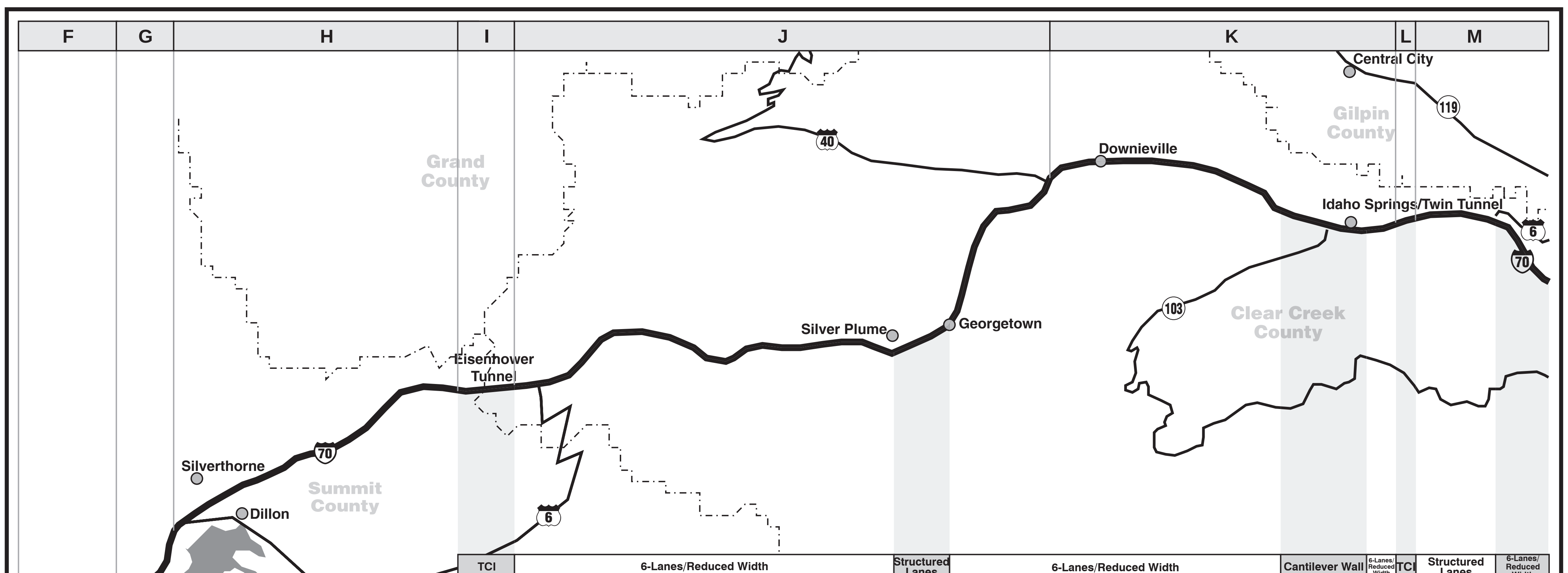
Cantilever Wall

Description of Highway Alternatives

Same as Alternative 4, but with a Cantilevered Wall through Idaho Springs.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 6	0.56 LOS C	0.83 LOS D	64	61	0	0			

Technical Summary:



Alternative 6 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Summary

Community/Recreation/ 4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict

Greatest - Intermediate Potential for Conflict

Intermediate Potential for Conflict

Intermediate - Least Potential for Conflict

Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

Highway Alternative 6

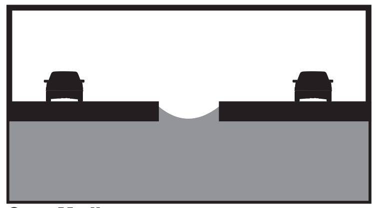
03/20/01

Highway Alternative 7

6-Lane/Reduced Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)

Barrier Separated



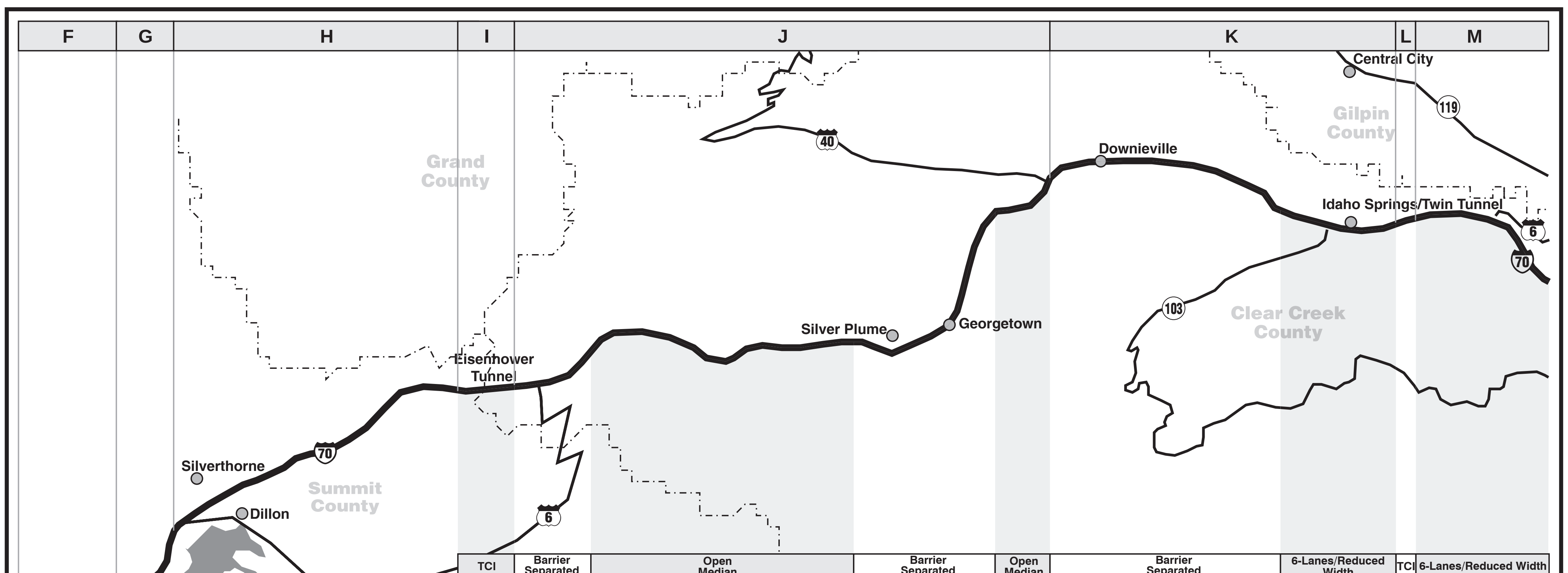
Open Median

Description of Highway Alternatives

Same al Alternative 1, but with a Reduced-width section east of the Twin Tunnels.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 7	0.56 LOS C	0.83 LOS D	65	61	0	0			

Technical Summary:



Alternative 7 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

DRAFT
03/20/01

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict

Greatest - Intermediate Potential for Conflict

Intermediate Potential for Conflict

Intermediate - Least Potential for Conflict

Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

Highway Alternative 7

03/20/01

Highway Alternative 8

No Build

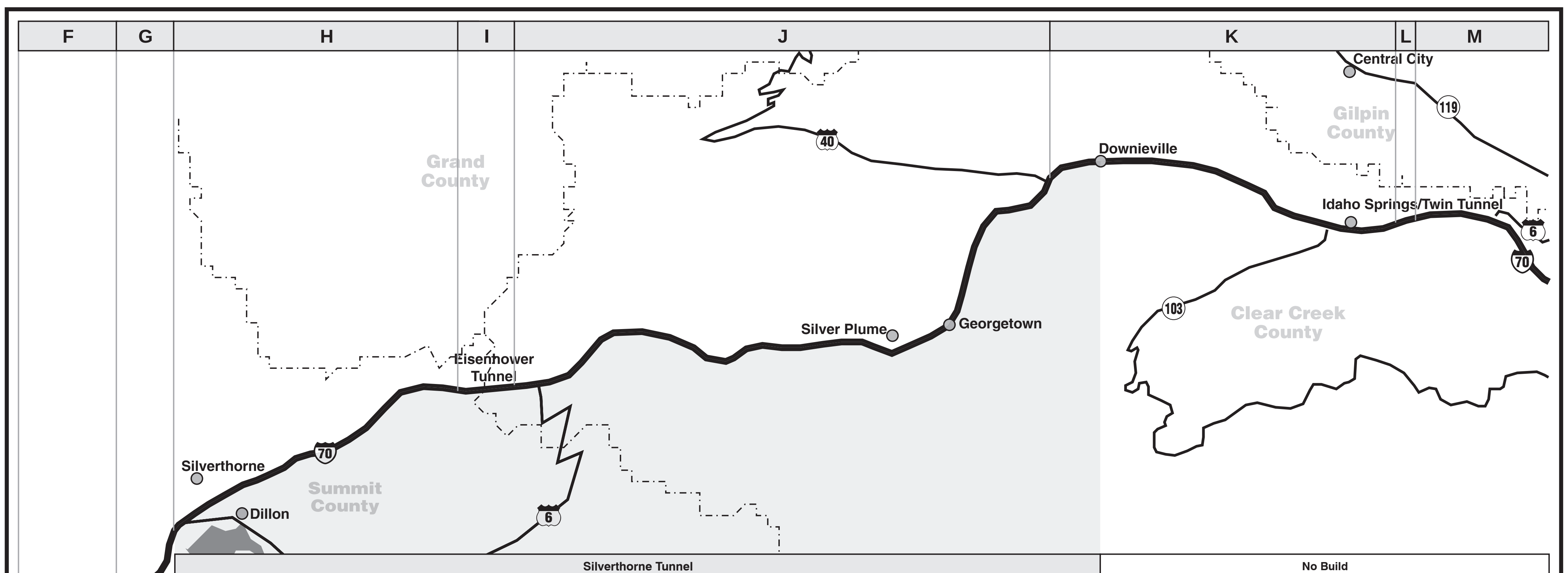
Silverthorne Tunnel

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020							Not Identified	NA	NA
2020 Alternative 8									

Description of Highway Alternatives

Tunnel from just east of Silverthorne to just west of the Empire Junction Interchange.

Technical Summary:



Alternative 8 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs	George-town	Silver Plume	Dillon	Vail

24-Hour Increase

Idaho Springs	George-town	Silver Plume	Dillon	Vail

Number of Receptors

Idaho Springs	George-town	Silver Plume	Dillon	Vail

Potential for Mitigation

Idaho Springs	George-town	Silver Plume	Dillon	Vail

Summary

Community/Recreation/ 4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict	Greatest - Intermediate Potential for Conflict	Intermediate Potential for Conflict	Intermediate - Least Potential for Conflict	Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

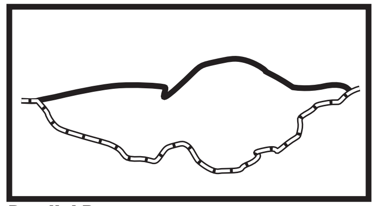
DRAFT

Highway Alternative 8

03/20/01

Highway Alternative 10


No Build

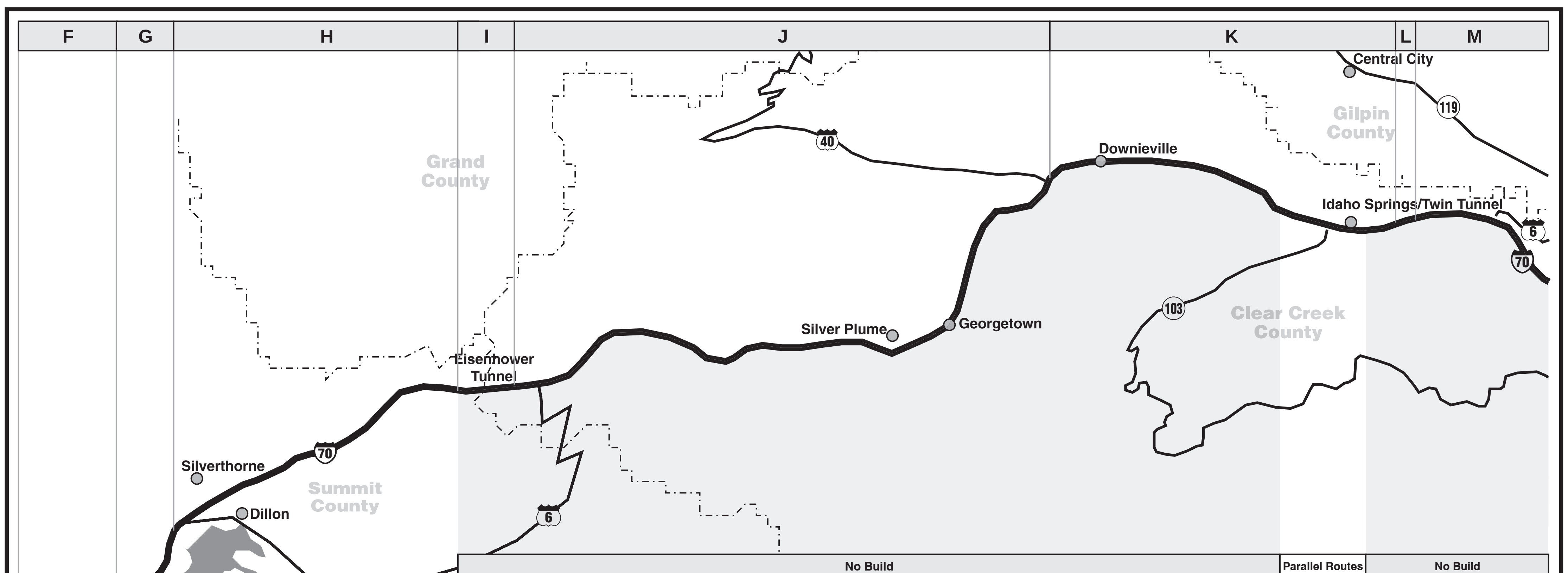

Parallel Routes

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020							Not Identified	NA	NA
2020 Alternative 10									

Description of Highway Alternatives

Relief routes around Idaho Springs. The specific use of these roads has not been evaluated; this analysis only investigated the possibility of another roadway platform.

Technical Summary:



Alternative 10 I-70 Context

Legend

Lowest/Worst | Worst to Intermediate | Intermediate | Best to Intermediate | Highest/Best

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*	Water Quality*	Waters of the U.S./Wetlands*	Fish Habitats	Wildlife Habitats and Crossings	Threatened, Endangered, and Sensitive Species*	Geologic Hazards/Mining
Total Emissions Under Study % Change Between Alternatives and Current Conditions	Mine Tailings/Waste Rock	Open and Flowing Waters	High Value Fishery	Elk and Big Horn Sheep Range	Potential Lynx Movement Corridor	Rockfall
Total Particulates and Dust Under Study % Change Between Alternatives and Current Conditions	Mineralized Rock	Vegetated Wetlands	Gold Medal Fisheries	Crossings	Boreal Toad	Debris/Mud Flow
	Winter Maintenance	Fen/Seep/Spring		Biodiversity Area	Colorado Cutthroat Trout	Landslide
	Stormwater Runoff			Deer Under Study	Greenback Cutthroat Trout	Avalanche
	Summary	Summary	Summary	Summary	Summary	Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*	Community/Recreation/ 4(f) and 6(f)*	Cultural Resources/4(f)*	Federal Management and Scenic Features/Views*
Peak Hour Increase Idaho Springs · Georgetown · Silver Plume · Dillon · Vail	Community Areas	Historic Districts	USFS/Visual Quality Objectives/Retention* Under Study
24-Hour Increase Idaho Springs · Georgetown · Silver Plume · Dillon · Vail	Recreation (4(f)/6(f))	Historic Sites & Trails	USFS/ROS/Roaded Natural* Under Study
Number of Receptors Idaho Springs · Georgetown · Silver Plume · Dillon · Vail	Hike and Bike Trails Under Study	Archaeological Sites	Visually Sensitive Areas Community Setting/Foreground Views
Potential for Mitigation Idaho Springs · Georgetown · Silver Plume · Dillon · Vail			Recreation Sites/Foreground Views
			Historic Sites, Districts & Landmarks/Foreground Views
Summary	Summary	Summary	Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict	Greatest - Intermediate Potential for Conflict	Intermediate Potential for Conflict	Intermediate - Least Potential for Conflict	Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

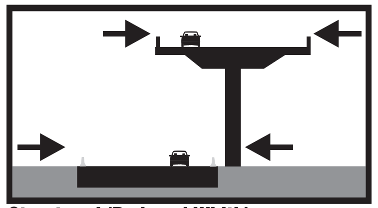
Highway Alternative 10

03/20/01

Highway Alternative 11

6-Lane/Reduced Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)



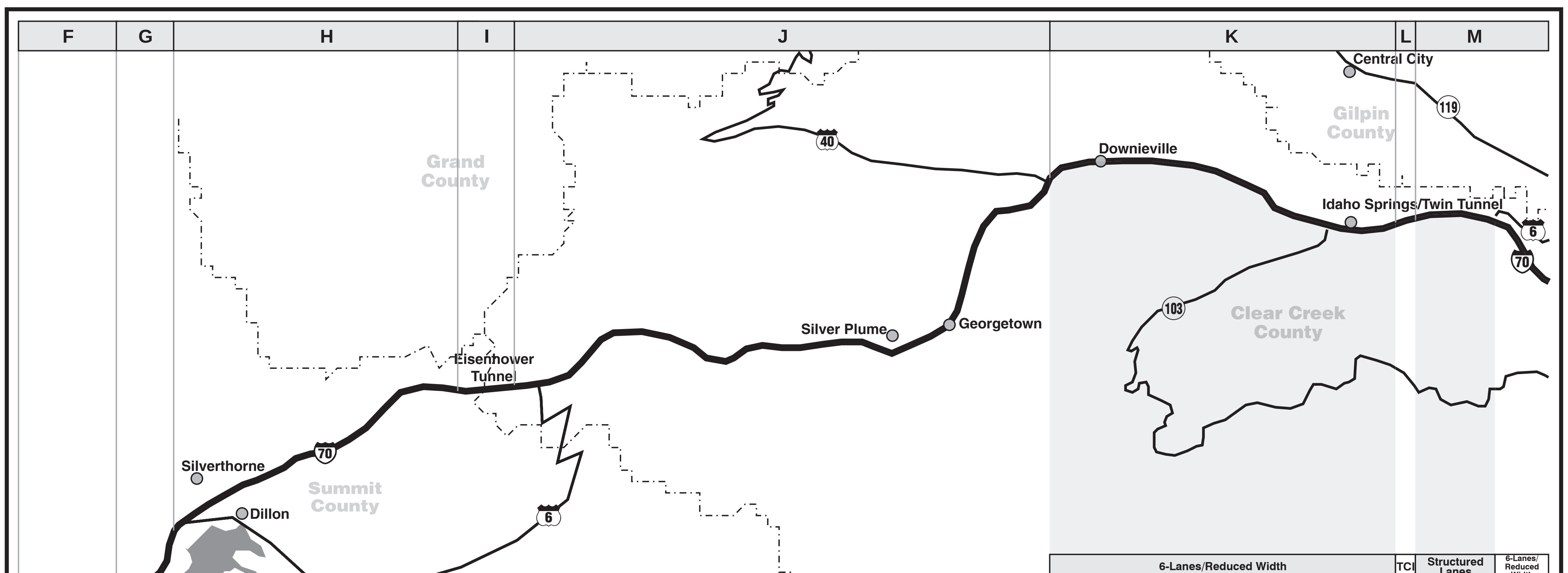
Structured (Reduced Width)

Description of Highway Alternatives

This Alternative is Reduced-width, except for Structured Lanes east of the Twin Tunnels.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 11	1.10 LOS F	0.82 LOS D	45	62	4	0			

Technical Summary:



Alternative 11 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

DRAFT

03/20/01

Environmental Sensitivity

Air Quality*
Total Emissions
Under Study
% Change Between Alternatives and Current Conditions

Total Particulates and Dust
Under Study
% Change Between Alternatives and Current Conditions

Water Quality*
Mine Tailings/Waste Rock
Mineralized Rock
Winter Maintenance
Stormwater Runoff
Summary

Waters of the U.S./Wetlands*
Open and Flowing Waters
Vegetated Wetlands
Fen/Seep/Spring
Summary

Fish Habitats
High Value Fishery
Gold Medal Fisheries
Summary

Wildlife Habitats and Crossings
Elk and Big Horn Sheep Range
Crossings
Biodiversity Area
Deer
Under Study
Summary

Threatened, Endangered, and Sensitive Species*
Potential Lynx Movement Corridor
Boreal Toad
Colorado Cutthroat Trout
Greenback Cutthroat Trout
Summary

Geologic Hazards/Mining
Rockfall
Debris/Mud Flow
Landslide
Avalanche
Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*
Peak Hour Increase
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

24-Hour Increase
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Number of Receptors
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Potential for Mitigation
Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Summary

Community/Recreation/ 4(f) and 6(f)*
Community Areas
Recreation (4(f)/6(f))
Hike and Bike Trails
Under Study
Summary

Cultural Resources/4(f)*
Historic Districts
Historic Sites & Trails
Archaeological Sites
Summary

Federal Management and Scenic Features/Views*
USFS/Visual Quality Objectives/Retention*
Under Study
USFS/ROS/Roaded Natural*
Under Study
Visually Sensitive Areas
Community Setting/Foreground Views
Recreation Sites/Foreground Views
Historic Sites, Districts & Landmarks/Foreground Views
Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict | Greatest - Intermediate Potential for Conflict | Intermediate Potential for Conflict | Intermediate - Least Potential for Conflict | Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

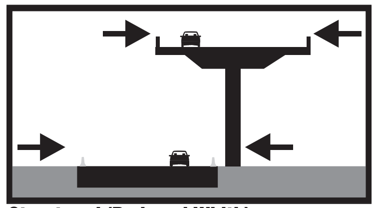
Highway Alternative 11

03/20/01

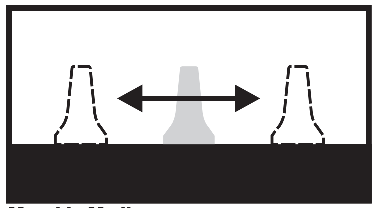
Highway Alternative 12

6-Lane/Reduced Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)



Structured (Reduced Width)



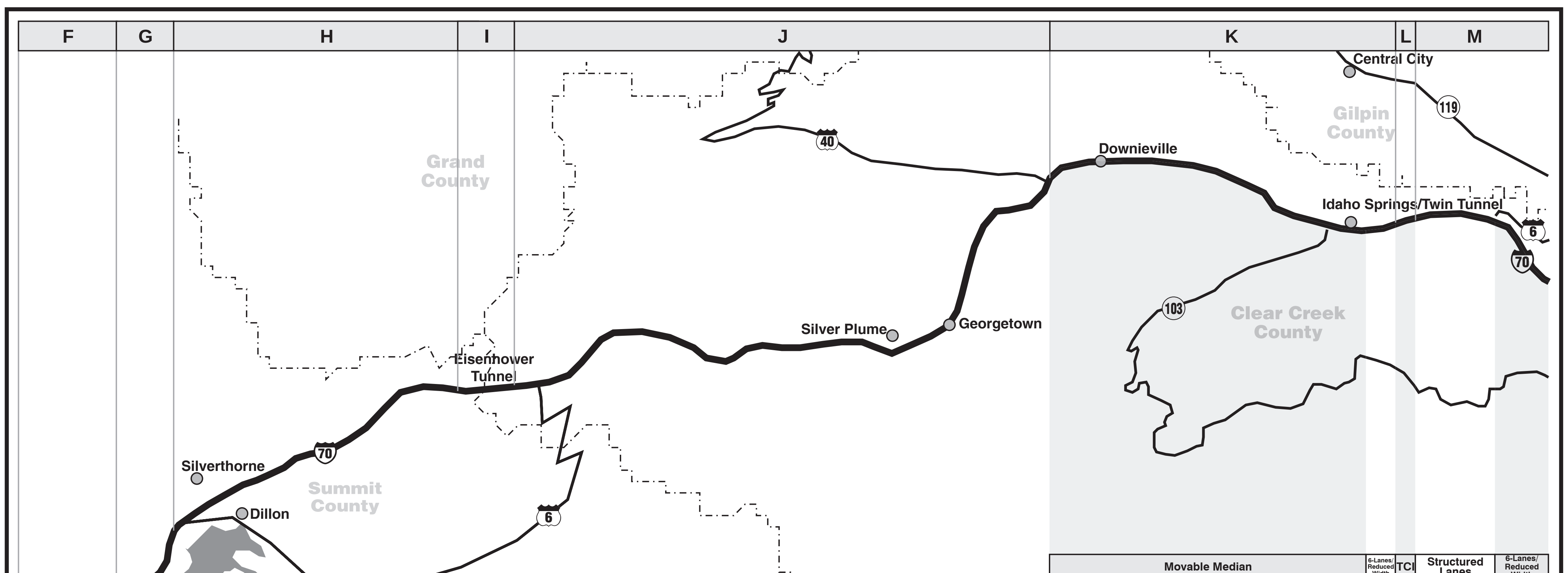
Movable Median

Description of Highway Alternatives

Same as Alternative 11, but using Movable Median through Idaho Springs instead of Reduced-width.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 12	1.10 LOS F	0.82 LOS D	45	62	4	0			

Technical Summary:



Alternative 12 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

· Air Quality

· Water Quality

· Wetlands

· Wildlife Habitats and Crossings

· Threatened, Endangered & Sensitive Species

· Fish Habitats

· Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | Georgetown | Silver Plume | Dillon | Vail

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

· Noise

· Land Use/Recreation/4(f) and 6(f)

· Cultural Resources/4(f)

· Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict | Greatest - Intermediate Potential for Conflict | Intermediate Potential for Conflict | Intermediate - Least Potential for Conflict | Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

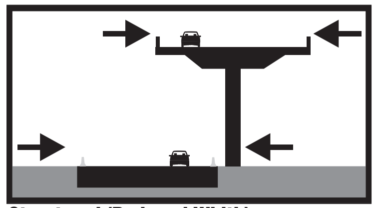
Highway Alternative 12

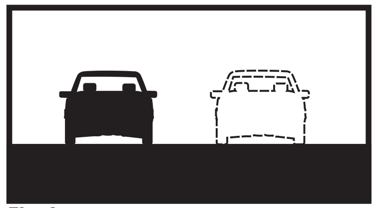
03/20/01

Highway Alternative 13


6-Lane/Reduced Width


Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)


Structured (Reduced Width)

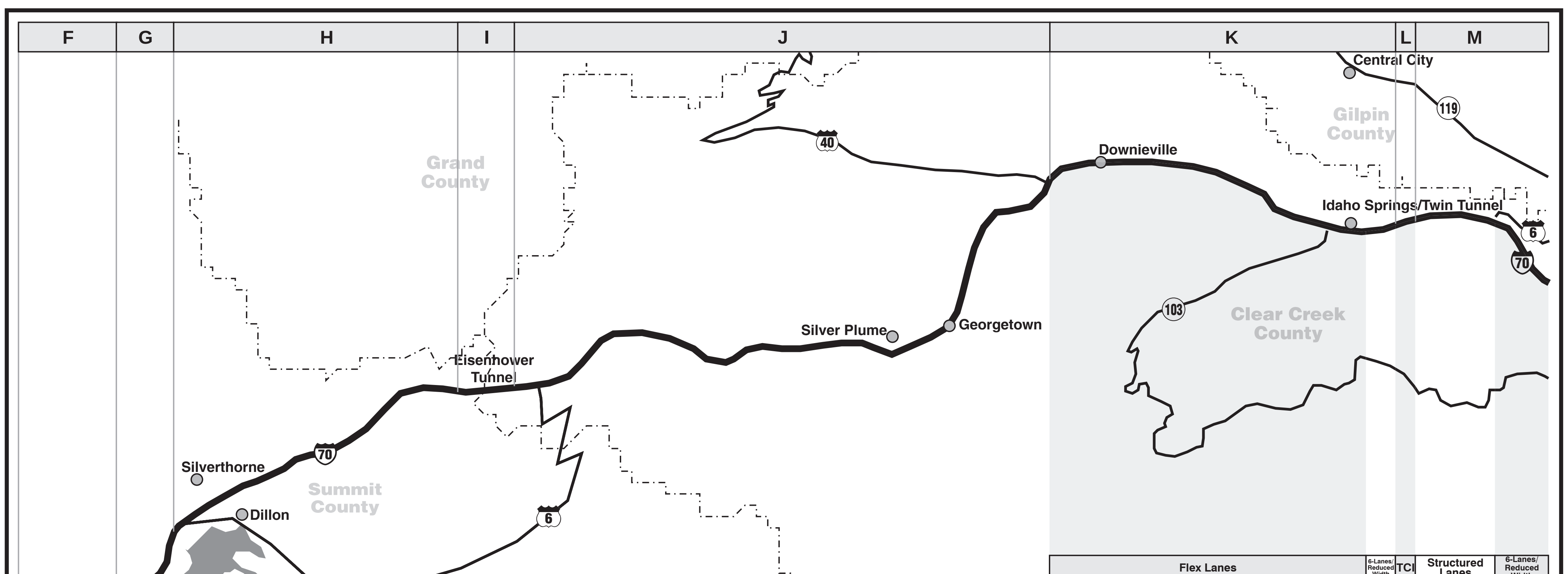

Flex Lanes

Description of Highway Alternatives

Same as Alternative 11, but using Flex Lanes through Idaho Springs instead of Reduced-width.

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 13	1.10 LOS F	0.82 LOS D	45	62	4	0			

Technical Summary:



Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

Alternative 13 I-70 Context

03/20/01

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | George-town | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Summary

Community/Recreation/4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict

Greatest - Intermediate Potential for Conflict

Intermediate Potential for Conflict

Intermediate - Least Potential for Conflict

Least Potential for Conflict

* Applicable Federal Regulations (Refer to Table x)

DRAFT

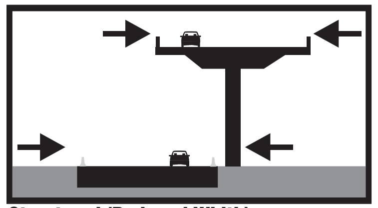
Highway Alternative 13

03/20/01

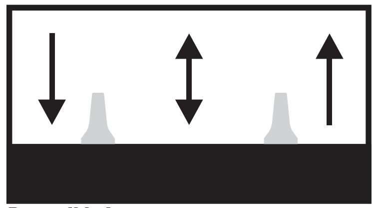
Highway Alternative 14

6-Lane/Reduced Width

Tunnel Capacity Improvements (TCI) (Eisenhower Jefferson Memorial Tunnel and Twin Tunnels)



Structured (Reduced Width)



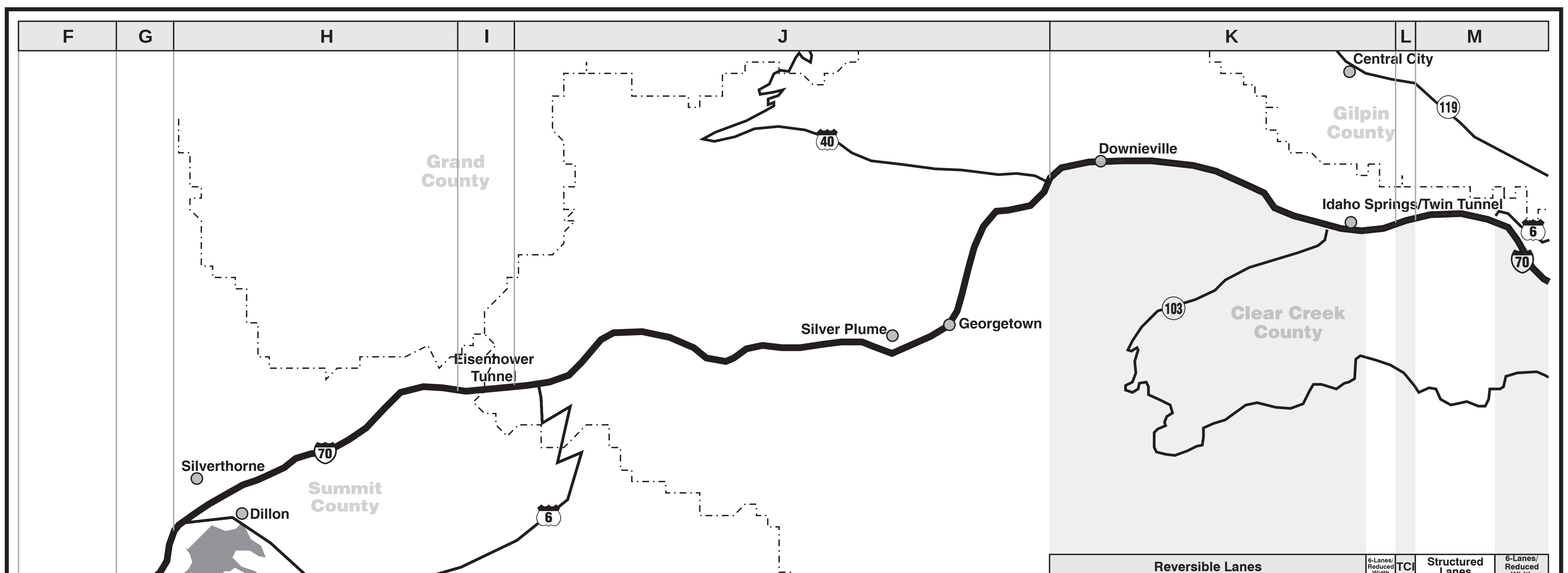
Reversible Lanes

	Need						Safety	Implementation	
	Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
No Build/ 2020	1.05 LOS F	1.10 LOS F	29	25	4	5	Not Identified	NA	NA
2020 Alternative 14	1.10 LOS F	0.82 LOS D	45	62	4	0			

Description of Highway Alternatives

Same as Alternative 11, but using Reversible Lanes through Idaho Springs instead of Reduced-width.

Technical Summary:



Alternative 14 I-70 Context

Legend

Lowest/Worst	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best

Environmental Sensitivity

Air Quality*

Total Emissions

Under Study

% Change Between Alternatives and Current Conditions

Total Particulates and Dust

Under Study

% Change Between Alternatives and Current Conditions

Water Quality*

Mine Tailings/Waste Rock

Mineralized Rock

Winter Maintenance

Stormwater Runoff

Summary

Waters of the U.S./Wetlands*

Open and Flowing Waters

Vegetated Wetlands

Fen/Seep/Spring

Summary

Fish Habitats

High Value Fishery

Gold Medal Fisheries

Summary

Wildlife Habitats and Crossings

Elk and Big Horn Sheep Range

Crossings

Biodiversity Area

Deer

Under Study

Summary

Threatened, Endangered, and Sensitive Species*

Potential Lynx Movement Corridor

Boreal Toad

Colorado Cutthroat Trout

Greenback Cutthroat Trout

Summary

Geologic Hazards/Mining

Rockfall

Debris/Mud Flow

Landslide

Avalanche

Summary

Summary - Environmental Sensitivity

- Air Quality
- Water Quality
- Wetlands
- Wildlife Habitats and Crossings
- Threatened, Endangered & Sensitive Species
- Fish Habitats
- Geologic Hazards/Mining

Community Values

Noise*

Peak Hour Increase

Idaho Springs | George-town | Silver Plume | Dillon | Vail

24-Hour Increase

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Number of Receptors

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Potential for Mitigation

Idaho Springs | George-town | Silver Plume | Dillon | Vail

Summary

Community/Recreation/ 4(f) and 6(f)*

Community Areas

Recreation (4(f)/6(f))

Hike and Bike Trails

Under Study

Summary

Cultural Resources/4(f)*

Historic Districts

Historic Sites & Trails

Archaeological Sites

Summary

Federal Management and Scenic Features/Views*

USFS/Visual Quality Objectives/Retention*

Under Study

USFS/ROS/Roaded Natural*

Under Study

Visually Sensitive Areas

Community Setting/Foreground Views

Recreation Sites/Foreground Views

Historic Sites, Districts & Landmarks/Foreground Views

Summary

Summary - Community Values

- Noise
- Land Use/Recreation/4(f) and 6(f)
- Cultural Resources/4(f)
- Federal Management and Scenic Features/Views

Legend

Level of Conflict

Greatest Potential for Conflict	Greatest - Intermediate Potential for Conflict	Intermediate Potential for Conflict	Intermediate - Least Potential for Conflict	Least Potential for Conflict

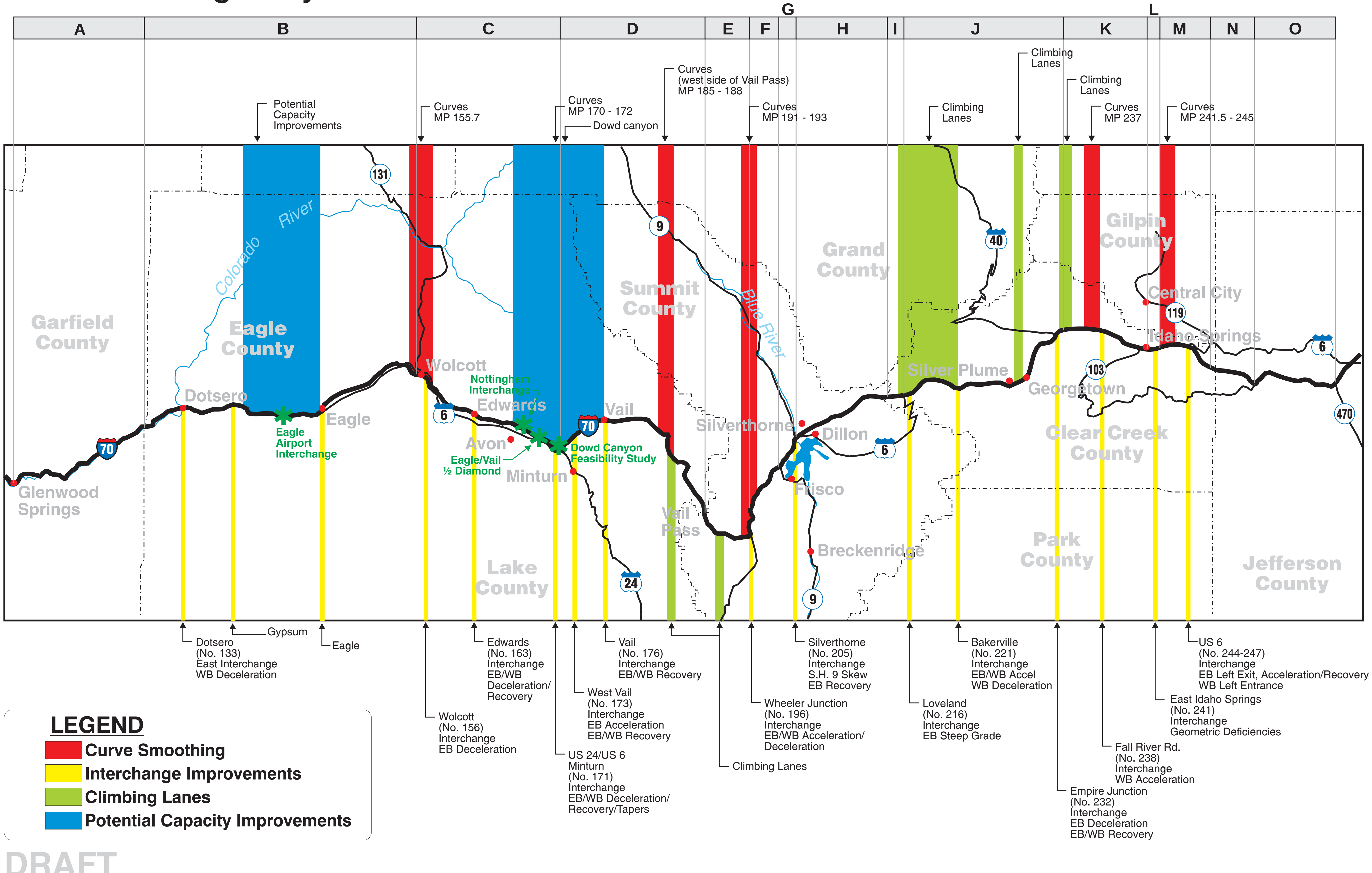
* Applicable Federal Regulations (Refer to Table x)

DRAFT

Highway Alternative 14

03/20/01

Localized Highway Alternatives



03/20/01

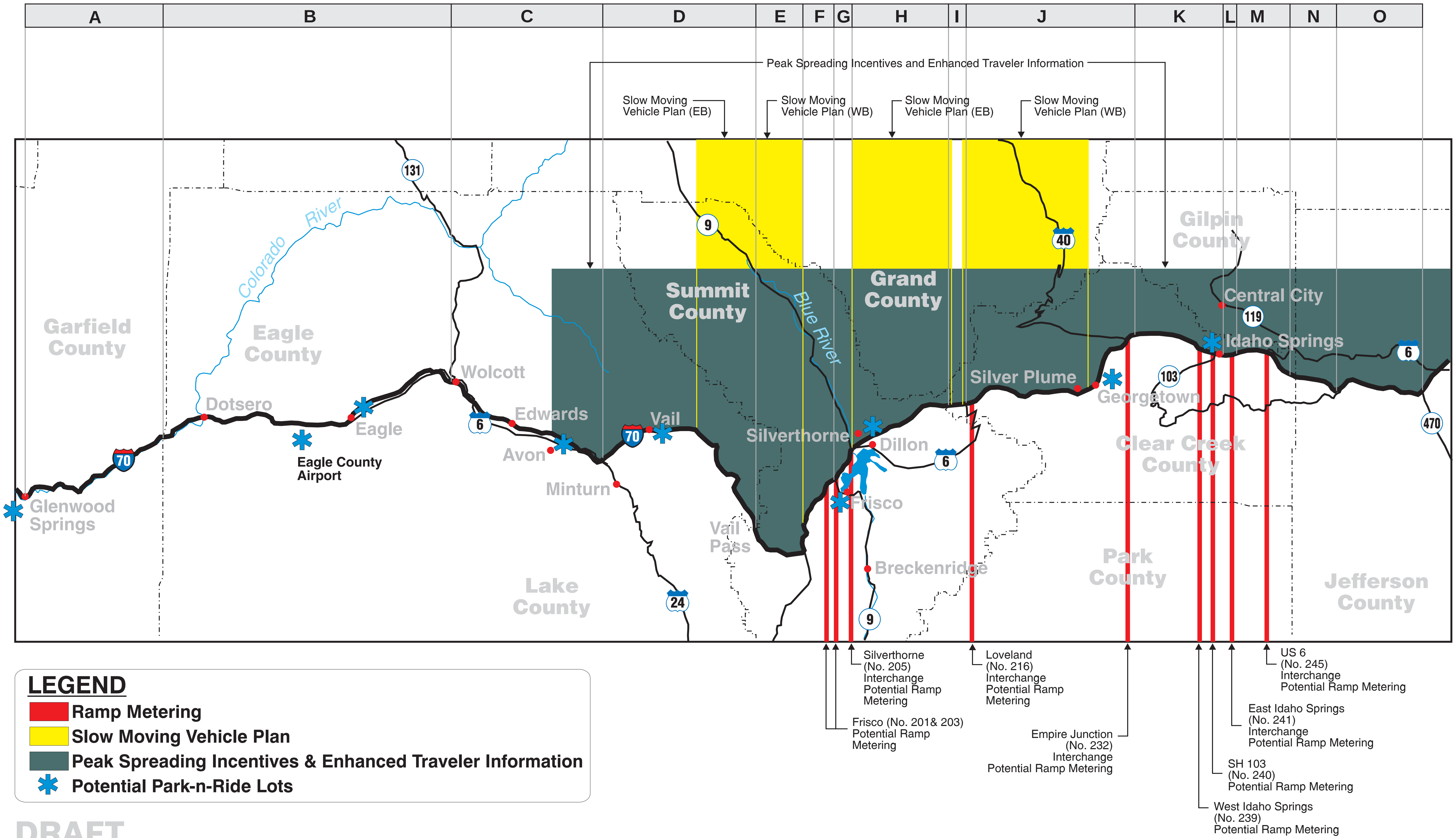
Localized Highway Alternatives					Evaluation Criteria					
Description of Alternative	**Description of Improvements**	**Mile Point**	**Problematic Area Definition**	**Potential Benefit**	**V/C**	**Speed**	**Congestion Duration**	**Safety**	**Cost**	**Constructibility**
CURVE SMOOTHING	Increase design speed of all curves to 65 mph.	See Below	Curves with Design Speed < 65 mph	Increase Safety						
Wolcott	60' lateral shift to the north.	155.70	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
Dowds Junction/Minturn	105' lateral shift to the South. Located in the vicinity of a slide area.	170.34	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
	124' lateral shift to the North. Located in the vicinity of a slide area.	170.68	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
	153' lateral shift. Requires reconstruction of Dowd Jct. Interchange.	171.11	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
	46' lateral shift to the South would require filling onto a steep slope.	171.58	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
	16' lateral shift to the North. Requires cut into the mountain.	171.77	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
West Side of Vail Pass	34' lateral shift. Requires replacing existing bridges w/ new ones.	185.40	Existing MDS = 60 mph, radius = 1273'	Increase Safety						
		186.40	Existing MDS = 60 mph, radius = 1273'	Increase Safety						
	26' lateral shift to the North. Would require a cut into the hillside.	186.27	Existing MDS = 60 mph, radius = 1206'	Increase Safety						
	37' lateral shift to the North. Would require a cut into the hillside.	188.00	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
East Side of Vail Pass	17' lateral shift to the North. Would require a cut into the hillside.	191.18	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
	19' lateral shift to the South. Would require filling onto the slope.	191.46 WB	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
	32' lateral shift to the North. Would require a cut into the hillside.	192.09 WB	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
	23' lateral shift to the North. Would require a cut into the hillside.	192.32 WB	Existing MDS = 55 mph, radius = 1146'	Increase Safety						
Fall River Road	Lateral shift of between 14' and 76'. Would require either a cut into the North hillside or fill over the river to the South.	237.14-237.86	Various curves have existing MDS = 55 mph, radius = 716' or 1146'	Increase Safety						
Twin Tunnels	Refer to Transystem's Study	241.5-245.6	Various curves have existing MDS = 45 mph.	Increase Safety						
INTERCHANGE IMPROVEMENTS	Make modifications to improve interchange operations.	See Below	See Below	Increase Safety						
Dotsero	Increase WB decel lane at east interchange. Could possibly combine east and west split diamonds into one single diamond.	133.0	West interchange is OK; East interchange- the WB deceleration lane is inadequate.	Increase Capacity						
Gypsum & Eagle	Increase ramp terminal traffic signal capacity.	140.0 / 147.0	Ramp terminal signal capacity is inadequate.	Increase Capacity						
Wolcott	Increase EB decel lane length	156.0	The EB off ramp has an inadequate deceleration lane.	Increase Capacity						
Edwards	Increase EB & WB decel lengths. Increase WB recovery lane length.		The WB off ramp has an inadequate deceleration lane and recovery lane. EB off-ramp has an inadequate deceleration lane.	Increase Capacity						
US 24/US 6/Minturn/Dowd Jct.	The new Eagle Vail 1/2 diamond interchange will improve traffic congestion at both Avon and Dowd Jct. Interchanges.	171.0	WB and EB off-ramps at Dowd Jct. interchange have inadequate decel and recovery lanes. EB on-ramp has a sharp curve, MDS=20 mph.	Increase Capacity						
West Vail	Increase the taper length of accel and decel lanes. EB accel lane is too short. Incr. recovery lengths on both decel lanes.	173.0	EB acceleration lane is too short. Recovery lanes on both WB and EB deceleration lanes are too short.	Increase Capacity						
Vail	Increase taper lengths of accel and decel lanes from 250' to 300'. Increase recovery lanes on both WB and EB deceleration lanes to	176.0	Taper lengths of acceleration and deceleration lanes are too short. Recovery lanes on both WB and EB deceleration lanes are too short.	Increase Capacity						
Wheeler Junction	Both WB and EB acceleration and deceleration lanes should be lengthened.	196.0	All accel and decel lanes are too short. WB on-ramp has a sharp curve, MDS = 20 mph. Also, the compound curves should be modified.	Increase Capacity						
SH 9 / Silverthorne	Lengthen EB recovery lane length.	205.0	The EB recovery lane length is too short. Align skews potential problem.	Increase Capacity						
Loveland	Investigate grade reduction.	216.0	Steep downgrade on EB.	Increase Capacity						
Bakerville	Lengthen WB and EB acceleration lanes and WB deceleration lane.	221.0	WB and EB accel lanes and the WB deceleration lanes are too short.	Increase Capacity						
Empire Junction	Lengthen EB deceleration lane. Improve recovery lanes. Check geometry for possible improvements.	232.0	The EB deceleration and recovery lanes are too short. EB off-ramp has a sharp curve, MDS=20mph. Excessive compound curve.	Increase Capacity						
Fall River Road	Lengthen WB acceleration lane.	238.0	The WB acceleration lane is inadequate.	Increase Capacity						
East Idaho Springs	Lengthen acceleration and deceleration lanes. Improve geometry.	241.0	Accel and decel lanes are inadequate. Very sharp curves for ramps, MDS=10mph-20mph. WB accel and decel lanes are too close together.	Increase Capacity						
US 6	A "left exit" to US 6 and a "left entrance" ramp to I-70 WB are used. The accel lane and recovery lane at Floyd Hill should be lengthened.	244.0	The "left exit" to US 6 and the "left entrance" to I-70 WB are not desirable. The accel and recovery lanes at Floyd Hill should be longer.	Increase Capacity						
Top of Floyd Hill (Hyland Hills)	The accel lane and recovery lane at Floyd Hill should be lengthened.	247.0	The accel lane and recovery lane at Floyd Hill should be lengthened.	Increase Capacity						
CLIMBING LANES	Add an additional uphill lane on steep grades and where the proximity of adjacent accel and decel lanes makes it difficult for slow-moving vehicles to achieve the proper speed for a safe lane	See Below	Slow-moving vehicles on steep grades reduce I-70's capacity. Climbing lanes will improve the (v/c) ratio. It can cause problems when slow-moving vehicles can't obtain a proper speed before merging.	Increase Capacity						
West Side of Vail Pass	Eastbound climbing lanes.	181.0-188.0	Slow moving vehicles on grades cause capacity reduction.	Increase Capacity						
East Side of Vail Pass	Westbound climbing lanes.	190.0-195.5	Slow moving vehicles on grades cause capacity reduction.	Increase Capacity						
Eisenhower Tunnels to Bakerville	Westbound climbing lanes.	215.0-221.2	Slow moving vehicles on grades cause capacity reduction.	Increase Capacity						
Georgetown Hill	Westbound climbing lanes.	226.0-228.0	Slow moving vehicles on grades cause capacity reduction.	Increase Capacity						
Downieville to Empire Junction	Create a continuous auxiliary lane between the two interchanges.	232.5-233.7	Slow moving vehicles on grades cause capacity reduction and trucks entering from the weigh station cause weaving problems at US 40 exit.	Increase Capacity						

6 – TRANSPORTATION SYSTEM MANAGEMENT

Transportation Management Family

(Including Transportation System Management and Travel Demand Management)

Potentially Mitigate the Need For Constructing a Third Bore at The Eisenhower/Johnson Memorial Tunnels by Improving Travel Efficiency, or by Reducing Peak-Hour Travel Demand.



DRAFT

03/20/01

Transportation Management Alternatives					Evaluation Criteria					
Description of Alternative	**Description of Improvements**	**Mile Point**	**Problematic Area Definition**	**Potential Benefit**	**V/C**	**Speed**	**Congestion Duration**	**Safety**	**Cost**	**Constructibility**
MINOR HIGHWAY IMPROVEMENTS AWAY FROM THE MAINLINE	Make alterations near certain highway interchanges, as necessary to set up a ramp metering operation, such as currently exists at many locations in Metro Denver.	See Below	Traffic entering I-70 at interchanges can overload the highway capacity and help cause congested flow. Ramp metering controls the rate at which vehicles enter I-70.	Reduce Overall System Congestion						
Frisco Interchanges (East & West)	Potential Ramp metering location. Would only apply to the EB dir.	201 & 203	Congested traffic flow occurs periodically.	Reduce Congestion						
Silverthorne Interchange	Potential Ramp metering location. Would only apply to the EB dir.	205.00	Congested traffic flow occurs periodically.	Reduce Congestion						
Loveland Interchange	Potential Ramp metering location. Might apply to both directions.	216.00	Congested traffic flow occurs regularly.	Reduce Congestion						
Empire Junction Interchange	Potential Ramp metering location. Would only apply to the EB dir.	232.00	Congested traffic flow occurs frequently.	Reduce Congestion						
West Idaho Springs Interchange	Potential Ramp metering location. Might apply to both directions.	239.00	Congested traffic flow occurs frequently.	Reduce Congestion						
SH 103 Interchange	Potential Ramp metering location. Might apply to both directions.	240.00	Congested traffic flow occurs frequently.	Reduce Congestion						
East Idaho Springs Interchange	Potential Ramp metering location. Might apply to both directions.	241.00	Congested traffic flow occurs frequently.	Reduce Congestion						
US 6 Interchange	Potential Ramp metering location. Would only apply to the WB dir.	245.00	Congested traffic flow occurs periodically.	Reduce Congestion						
PASSIVE MANAGEMENT STRATEGIES	Involves no highway construction, other than new signing. Enforcement would be required for some of the ideas to be effective.	See Below	Decrease congestion by reducing the V/C ratios. The Slow-Moving Vehicle plan is a TSM idea that would increase the Capacity (C) and the Peak Spreading Incentives are a TDM idea that would decrease the Volume (V) during Peak Hours.	Reduce Congestion						
PEAK SPREADING INCENTIVES	Through the coordinated efforts of stakeholders throughout the corridor, reduce peak hour travel through the use of incentives to alter people's travel behavior. Changes could involve the hour or day during which people travel. An example of one such idea currently in practice involves inexpensive late season monthly or season ski passes that allow user's to vary their travel schedules.	All areas that are expected to experience congestion by 2020	Travelers on I-70 are experiencing high levels of congestion, primarily during the winter and summer travel periods. The congestion, however, occurs only during a small percentage of the week. Traffic data currently shows a reduction in winter congestion, as compared with the summer, due to self-imposed travel demand management. A focused, coordinated program could prove to be effective.	Reduce Peak Hour Travel Demand and decrease Congestion						
SLOW-MOVING VEHICLE PLAN	Potential ideas include a restriction on peak hour, peak direction travel by slow-moving vehicles in certain stretches of the corridor. High-powered buses that could hold a minimum speed of 55 - 60 mph throughout steep grades could potentially be provided to local transit services. If a truck could maintain a minimum speed of 50-55 mph throughout those grades, such as if it were on an empty return trip, then the restriction wouldn't apply to them. Additional chain-up, rest area, WIM and AVI facilities area could be provided.	See Below	An ideal 4 lane highway carries 4400 vehicles per hour in each direction. Factors on I-70, other than heavy vehicles, drop the capacity to about 3400 vehicles per hour. The Eisenhower / Johnson Tunnels have a maximum reported traffic volume of about 2150 vph WB and 2600 vehicles per hour EB. This type of plan could provide significant increase in WB capacity. The current highway can't handle increases in EB traffic, because the congestion occurs where the grades are fairly level or slightly downhill.	Increase Peak Hour Travel Capacity and decrease Congestion						
West side of Vail Pass	Would involve restrictions in the EB direction	178 - 190	According to the Highway Capacity Manual, a 4 lane highway with 0% slow-moving vehicles can handle 28% more traffic than one with only 2% trucks.	Reduce Congestion						
East side of Vail Pass	Would involve restrictions in the WB direction	195 - 190		Reduce Congestion						
Western Approach to Eisenhower	Would involve restrictions in the EB direction	205-214	This alternative would work well with highway alternatives that add additional EB capacity by adding new lanes.	Reduce Congestion						
Eastern Approach to Eisenhower	Would involve restrictions in the WB direction	228 - 216	The volumes in the Eisenhower Tunnels are not limited by the tunnels, but rather by the steep highways on either side.	Reduce Congestion						
PARK-N-RIDE LOTS	Construct additional park-n-ride lots, similar to the one at the Hogback, that would allow people to ride-share, thus reducing the number of vehicles on the highway.	9 potential locations, see the map	Decrease congestion by increasing the average vehicle occupancy, thus reducing the number of cars on the road.	Reduce Congestion						
ENHANCED TRAVELER INFORMATION	This alternative would involve exploring the benefit of providing additional funding beyond that currently allocated for traveler and agency information related to I-70 travel. Ideas that provided useful info to the users at convienient places, such as at home, on the road or at ski areas will be investigated.	Throughout the corridor	Provide travelers with info to help them to pick a time for their trip when they can avoid congestion. Inform them about incidents up ahead. Allow them to alter their travel plans while they can still make changes. Provide CDOT with more info so they can provide quicker incident response.	Reduce Congestion and Improve Safety						
BICYCLE IMPROVEMENTS	Improve the continuity and safety of bicycle travel throughout the corridor.	Throughout the corridor	Currently cyclists are required to make unpleasant choices to get through some parts of the corridor. There are many areas where the motorist / cyclist interface can be improved.	Improve Safety						
NO ACTION	This alternative explains the portions of the Incident Management Plan and the Traveler Information Plan for this corridor for which funding had been identified.	Throughout the corridor	CDOT has just completed plans for both of these areas. These plans include many ideas which will provide a safer and more pleasant traveling experience to the public. The implementation of many of these ideas will occur, regardless of the outcome of this study.	Improve Safety						

DRAFT

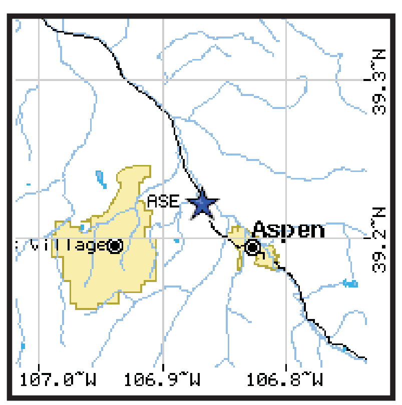
7 – AVIATION

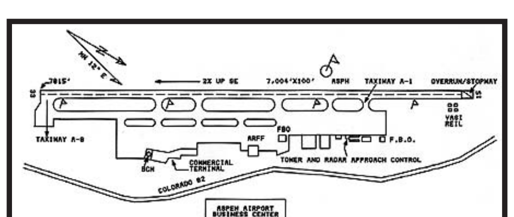
Aviation Improvements

DRAFT

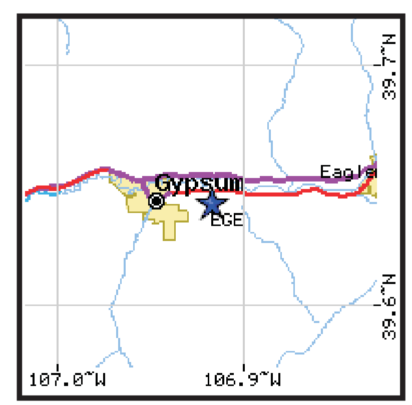
	Need		Implementation	
	Number of Additional Air Passengers Accommodated	Number of Vehicles Removed From I-70 per day During Peak Season	Cost	Technology
Improve Existing Commercial Aviation Airports Through Advance Technology to Allow Additional Flights	Estimates Range From: 500 - 1,000 6,100 - 7,000	Estimates Range From: 200 - 400 2,350 - 2,700	$4 - $6 Million for the ASR-11 $175,000 to $185,000 for Improved Instrument Landing System for HDN	Raytheon was awarded a joint procurement contract in 1996 with the DOD and FAA to develop the ASR-11 - the next generation ASR after ASR-9. This navigational aid has been extensively testedat Elgin AFB for two Years. ILS available from numerous producers and distributors
Improve General Aviation Facilities	Included in Above	Included in Above	See Above	Raytheon was awarded a joint procurement contract in 1996 with the DOD and FAA to develop the ASR-11 - the next generation ASR after ASR-9. This navigational aid has been extensively tested at Elgin AFB for two Years. ILS available from numerous producers and distributors. Additionally, the ability to accommodate commercial service is not desired by GA facilities; rather the ability to meet burgeoning demand for better GA facilities is needed.
Develop Systems Management and Subsidy Programs			$3 - $5 Million Annually	N/A

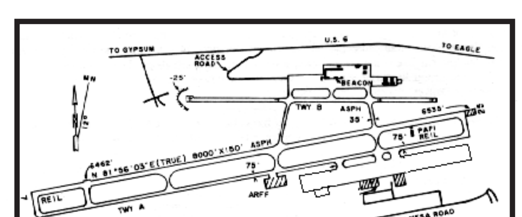
ASE



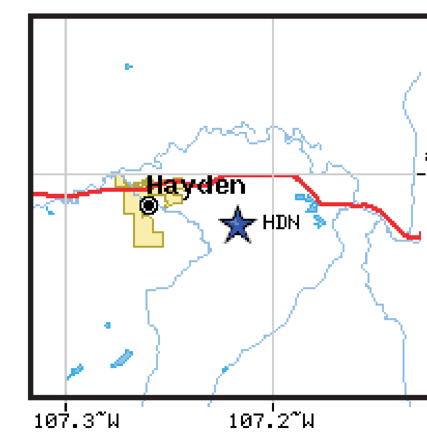


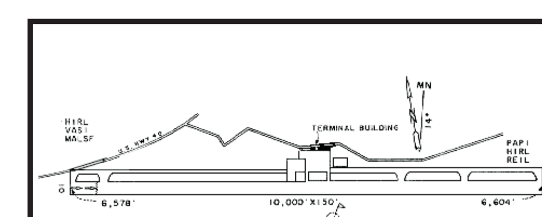
EGE





HDN





03/20/01

DEFINITION OF ALTERNATIVES

Improve Existing Commercial Aviation Facilities

Longer runways have the potential to boost airport operations, but there is general concurrence that improved navigational aids can do more to “grow the capacity” of mountain airports than any other capital investment. One navigational aid being considered for EGE, is the ASR-11. It has been reported that one ASR-11, strategically located, also could improve operations at ASE (Aspen-Pitkin County Airport) and Glenwood Springs Airport (a general aviation facility where where demand is outstripping supply). Reportedly, there is no airspace conflicts with HDN, therefore, The ASR-11 has limited benefits for that airport.

Improve General Aviation Facilities

Similar to improvements to commercial service airports, the identified improvement is better airport surveillance radar to accommodate the rapidly growing general aviation traffic.

Develop Systems Management and Subsidy Programs

The subsidy program identified as most likely to boost air travel, are seat guarantees, currently paid by the ski resorts to the airlines does not achieve its desired load factor.

Resorts contract with an airline or airlines to ensure service and routes are continued by paying “seat guarantees”. The contracted amount is only paid by the resorts to the airlines if the airline does not meet their projected load factor or profitability for a particular flight or route.

Presently, air travel demand is so great, that the airlines have met their load factors, and none of the resorts have had to fulfill their “seat guarantee” agreements

DEFINITION OF CRITERIA AND MEASURES

Additional Air Passengers

EGE could accommodate twice as many flights during their peak hours (10am to 3pm, Saturday, 100-day winter season). It also has been maintained (and two airport managers concurred) that without navigational aids, 500 to 1,000 person trips would be added daily to I-70 during the 100-day winter season. Officials at DIA, estimate that diversions are greater, and projected 6,100 to 7,000 person trips would be added daily to I-70 during the 100-day winter season.

Number of Vehicles Removed from I-70?

Range of additional person trips divided by an average vehicle occupancy of 2.6.

Cost

Based on estimated by FAA, CDOT Aeronautics Division, Airport Operators and Resort operators.

Technology

ASR-11 is an airport surveillance radar with primary surveillance coverage to 60 nautical miles and secondary surveillance coverage to nautical 120 miles. It provides improved detection in clutter and weather, increased reliability and low life-cycle, costs, and it further can detect six levels of weather.

The improved ILS for HDN would include an RVR. None of the airports currently has these navaids programmed in their six-year capital plans. (HDN references improved ILS 2007 ans beyond).

8 – SUMMARY

Fixed Guideway Transit Alternative

Fixed Guideway Transit Alternative	Need: System Capacity (Peak Hour) – Actual	Need: System Capacity (Peak Hour) – Rating	Need: System Attractiveness	Need: Average Speed – Actual	Need: Average Speed – Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs	Implementation: Technology Available	Implementation: Fuel – Avail.	Implementation: Fuel – Limit	Implementation: Energy Consumption
Highway Alignment - Diesel Power													
· LRT - Single	1416			46.1									
· LRT - Double	2832			46.1									
· PRR - Winter Park	1400			23.2									
· PRR - Glenwood Springs	1400			28.7									
Highway Alignment - Electric Power													
· LRT - Single	1320			48.6									
· LRT - Double	2640			48.6									
· AGS - Supported - Double	4200			63									
· AGS - Suspended - Double	4200			63									
· AGS - Side Hanging - Unit	4200			63									
6% Alignment - Diesel Power													
· LRT - Single	1416			45.8									
· LRT - Double	2832			45.8									
· HRT - Single	4320			33.3									
· HRT - Double	8640			33.3									
· PRR in Corridor - Single	--												
· PRR in Corridor - Double	--												
6% Alignment - Electric Power													
· LRT - Single	1320			48.4									
· LRT - Double	2640			48.4									
· HRT - Single	4200			44.6									
· HRT - Double	4200			44.6									
· PRR in Corridor - Single	--												
· PRR in Corridor - Double	--												
· AGS - Supported - Double	4200			64.5									
· AGS - Suspended - Double	4200			64.5									
· AGS - Side Hanging - Unit	4200			64.5									
· MUP - Single	4380			42.8									
· MUP - Double	8760			42.8									
4% Alignment - Diesel Power													
· LRT - Single	1416			48.7									
· LRT - Double	2832			48.7									
· HRT - Single	4320			36.4									
· HRT - Double	8610			36.4									
· PRR in Corridor - Single	--												
· PRR in Corridor - Double	--												
4% Alignment - Electric Power													
· LRT - Single	1320			50.2									
· LRT - Double	2640			50.2									
· HRT - Single	4200			47.2									
· HRT - Double	4200			47.2									
· PRR in Corridor - Single	--												
· PRR in Corridor - Double	--												
· AGS - Supported - Double	4200			68.3									
· AGS - Suspended - Double	4200			68.3									
· AGS - Side Hanging - Unit	4200			68.3									
· MUP - Single	4380			45.7									
· MUP - Double	8760			45.7									

Legend

Highest/Best · Best to Intermediate · Intermediate · Worst to Intermediate · Lowest/Worst

DRAFT

I-70 Mountain Corridor PEIS
FGT Need, Safety & Implementation Summary

03/20/01

Rubber Tire Transit Alternatives

RUBBER TIRE TRANSIT ALTERNATIVES	Direction	Need: Practical Capacity (Peak Hour) – Rating	Need: System Attractiveness	Need: Average Speed – Actual MPH	Need: Average Speed – Rating	Need: Connectivity	Need: Feeder/Distribution Requirements	Safety: System Safety	Implementation: Costs – CAP.	Implementation: Technology Available	Implementation: Fuel Usage	Implementation: Energy Consumption
Bus/Van in Mixed Traffic or HOV Lanes (Diesel Only)												
· Bus/Van in Mixed Traffic	Both	Highest/Best	Lowest/Worst	36	Lowest/Worst	Highest/Best	Highest/Best	Lowest/Worst	Highest/Best	Highest/Best	Highest/Best	Highest/Best
· Marked Lane	Peak	Highest/Best	Lowest/Worst	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Best to Intermediate	Best to Intermediate	Highest/Best	Highest/Best
· Marked Lane	Both	Highest/Best	Lowest/Worst	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Best to Intermediate	Best to Intermediate	Highest/Best	Highest/Best
· Separated Lane	Peak	Highest/Best	Worst to Intermediate	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Highest/Best	Highest/Best
· Separated Lane	Both	Highest/Best	Worst to Intermediate	51	Intermediate	Highest/Best	Highest/Best	Worst to Intermediate	Worst to Intermediate	Best to Intermediate	Highest/Best	Highest/Best
Transitway												
· Diesel Power	Peak	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Intermediate	Best to Intermediate	Highest/Best	Highest/Best
	Both	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Intermediate	Best to Intermediate	Highest/Best	Highest/Best
· Dual Power (Diesel/Electric)	Peak	Highest/Best	Worst to Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Worst to Intermediate	Worst to Intermediate	Intermediate	Highest/Best
	Both	Highest/Best	Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Intermediate	Worst to Intermediate	Worst to Intermediate	Intermediate	Highest/Best
· Electric Power	Both	Highest/Best	Intermediate	60	Highest/Best	Worst to Intermediate	Intermediate	Best to Intermediate	Lowest/Worst	Worst to Intermediate	Lowest/Worst	Best to Intermediate
Guideway (Guided Transitway)												
· Diesel Power	Peak	Highest/Best	Worst to Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Best to Intermediate	Best to Intermediate	Intermediate	Highest/Best	Highest/Best
	Both	Highest/Best	Intermediate	51	Best to Intermediate	Highest/Best	Highest/Best	Best to Intermediate	Best to Intermediate	Intermediate	Highest/Best	Highest/Best
	BRT Station	Highest/Best	Intermediate	54	Best to Intermediate	Highest/Best	Intermediate	Best to Intermediate	Intermediate	Intermediate	Highest/Best	Highest/Best
· Dual Power (Diesel/Electric)	Peak	Highest/Best	Best to Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Highest/Best	Intermediate	Lowest/Worst	Intermediate	Highest/Best
	Both	Highest/Best	Best to Intermediate	60	Best to Intermediate	Highest/Best	Highest/Best	Highest/Best	Worst to Intermediate	Lowest/Worst	Intermediate	Highest/Best
	BRT Station	Highest/Best	Best to Intermediate	64	Highest/Best	Highest/Best	Intermediate	Highest/Best	Worst to Intermediate	Lowest/Worst	Intermediate	Highest/Best
· Electric Power	Both	Highest/Best	Highest/Best	60	Best to Intermediate	Worst to Intermediate	Intermediate	Highest/Best	Lowest/Worst	Lowest/Worst	Lowest/Worst	Best to Intermediate
	BRT Station	Highest/Best	Highest/Best	64	Highest/Best	Worst to Intermediate	Intermediate	Highest/Best	Lowest/Worst	Lowest/Worst	Lowest/Worst	Best to Intermediate

Legend

Highest/Best | Best to Intermediate | Intermediate | Worst to Intermediate | Lowest/Worst

DRAFT

I-70 Mountain Corridor PEIS
Rubber Tire Transit Need, Safety & Implementation Summary

03/20/01

Highway Alternatives

HIGHWAY ALTERNATIVES		Need						Safety	Implementation	
		Volume to Capacity Ratio		Speed		Duration of Congested Hours		Accident Reduction Potential	Cost	Constructability
		Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill	Sections I - J Eisenhower Tunnel to US 40	Sections K - M US 40 to Floyd Hill			
· No Build/2020		1.05/LOS F	1.10/LOS F	29	25	4	5			
· Alternative 1	6 Lane Full Width Including TCI with Mixed Barrier Sepatated and Open Median Template	0.56/LOS C	0.83/LOS D	65	61	0	0	Best to Intermediate	Best to Intermediate	Intermediate
· Alternative 2	6 Lane Full Width Including TCI with Structured Lanes	0.56/LOS C	0.83/LOS D	65	61	0	0	Best to Intermediate	Lowest/Worst	Intermediate
· Alternative 3	6 Lane Reduced Width Including TCI	0.56/LOS C	0.83/LOS D	65	61	0	0	Intermediate	Highest/Best	Intermediate
· Alternative 4	6 Lane Reduced Width Including TCI with Structured Lanes	0.56/LOS C	0.83/LOS D	65	61	0	0	Intermediate	Worst to Intermediate	Intermediate
· Alternative 5	6 Lane Reduced Width Including TCI with Structured and Tunneled Lanes	0.56/LOS C	0.83/LOS D	65	61	0	0	Intermediate	Worst to Intermediate	Intermediate
· Alternative 6	6 Lane Reduced Width Including TCI with Structured and Cantilevered Lanes	0.56/LOS C	0.83/LOS D	64	61	0	0	Intermediate	Intermediate	Intermediate
· Alternative 7	6 Lane Mixed Full and Reduced Width Including TCI	0.56/LOS C	0.83/LOS D	64	61	0	0	Best to Intermediate	Best to Intermediate	Intermediate
· Alternative 8	Silverthorne Tunnel							Intermediate	Lowest/Worst	Worst to Intermediate
· Alternative 10	Parallel Routes from East of Twin Tunnels to Approximately Fall River Road							Lowest/Worst	Lowest/Worst	Best to Intermediate
· Alternative 11	6 Lane Reduced Width Including Structured Lanes	1.10/LOS F	0.82/LOS D	45	62	4	0	Worst to Intermediate	Best to Intermediate	Intermediate
· Alternative 12	6 Lane Reduced Width Including TCI with Movable Median and Structured Lanes	1.10/LOS F	0.82/LOS D	45	62	4	0	Worst to Intermediate	Best to Intermediate	Intermediate
· Alternative 13	6 Lane Reduced Width Including TCI with Flex and Structured Lanes	1.10/LOS F	0.82/LOS D	45	62	4	0	Lowest/Worst	Best to Intermediate	Best to Intermediate
· Alternative 14	6 Lane Reduced Width Including TCI with Reversible and Structured Lanes	1.10/LOS F	0.82/LOS D	45	62	4	0	Worst to Intermediate	Intermediate	Best to Intermediate

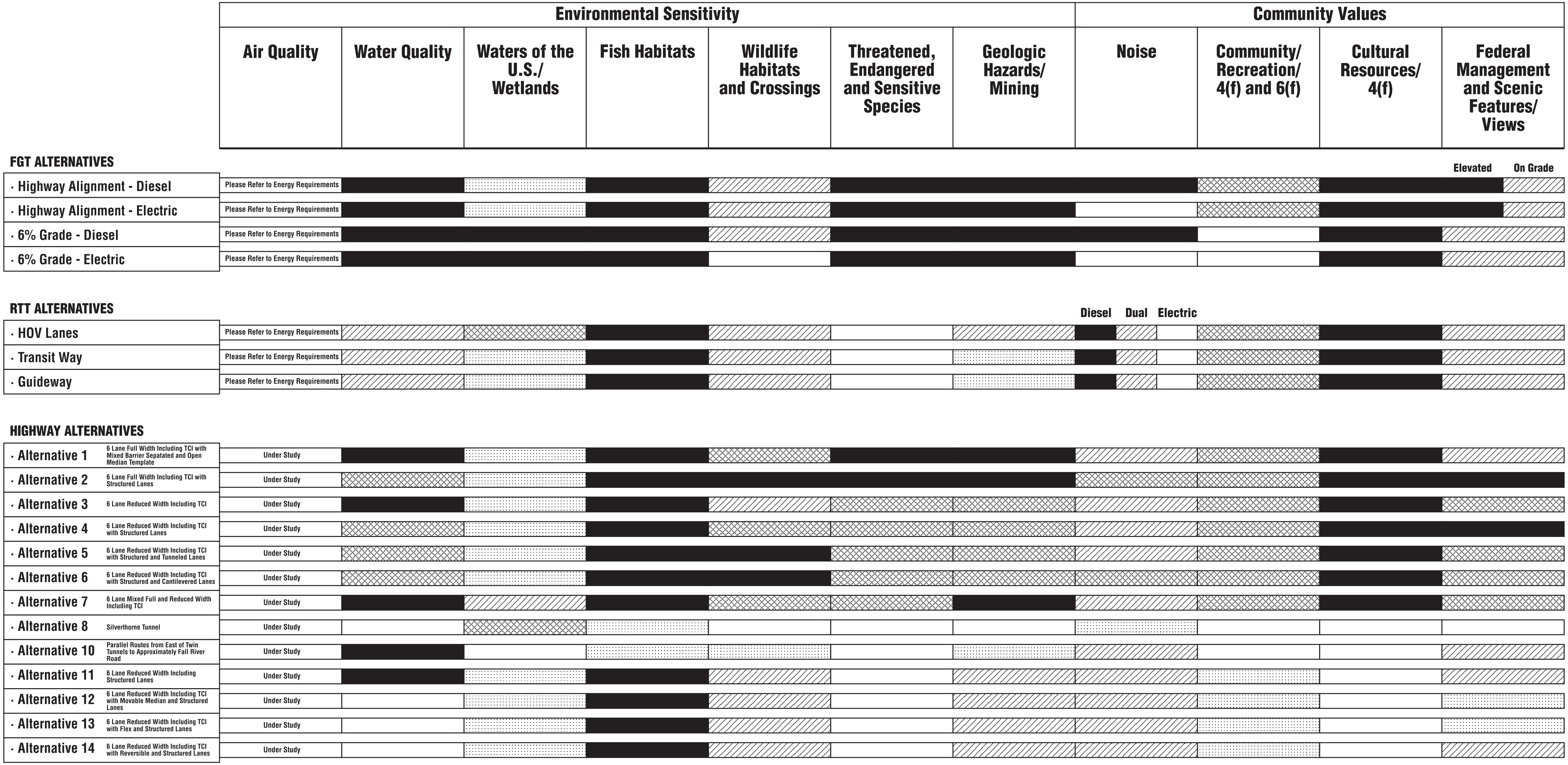
Legend

Highest/Best	Best to Intermediate	Intermediate	Worst to Intermediate	Lowest/Worst

DRAFT

I-70 Mountain Corridor PEIS
Highway Need, Safety & Implementation Summary

03/20/01



Legend

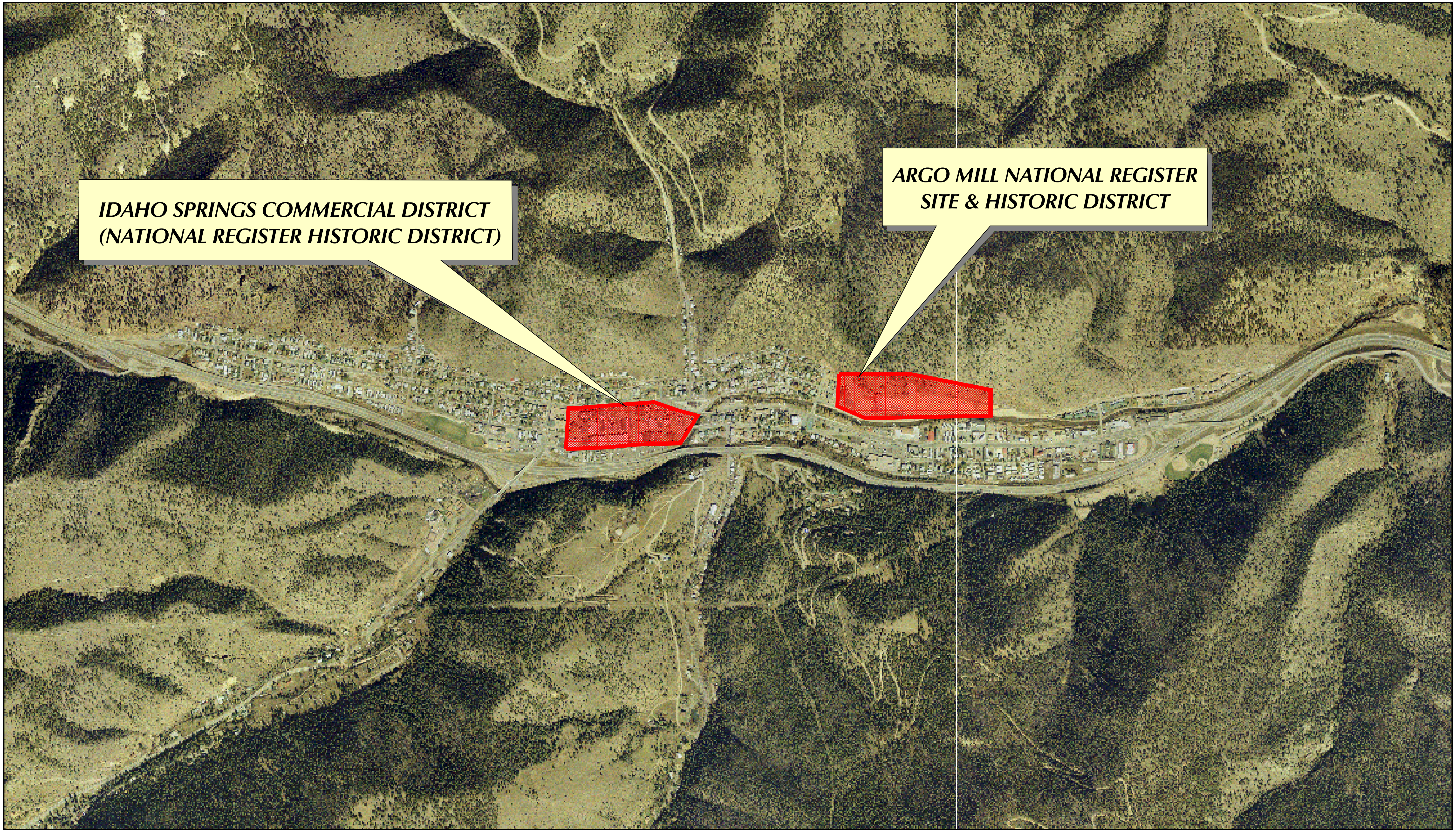
Level of Conflict

DRAFT

I-70 Mountain Corridor PEIS
Environmental Resource Summary

03/20/01

9 – NATIONAL HISTORIC DISTRICT AREAS



DOT
DEPARTMENT OF TRANSPORTATION

J. F. SATO AND ASSOCIATES
5898 South Rapp Street
Littleton, Colorado 80120
Phone: (303) 797-1200

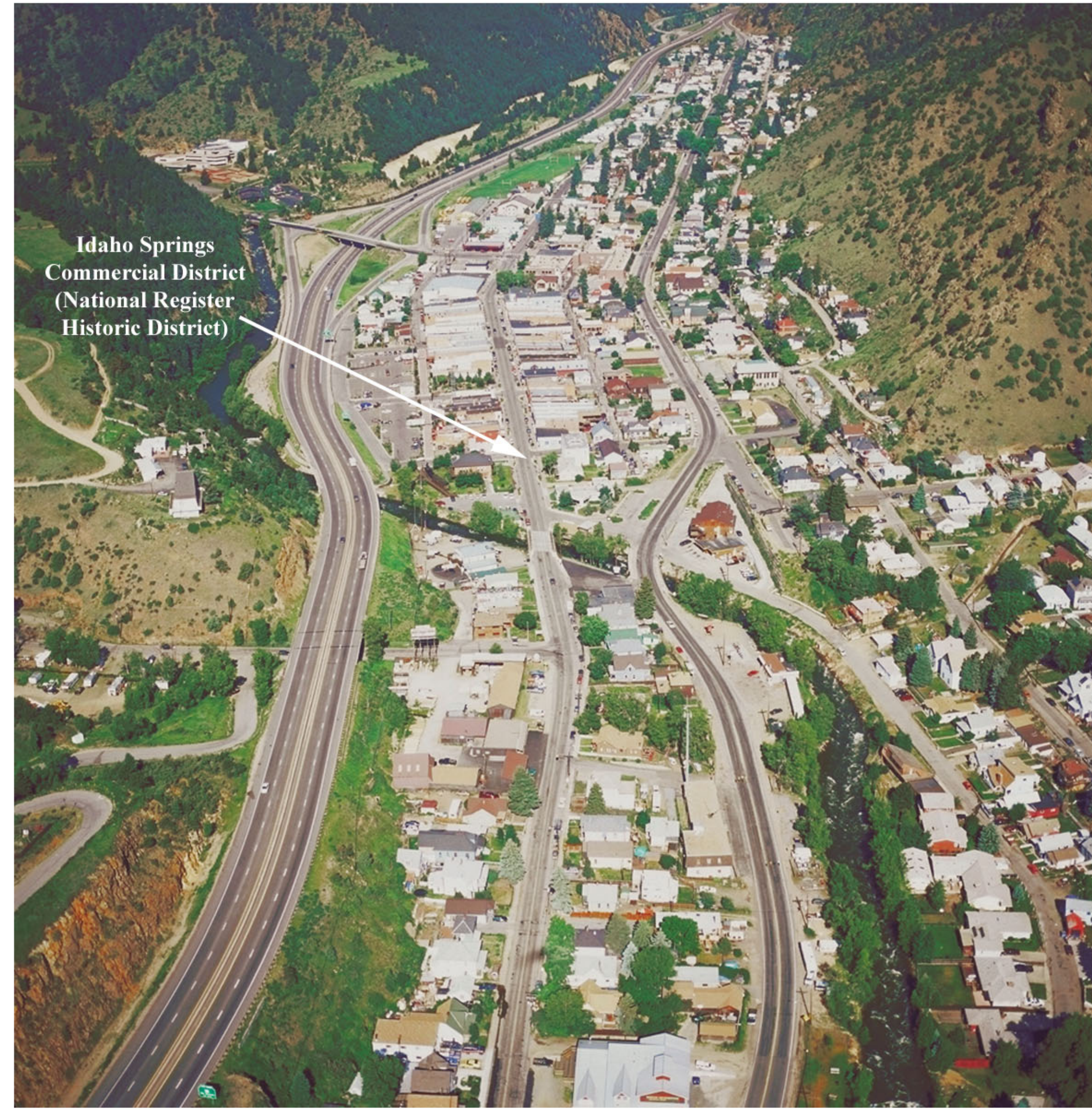
2000 0 2000 Feet

500 0 500 Meters

N W E S

Figure 9-1

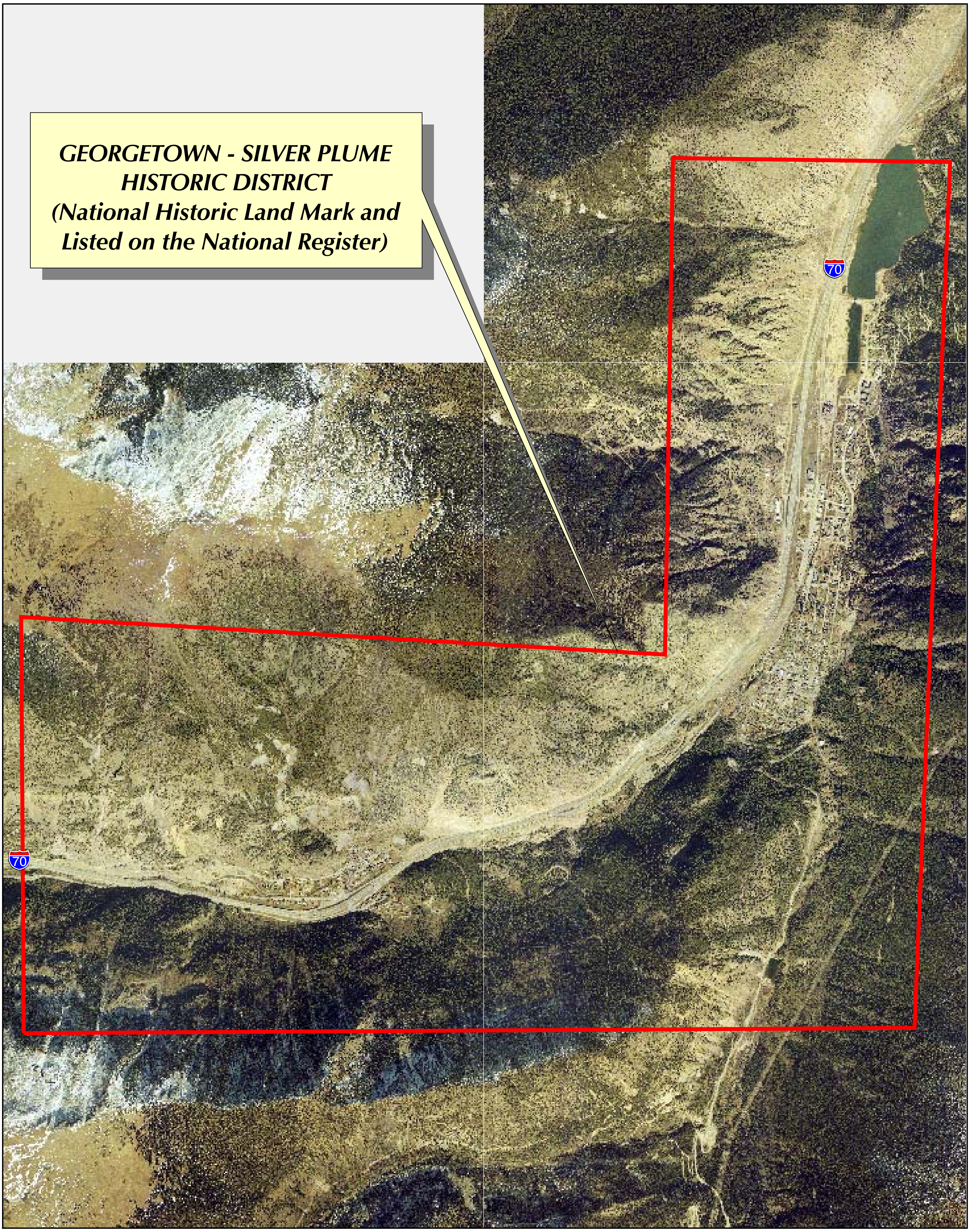
I-70 Mountain Corridor PEIS
Level 2 Screening
Idaho Springs
Historic Districts



I-70 Mountain Corridor PEIS
Level 2 Screening
Idaho Springs Historic Districts
View West

3/20/01

Figure 9-2



2000 0 2000 Feet

500 0 500 Meters

N
W E
S

DOT
DEPARTMENT OF TRANSPORTATION

J. F. SATO AND ASSOCIATES
5898 South Rapp Street
Littleton, Colorado 80120
Phone: (303) 797-1200

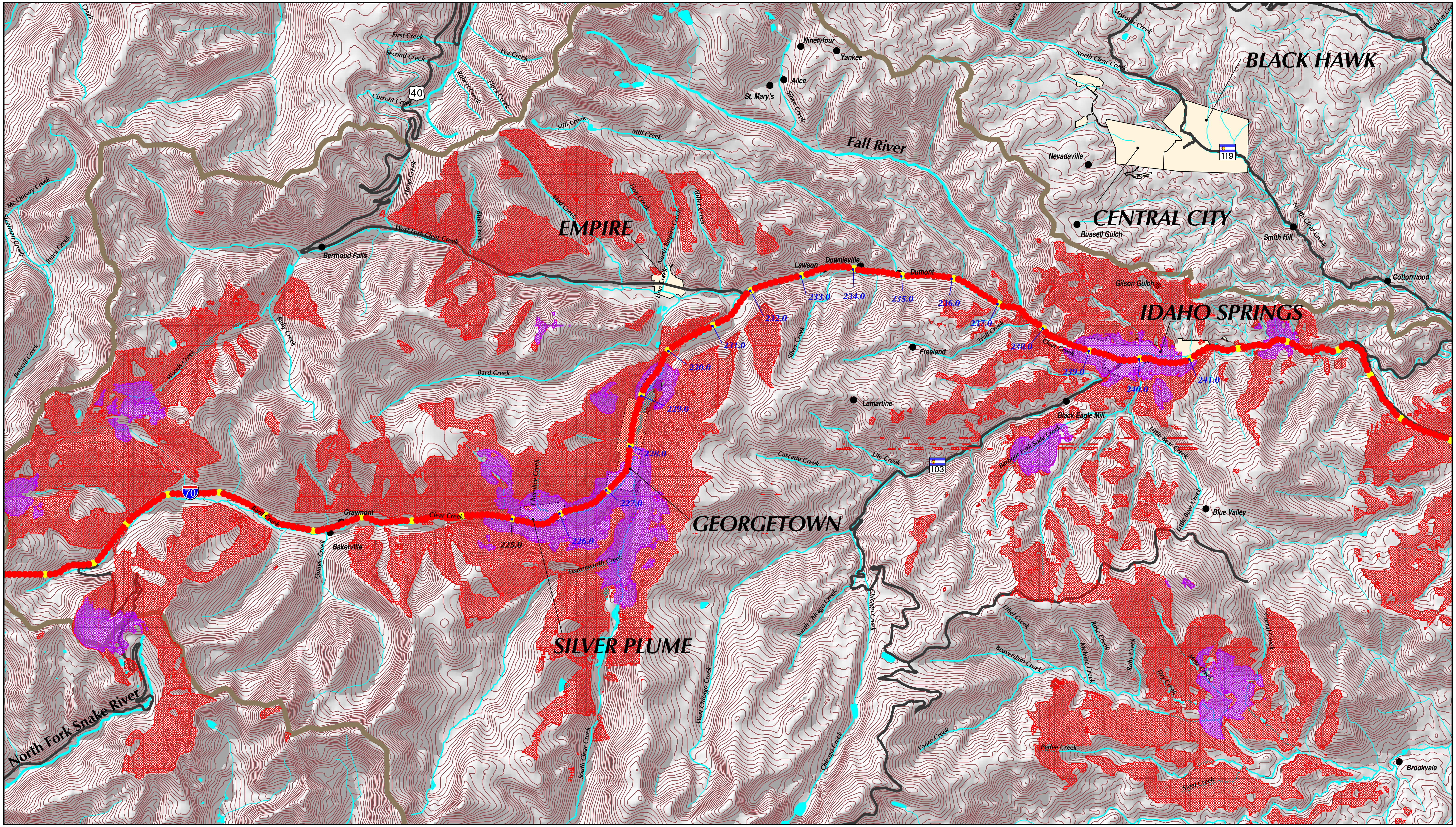
I-70 Mountain Corridor PEIS
Level 2 Screening
Georgetown - Silver Plume
Historic District

Figure 9-3

I-70 Mountain Corridor PEIS
Level 2 Screening
Georgetown & Silver Plume Historic District
(National Historic Landmark, Listed
on the National Register)

3/20/01

Figure 9-4



DOT
DEPARTMENT OF TRANSPORTATION

LEGEND

- Foreground Visibility from Historic Site / District
- Middleground Visibility from Historic Site / District
- Municipal Boundaries
- County Boundaries
- Water Body
- Interstate Highway 70
- State or U.S. Highway
- Streams & Rivers
- 100-Foot Contours
- I-70 1/10th Mile Posts
- Towns

SCALE - 1:110000

2 0 2 Miles

3 0 3 Kilometers

Figure 9-5

SOURCE: Contours, hillshade, and visibility calculated from mosaicked 7.5' USGS DEM data. Municipal, county, and stream information provided by the State of Colorado. Map produced March 20, 2001 by JFSA.

I-70 Mountain Corridor PEIS
Level 2 Screening
Historic Sites & Districts
Foreground & Middleground Visibilities

Appendix G
TranSystems
I-70 Mountain Corridor Air Service Characteristics and Operational Inventory

July 2000

This page intentionally left blank.

I-70 Mountain Corridor
Air Service Characteristics & Operational Inventory

Prepared for:

Colorado Department of Transportation

DOT

J.F. Sato & Associates, Inc.

Prepared by:

TRANSYSTEMS CORPORATION
CONSULTANTS

July 2000

I-70 MOUNTAIN CORRIDOR PROGRAMMATIC EIS:

Air Service Characteristics & Operational Inventory

DRAFT FINAL REPORT

Prepared For:

J. F. Sato & Associates

Prepared By:

TranSystems Corporation

July 26, 2000

Executive Summary

Purpose

The purpose of developing an inventory of aviation service in the I-70 mountain corridor is to gain an understanding of the role that aviation plays in meeting the mobility needs of travelers in the corridor. The inventory also will be used to assess the role that aviation might play in meeting future travel demand in the corridor.

Mountain Corridor Airports

There are nine airports in the I-70 mountain corridor. Five of them are general aviation facilities and four are primary commercial service airports. The latter is distinguished from the former by its scheduled air carrier service and aircraft capacity. General aviation facilities generally have lesser aircraft capacity and are used for air activities such as recreational flyers and private charter and air taxi operators.

Air Service Activity

Over the past eight years, passenger enplanement activity at the four primary airports has increased for all of the airports except Walker Field (GJT), which has seen considerable fluctuations. Eagle County Regional Airport (EGE) has seen the greatest annual growth among the four airports, with Aspen-Pitkin County (ASE) and Yampa Valley (HDN) experiencing steady growth from year to year.

Despite the relatively year-round stability of EGE and GJT, air service activity in the I-70 mountain corridor remains largely driven by the winter ski season. For example, fare subsidies or revenue guarantees offered by the resort communities to entice air passengers and ensure airlines continue otherwise unprofitable routes, have considerable impact on the enplanements of the four airports. For example, without seat guarantees, annual enplanement projections for 2020 drop by as much as 30,000 seats for HDN. By way of another example, decreased enplanements at GJT coincide with increased fare subsidies at ASE and HDN in the same years.

Airport Operational Characteristics

Aspen-Pitkin County Airport is served by three airlines with nearly 200 flights per week during the winter season. It is located three miles northwest of Aspen and seven miles southeast of Snowmass Village along Colorado Highway 82. The elevation at which the airport is sited is approximately 7,800 feet. Passenger enplanements at ASE have increased steadily in the last eight years although enplanements fell from a peak of 252,025 in 1993 to 203,782 in 1995. (Enplanements were at 206,041 in 1991.) However, passenger activity climbed again to 249,651 by 1998.

Eagle County Regional Airport is just off I-70 in the western part of Eagle County, four miles west of Eagle. The airport is sited at an elevation of 6,500 feet. There are a limited number of flights (mainly in the ski season) each day to and from some of the larger U.S. cities operated by five commercial carriers. Prior to 1990, the airport did not have commercial air service. Since then, growth in passenger enplanements has been substantial. Beginning with slightly more than 30,000 enplanements in 1991, there has been a 465% increase to 171,272 enplanements reported for 1998. EGE has seen significant increases from year to year in passenger enplanements, leaping approximately 20,000 each year from 1992 to 1995; 30,000 enplanements between 1995 and 1996; and 51,000 enplanements between 1996 and 1997. In the late 90s, a $9-million passenger terminal was built to accommodate this air passenger growth.

Grand Junction's Walker Field has the most highly developed and modern airfield facilities between Denver and Salt Lake City. Located in western Colorado, it is considered to be a premier airport serving western Colorado and eastern Utah. Walker Field is located three miles northeast of the city at a 4,800 ft. elevation. Located one mile from I-70, Walker Field hosts three commercial carriers with over 18 year-round daily departures to Denver, Phoenix and Salt Lake City. In the last eight years, enplanements at GJT peaked in 1993 at 151,695 and fell as low as 125,411 in 1995. Average annual enplanements over the same period hovered at 136,000.

Yampa Valley Regional Airport is owned and operated by Routt County, Colorado. It is situated at an elevation of 6,600 ft., two miles southeast of the town of Hayden. Near the Steamboat Springs ski resort, it is host to three major airlines during the ski season (mid-December through March) with direct service from Chicago, Dallas/Ft. Worth, Houston, Newark, Atlanta/St. Louis, Los Angeles and Denver. Commuter service is provided year-round to Denver by United Express. Enplanements have climbed steadily since 1991 (59,129) with a slight dip of 3,000 fewer enplanements in 1992. Nevertheless, passenger activity has climbed since 1992 increasing by 34% between 1994 and 1995 alone. HDN reports that 90% of their enplanements take place during the four-month winter ski season.

Air Activity Trends

Compared with national data, enplanement projections for regional airports (such as ASE, EGE, GJT and HDN) are forecast to increase at an annual rate of 5.5% between 1998 and 2009. Enplanements are forecast to slow to 3.6% between 2010 and 2020. Each of the primary airports in the mountain corridor projects steady increases in enplanements through 2020. General aviation facilities will be greatly improved by advances in air system technology and demand will outstrip supply. Other trends that are expected to impact air activity service in the mountain corridor are summarized as follows:

- Airline fleet changeovers from propeller driven aircraft to regional jet aircraft will boost aircraft capacity, serve greater markets, and attract air passengers previously unwilling to travel in propeller aircraft.
- Advances in national air system technology will "grow" the capacity of primary and general aviation facilities.
- Greater pressure will be placed on summer recreational industries to help bear the costs of revenue guarantees and even-out the seasonal vagaries of air activity.
- In the absence of greater marketing efforts, declines in out-of-state skiers and greater reliance on Front Range skiers are expected.
- With continued economic growth and aging Baby Boomer population, increased second-home development is expected.

Hub Access Airports

Colorado's major hub airports, Denver International Airport (DEN) and Colorado Springs Airport (COS) serve as gateway facilities to the mountain airports. At DEN, 100 nonstop domestic destinations and 10 nonstop international destinations are available from the airport, including service to the four mountain corridor airports. Numerous charter and scheduled shared-ride transportation is available from DIA to the mountain resorts. At COS, twelve nonstop destinations are available from the airport, however none of those include the four mountain corridor airports. COS passengers seeking access to the mountain resorts by air, must take connecting flights at DIA. Presently, there are no scheduled shared-ride ground transportation services available from COS to the mountain resorts. Charter services, such as Timberline Express, are available, however.

General Aviation Activity

General aviation activity includes everything from single-engine propeller-driven aircraft to sophisticated corporate jets. General aviation airports in the mountain corridor include Garfield County Regional Airport, Glenwood Springs Municipal Airport, Kremmling Airport (formerly McElroy Airfield), Lake County Airport, and Steamboat Springs/Bob Adams Field. These airports have critical significance to a region even when shared with a primary airport as they transport cargo and provide air ambulances services and charter and aircraft rental.

Air Cargo

Air cargo is typically transported in the baggage compartments of scheduled passenger aircraft and by all-cargo aircraft. Most all-cargo flights are scheduled during off-peak periods and do not substantially contribute to airport congestion and delay problems. Historically, air cargo service has not substituted in any significant way for freight shipping by truck to the communities and airports in the mountain corridor. However, just-in-time logistics will require that producers receive and ship smaller quantities more frequently and quickly over long distances. Air cargo, once considered a luxury and reserved for small, lightweight, compact products with high value-to-weight ratios, is predicted to triple in the next 20 years for some airports.

Introduction

There are nine airports in the I-70 mountain corridor. Five of them are general aviation facilities and four are primary commercial service airports. The latter is distinguished from the former by its scheduled air carrier service and aircraft capacity. General aviation facilities generally have lesser aircraft capacity and are used for air activities such as recreational flyers and private charter and air taxi operators. The Federal Aviation Administration (FAA) also defines commercial service airports as airports with at least 2,500 annual enplanements. Those with fewer enplanements are considered general aviation airports. Commercial service airports with greater than 10,000 annual enplanements are considered primary airports.

Purpose and Scope

The purpose of developing an inventory of aviation service in the I-70 mountain corridor is to gain an understanding of the role that aviation plays in meeting the mobility needs of travelers in the corridor. The inventory also will be used to assess the role that aviation might play in meeting future travel demand in the corridor. The scope of the current analysis includes aviation facilities that serve the I-70 corridor and air transportation services that link air passengers to their ultimate destinations within the mountain corridor "area of influence."

Methodology

For purposes of inventorying air service in the I-70 mountain corridor, the research focused on commercial service airports, however some anecdotal information about the general aviation facilities is included. Efforts to expand general aviation facilities to augment commercial air service in the mountain corridor recently have been unsuccessful due to extremes posed by weather, terrain and public objections. However, their value to the corridor's air service activity and potential to augment air service should not be dismissed. Please reference the map on the following page.

Commercial Aviation

The four principal commercial airports in the I-70 corridor were selected based on their proximity and access to I-70. These include Aspen-Pitkin County/Sardy Field (ASE) in Aspen, Eagle County Regional Airport (EGE) in the Avon/Beaver Creek area, Walker Field (GJT) in Grand Junction, and Yampa Valley Regional Airport (HDN) near Steamboat Springs.

Airport data for commercial airports are largely derived from counts of air passenger enplanements, or the number of passengers boarding an aircraft. This is the standard number by which airport passenger activity is compared. Aircraft operations, such as the percentages of types of air activity (commercial flights, air taxis, military) at the airport, also are included in these data. For purposes of the PEIS, historical, current and forecast data regarding enplanements were used to assess the current capacity of air service and to determine future airport needs. Additional information was gathered regarding each airport's infrastructure such as runway type and capacity, approach type, size of aircraft accommodated, hangar facilities, type of air traffic control, and terminal features. Information regarding seasonal variations and ratios of residential use was used to supplement the passenger data. Descriptions of the airline carriers serving each airport also were included such as type of aircraft, schedules, and flights.

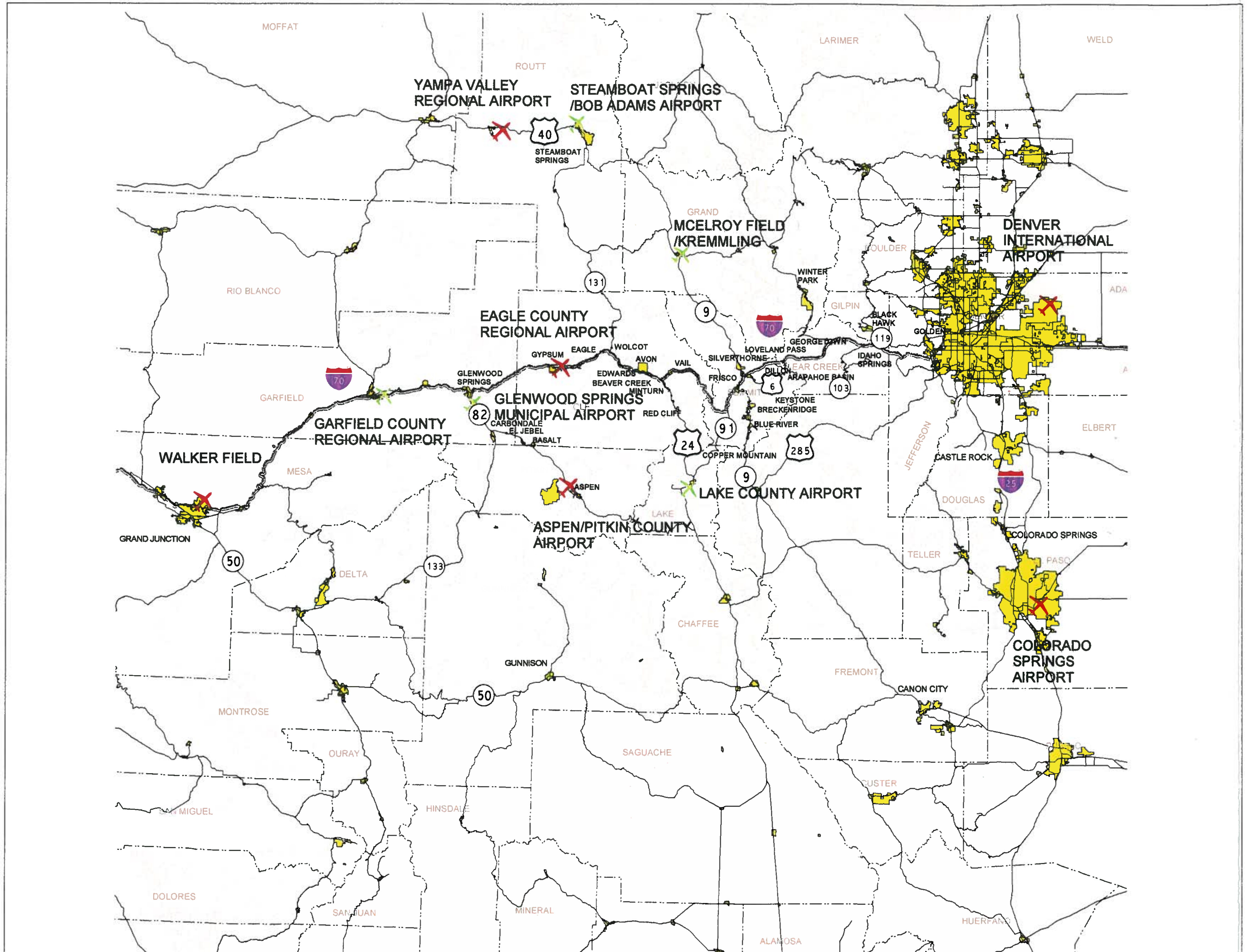


EXHIBIT 1-5

LEGEND

COMMERCIAL SERVICE AIRPORTS

GENERAL AVIATION AIRPORTS

N W E S

EXISTING AVIATION SYSTEM

DATE : 7-26-00

This information was collected from a variety of sources including the airports' aviation directors, the airports' websites, and annual reports of the Federal Aviation Administration's Aviation Capacity Branch.

Results

All of the contacted airport managers at both the commercial service and the general aviation airports responded with the exception of Aspen-Pitkin County/Sardy Field. Several attempts were made to reach the manager and assistant manager, but they did not respond. Calls were placed to the county facilities manager, but that person also did not respond.

Findings

Air Service Activity

Airport activity data for commercial service airports are based on air passenger enplanements; that is, the number of passengers boarding the aircraft. Current and forecast passenger enplanement data and aircraft operations are the basis for determining future airport needs.

Over the past eight years, passenger enplanement activity at the four primary airports has increased for all of the airports except Walker Field (GJT), which has seen considerable fluctuations. Eagle County Regional Airport (EGE) has seen the greatest annual growth among the four airports, with Aspen-Pitkin County (ASE) and Yampa Valley (HDN) experiencing steady growth from year to year.

Table 1.1 Passenger Enplanement Activity at the Four Primary Airports

Airport	Historical Enplanements		Historical Annual Growth Rate	Projected Enplanements		Projected Annual Growth Rate	Seasonal Variation	Residential To Transient Ratio
	1991	*1998*		*2010*	*2020*			
ASE	206,041	249,651	2.80%	Data not supplied	DNS	DNS	Winter, 50%	DNS
EGE	30,308	171,272	58%	200,000*	260,000*	5%	Winter, 70%	27%
GJT	133,735	129,697	-0.38%	264,000	299,800*	2.3%	May-Oct, Slight↑	30-40%
HDN	59,129	106,092	10%	128,800*	188,200	2.9%	Winter, 90%	N/a

Source: FAA DOT/TSC CY1998 ACAIS Database, Airport Managers
* Projections for EGE are 2001 and 2006; Projections for GJT are 2010 and 2015; Projections for HDN are 2005 and 2020

Compared with national data, enplanement projections for regional airports (such as ASE, EGE, GJT and HDN) are forecast to increase at an annual rate of 5.5% between 1998 and 2009. Enplanements are forecast to slow to 3.6% between 2010 and 2020.

Despite the relatively year-round stability of EGE and GJT, air service activity in the I-70 mountain corridor remains largely driven by the winter ski season. For example, fare subsidies or revenue guarantees offered by the resort communities to entice air passengers and ensure airlines continue otherwise unprofitable routes, have considerable impact on the enplanements of the four airports. For example, without seat guarantees, annual enplanement projections for 2020 drop by as much as 30,000 seats for HDN. By way of another example, decreased enplanements at GJT coincide with increased fare subsidies at ASE and HDN in the same years.

Nevertheless, airlines at two of the primary airports, GJT and EGE, function without revenue guarantees and are well-served by the airlines. GJT and EGE both enjoy year-round air activity with one of GJT's airlines actually stepping up service in the summer months. ASE and HDN continue to rely on revenue guarantees to maintain desired levels of skier activity and airline service. EGE still experiences drop-offs in enplanements after the ski season, but nothing compared to the sharp drop-offs experienced by ASE and HDN.

The four airports also differ in the types of aircraft serving the airport. For example, ASE and HDN predominantly are served by airlines with small (20-30 passenger), propeller- or turbofan-driven aircraft such as the BAE 146, DH 8 (or Dash Abouts), Dornier 328, and Beechcraft 1900. Airlines serving EGE and GJT also use these types of aircraft but increasingly are accommodating regional jet aircraft that hold 50-80 passengers and are jet-powered. These jet aircraft, also dubbed RJs or mini-757s, provide numerous air flight efficiencies and benefits, not the least of which is greater passenger confidence.

With regard to weather and terrain, these mountain airports are subject to greater hazards and limitations than most airports. Advances in aviation technology are predicted to minimize some of these hazards and limitations (see the Aviation Alternatives Report), but it is important to note that, currently, severe weather contributes to significant flight delays. For example, 38% of arrivals to EGE, occur on-time, and 78% of departures occur on-time. At HDN, 78% of arrivals occur on-time, and 89% of departures occur on-time. Airports in Barrow and Dutch Harbor, Alaska, Jackson, Wyoming, and Monterey, California experience similar delays due to constraints of weather and terrain. Otherwise, these percentages are markedly below larger airport on-time percentages.

Airport characteristics and operational data

Each of the four airports serving the I-70 corridor has vastly differing characteristics that affect its air service market and frequency of service as shown in Table 1.2.

Table 1.2 Percentage of Aircraft Operations at the Four Primary Airports

Percentage of Aircraft Operations						
	Commercial	Transient GA	Air Taxi	Local GA	Military	Total Avg/Day
ASE	24%	57%	10%	9%	<1%	125
EGE	21%	48%	5%	15%	11%	88
GJT	13%	39%	20%	25%	3%	238
HDN	44%	42%	3%	11%	<1%	23

Source: Airport AirNav web sites

The general characteristics of each airport are described below with current operation levels and activity forecasts. Fare information for airlines serving each airport is intended to provide a frame of reference to compare prices (some of which may reflect seat subsidies) but readers should be aware that numerous fare specials are offered and fares cited in this report can be substantially lower or higher.

Aspen-Pitkin County Airport (ASE)

Aspen-Pitkin County Airport is served by three airlines with nearly 200 flights per week during the winter season. It is located three miles northwest of Aspen and seven miles southeast of Snowmass Village along Colorado Highway 82. The elevation at which the airport is sited is approximately 7,800 feet.

F.1. Aspen-Pitkin County Airport/Sardy Field

Passenger enplanements at ASE have increased steadily in the last eight years although enplanements fell from a peak of 252,025 in 1993 to 203,782 in 1995. (Enplanements were at 206,041 in 1991.) However, passenger activity climbed again to 249,651 by 1998.

Table 1.3 below summarizes ASE's enplanement data over an eight-year period, projected enplanements, as well as seasonal variations and the rate of residential use.

Table 1.3 ASE Enplanement Activity

ASPEN-PITKIN COUNTY/SARDY FIELD (ASE)							
Historical Enplanements		Historical Annual Growth Rate	Projected Enplanements		Projected Annual Growth Rate	Seasonal Variation	Residential Use Ratio
1991	*1998*					*Winter*	
206,041	249,651	2.80%	Data not supplied (DNS)	DNS	DNS	50%	DNS

Source: FAA DOT/TSC CY1998 ACAIS Database

ASE has two runways each 7,000 feet long and 100 feet wide. They are composed of asphalt and can accommodate from 80,000 pounds of single-axle weight to 160,000 pounds of double-tandem weight. Over 100 aircraft are based on the field and the air traffic control tower is staffed from 7:00am to 11:00pm. On average, ASE handles 125 flights per day with nearly 25% of those flights being commercial air service. Improvements include upgrades to the general aviation facilities.

Infrastructure features are summarized in Table 1.4 below.

Table 1.4 ASE Infrastructure Features

ASPEN-PITKIN COUNTY/SARDY FIELD (ASE)

Type of Airport (primary, GA, military, reliever):	Primary
Runway Info (length, width, capacity):	Two runways; Dimensions: 7004 x 100 ft.; Surface: asphalt/porous friction courses, in good condition; Weight limitations: PCN 26/F/C/X/T Single wheel: 80000 lbs Double wheel: 100000 lbs Double tandem: 160000 lbs
Approach Type (VFR, IFR*):	IFR
Based Aircraft:	Aircraft based on the field: 103; Single engine airplanes: 80; Multi engine airplanes: 11; Jet airplanes: 7; Gliders: 5
Hangar Facilities:	Hangars and tiedowns
Airport Operations:	Aircraft operations: average 125/day; 57% transient general aviation; 24% commercial; 10% air taxi; 9% local general aviation; <1% military
Air Traffic Control:	Attended 7am to 11pm
Terminal Features	45,000 SF, five rental car agencies, one restaurant, two vending machine companies, one gift shop, two ground transportation booths, two small baggage carousels (one exclusively for UA)

*VFR stands for visual flight rules and is typically the case for general aviation facilities. IFR stands for instrument flight rules and is typically the case for commercial service facilities. IFR differs from VFR in that non-precision instruments (or VFR) may be required during periods of extreme weather.

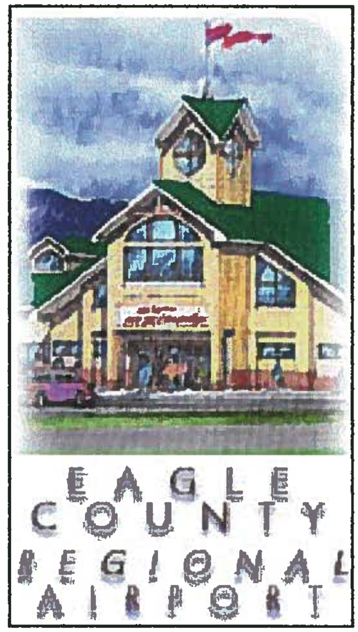
Source: AirNav Aspen-Pitkin County/Sardy Field Web Site

Airlines with direct service into ASE include the following:

Northwest Airlines offers two daily nonstop flights from Minneapolis/St. Paul, using RJ-85 jet aircraft, during the ski season. Round-trip fares are over $1,000 during the ski season for the least-expensive alternative. Northwest's global alliance with KLM Royal Dutch Airlines allows seamless two-stop connections from dozens of cities throughout Europe via their Amsterdam hub. No flights are offered in the shoulder seasons, but in the summer season, one nonstop is offered from MSP on BAE 146 aircraft.

United Airlines offers two daily one-stop flights (via Denver) from Los Angeles, with service on BAE-146 jet aircraft, and five daily nonstop flights from Denver during the ski season. There are numerous two-stop connections from most major international airports such as Dulles, Chicago, Newark, San Francisco, and Miami. Round-trip fares during the ski season from Denver are about $288 round-trip and flights from LAX are about $532 round-trip for the least-expensive alternatives. Flights are reduced considerably during the shoulder season but five flights are offered from Denver June through September on United Express/Wisconsin Air.

America West offers two daily nonstop flights from Phoenix on 37-passenger Dash-8-200 (DH8) aircraft during the ski season. This service also provides one-stop access, with a layover on the arrival, via British Airways nonstop from London/Gatwick. Round-trip fares during the ski season from Phoenix are about $380 for the least-expensive alternative. During the summer season, three daily nonstops are offered from Phoenix.



F.2. Eagle County Regional Airport

Eagle County Regional Airport (EGE)

Eagle County Regional Airport is just off I-70 in the western part of Eagle County, four miles west of Eagle. The airport is sited at an elevation of 6,500 feet. There are a limited number of flights (mainly in the ski season) each day to and from some of the larger U.S. cities operated by five commercial carriers.

Prior to 1990, the airport did not have commercial air service. Since then, growth in passenger enplanements has been substantial. Beginning with slightly more than 30,000 enplanements in 1991, there has been a 465% increase to 171,272 enplanements reported for 1998. EGE has seen significant increases from year to year in passenger enplanements, leaping approximately 20,000 each year from 1992 to 1995; 30,000 enplanements between 1995 and 1996; and 51,000 enplanements between 1996 and 1997. In the late 90s, a $9 million passenger terminal was built to accommodate this air passenger growth.

Table 1.5 below summarizes EGE's enplanement data over an eight-year period, projected enplanements, as well as seasonal variations and the rate of residential use.

Table 1.5 EGE Enplanement Activity

EAGLE COUNTY REGIONAL AIRPORT (EGE)							
Historical Enplanements		Historical Annual Growth Rate	Projected Enplanements		Projected Annual Growth Rate	Seasonal Variation	Residential Use Ratio
1991	*1998*		*2001*	*2006*		*Winter*	
30,308	171,272	58%	200,000	260,000	5%	70%	27%

Source: FAA DOT/TSC CY1998 ACAIS Database, EGE Airport Manager

EGE has two runways each 8,000 feet long and 150 feet wide. They are composed of grooved asphalt and can accommodate from 60,000 pounds of single-wheel weight to 115,000 pounds of double-wheel weight. Over 50 aircraft are based on the field and the air traffic control tower is staffed from 7:00am to 7:00pm. On average, EGE handles 88 flights per day with 21% of those flights being commercial air service. EGE is planning to extend Runway 7/25 by 1,000 feet to the east. No other major capital improvements are planned.

Infrastructure features are summarized in Table 1.6 below.

Table 1.6 EGE Infrastructure Features

EAGLE COUNTY REGIONAL AIRPORT (EGE)	
Type of Airport (primary, GA, military, reliever):	Primary
Runway Info (length, width, capacity):	Two runways; Dimensions: 8000 x 150 ft.; Surface: asphalt/grooved, in good condition; Weight limitations: Single wheel: 60000 lbs, Double wheel: 115000 lbs
Approach Type (VFR, IFR):	IFR
Based Aircraft:	Aircraft based on the field: 51; Single engine airplanes: 28; Multi-engine airplanes: 4; Jet airplanes: 10; Military: 9
Hangar Facilities:	Hangars and tiedowns
Airport Operations:	Aircraft operations: average 88/day; 48% transient general aviation; 21% commercial; 15% local general aviation; 11% military; 5% air taxi
Air Traffic Control:	Attended 7am to 9 pm
Terminal Features:	Two terminals; terminal A is 31,000 SF, Terminal B is 30,000 SF; various concessions; all major rental car agencies

Source: AirNav Eagle County Regional Airport Web Site, EGE Airport Manager

Air service is provided mainly in the ski season by five major carriers with nine daily nonstop flights from U.S. cities, plus eight daily nonstops from Denver, December through March.

American Airlines offers five daily nonstop flights from Chicago, Dallas/Fort Worth, and Newark, December through April. Additional, but limited, flights are offered on weekends only from Miami, New York/LaGuardia with San Francisco service Monday through Wednesday only. American Airlines primarily uses 757 aircraft. Round-trip fares from Chicago during the ski season are about $1,418 for the least-expensive alternative. Round-trip fares from DFW during the ski season are about $1,224 for the least-expensive alternative. Round-trip fares from Newark during the ski season are about $1,660 for the least-expensive alternative.

Continental Airlines offers one daily nonstop from Houston (IAH) December through April, and two Saturday nonstop flights from Newark, December through April. Continental primarily uses 757 aircraft. Round-trip fares from Houston during the ski season are about $1,300 for the least-expensive alternative.

Delta Airlines offers one daily nonstop from Atlanta, December through March. Delta primarily uses 757 aircraft. Delta has no scheduled flights into EGE for the 2000-2001 ski season.

Northwest Airlines offers one daily nonstop from Minneapolis/St. Paul, December through April. An additional nonstop weekend flight is offered from MSP, February through April. One Saturday nonstop flight is offered from Detroit, December through April. Northwest primarily uses 757 aircraft. Round-trip fares from Houston during the ski season are about $990 for the least-expensive alternative.

F.3. Airlines Serving Eagle County Regional Airport

United Airlines offers nonstop service from Chicago, New York, Los Angeles, and Denver. One weekend nonstop flight is offered from Chicago or New York, December through April. There are eight daily flights from Denver (*United Express/Great Lakes Aviation*) and one daily flight from Los Angeles, December through April. Year-round, United Airlines (United Express) offers seven daily nonstop flights to Denver. United Airlines primarily uses BAE 146 and Beechcraft 1900 aircraft. Round-trip fares from Chicago during the ski season are about $1,410 for the least-expensive alternative. Round-trip fares from New York during the ski season are about $1,750 for the least-expensive alternative. Round-trip fares from LAX during the ski season are about $586 for the least-expensive alternative.

Grand Junction-Walker Field (GJT)

Grand Junction's Walker Field has the most highly developed and modern airfield facilities between Denver and Salt Lake City. Located in western Colorado, it is considered to be a premier airport serving western Colorado and eastern Utah. Walker Field is located three miles northeast of the city at a 4,800 ft. elevation. Located one mile from I-70, Walker Field hosts three commercial carriers with over 18 year-round daily departures to Denver, Phoenix and Salt Lake City

In the last eight years, enplanements at GJT peaked in 1993 at 151,695 and fell as low as 125,411 in 1995. Average annual enplanements over the same period hovered at 136,000.

Table 1.7 below summarizes GJT's enplanement data over an eight-year period, projected enplanements, as well as seasonal variations and the rate of residential use.

Table 1.7 GJT Enplanement Activity

WALKER FIELD (GJT)							
Historical Enplanements		**Historical Annual Growth Rate**	**Projected Enplanements**		**Projected Annual Growth Rate**	**Seasonal Variation**	**Residential Use Ratio**
1991	*1998*		*2010*	*2015*		*May – Oct*	
133,735	129,697	-0.38%	264,000	299,800	2.3%	Slight ↑	30-40%

Source: FAA DOT/TSC CY1998 ACAIS Database, Walker Field Public Communications Director

GJT's two main runways are 10,500 feet long and 150 feet wide with 20-foot-wide paved shoulders. The other two runways are cross-wind runways that are 5,500 feet long and 75 feet wide. All runways feature parallel taxiways. They are composed of grooved asphalt. Over 120 aircraft are based on the field and the air traffic control tower is staffed around-the-clock. On average, GJT handles 238 flights per day with 13% of those flights being commercial air service. Walker Field is not planning any major capital improvements.

Infrastructure features are summarized in Table 1.8 below.

Table 1.8 GJT Infrastructure Features

WALKER FIELD (GJT)

Type of Airport (primary, GA, military, reliever):	Primary
Runway Info (length, width, capacity):	*Two runways*; Dimensions: 5502 x 75 ft.; Surface: asphalt/grooved, in good condition; Weight limitations: PCN 09/F/C/Z/T, Single wheel: 26000 lbs, Double wheel: 26000 lbs *Two runways*; Dimensions: 10501 x 150 ft.; Surface: asphalt/porous friction courses, in good condition; Weight limitations: PCN 54/F/C/X/T, Single wheel: 110000 lbs, Double wheel: 180000 lbs, Double tandem: 260000 lbs
Approach Type (VFR, IFR):	IFR
Based Aircraft:	Aircraft based on the field: 126; Single engine airplanes: 105; Multi engine airplanes: 19; Jet airplanes: 2
Hangar Facilities:	Hangars and tiedowns
Airport Operations:	Aircraft operations: average 238/day; 39% transient general aviation; 25% local general aviation; 20% air taxi; 13% commercial; 3% military
Air Traffic Control:	Continuous
Terminal Features	70,000 sq ft terminal with restaurant, espresso bar and gift shop; six major rental car companies

Source: AirNav Walker Field Web Site

Three major carriers serving GJT *year-round* include the following:

United Express/Air Wisconsin offers 10 nonstop daily flights from Denver on Dornier 328 and BAE 146 aircraft. Round-trip fares from Denver during the ski season are $304 for the least-expensive alternative.

Skywest/Delta offers four nonstop daily flights from Salt Lake City using DH8 aircraft. Round-trip fares from Salt Lake City during the ski season are $267 for the least-expensive alternative.

American West/Mesa Airlines offers four nonstop daily flights from Phoenix on DH 8 aircraft. Round-trip fares from Phoenix during the ski season are $329 for the least-expensive alternative.

Yampa Valley Regional Airport (HDN)

Yampa Valley Regional Airport is owned and operated by Routt County, Colorado. It is situated at an elevation of 6,600 ft., two miles southeast of the town of Hayden. Near the Steamboat Springs ski resort, it is host to three major airlines during the ski season (mid-December through March) with direct service from Chicago, Dallas/Ft. Worth, Houston, Newark, Atlanta/St. Louis, Los Angeles and Denver. Commuter service is provided year-round to Denver by United Express.

Enplanements have climbed steadily since 1991 (59,129) with a slight dip of 3,000 fewer enplanements in 1992. Nevertheless, passenger activity has climbed since 1992 increasing by 34% between 1994 and 1995 alone. HDN reports that 90% of their enplanements take place during the four-month winter ski season.

F.4. Walker Field Airport in Grand Junction

Table 1.9 below summarizes HDN's enplanement data over an eight-year period, projected enplanements, as well as seasonal variations and the rate of residential use.

TranSystems Corporation Consultants

Table 1.9 HDN Enplanement Activity

YAMPA VALLEY REGIONAL AIRPORT (HDN)							
Historical Enplanements		**Historical Annual Growth Rate**	**Projected Enplanements**		**Projected Annual Growth Rate**	**Seasonal Variation**	**Residential Use Ratio**
1991	*1998*		*2005*	*2020*		*Winter*	
59,129	106,092	10%	128,800	188,200	2.9%	90%	N/A

Source: FAA DOT/TSC CY1998 ACAIS Database, Yampa Valley Regional Airport Aviation Director

HDN's two runways are 10,000 feet long and 150 feet wide and composed of grooved asphalt. Six aircraft are based on the field and the air traffic control tower is staffed from 6:00am to 8:00pm. On average, HDN handles 23 flights per day with 44% of those flights being commercial air service. HDN is planning to complete a new 45,000 SF terminal in 2005 that will be designed for 2005 enplanement projections. Other improvements include development of general aviation facilities to meet demand.

Infrastructure features are summarized in Table 1.10 below.

Table 1.10 HDN Infrastructure Features

YAMPA VALLEY REGIONAL AIRPORT (HDN)

Type of Airport (primary, GA, military, reliever):	Primary
Runway Info (length, width, capacity):	Two runways; Dimensions: 10,000 x 150 ft.; Surface: asphalt/grooved, in good condition; Weight limitations: PCN 09/F/C/Z/T, Single wheel: 75000 lbs, Double wheel: 170000 lbs, Double tandem: 260000
Approach Type (VFR, IFR):	IFR on Runway 28 only
Based Aircraft:	Aircraft based on field: 6; single engine airplanes: 6
Hangar Facilities:	Two hangars (storage and maintenance and tiedowns
Airport Operations:	Aircraft operations: average 23/day; 42% transient general aviation; 28% commuters; 16% commercial; 11% local general aviation; 3% air taxi; <1% military
Air Traffic Control:	6:00am to 9:00pm
Terminal Features	20,000 SF; two rental car agencies, three concessions and gift shop

Source: AirNav Yampa Valley Regional Airport Web Site

F.5 Flight departing from Yampa Valley Regional Airport

American Airlines has a cooperative service relationship with United Airlines and offers five daily one-stop flights (via Denver) from Dallas/Fort Worth, mid-December through March. Five additional one-stop flights also are offered during the same winter period in a cooperative service relationship with United. American Airlines primarily uses BAE 146 aircraft on the flights from Denver to HDN. Round-trip fares from DFW during the ski season were as low as $524 for the least-expensive alternative.

Continental Airlines offers one daily nonstop flight from Houston (IAH). Four one-stop flights (via IAH) also are offered daily from Newark. Both routes are only available mid-December through March. Boeing 737 aircraft are used from IAH and Boeing 757 aircraft are used from Newark. Round-trip fares from Houston during the ski season were as low as $276 for the least-expensive alternative. Round-trip fares from Newark during the ski season were as low as $349 for the least-expensive alternative.

United Airlines offers two daily one-stop flights from Chicago O'Hare (via Denver) mid-December through March. Two daily flights are offered from Los Angeles (via Denver), mid-December through March. The connecting flights from Denver to Hayden are the same flight number for both Chicago and LAX flights. Dornier 328 aircraft primarily are used. Round-trip fares from Chicago during the ski season are $1,172 for the least-expensive alternative. Round-trip fares from LAX during the ski season are $600 for the least-expensive alternative.

Air Activity Trends

Each of the primary airports in the mountain corridor projects steady increases in enplanements through 2020. General aviation facilities will be greatly improved by advances in air system technology and demand will outstrip supply. Other trends that are expected to impact air activity service in the mountain corridor are summarized as follows:

- Airline fleet changeovers from propeller driven aircraft to regional jet aircraft will boost aircraft capacity, serve greater markets, and attract air passengers previously unwilling to travel in propeller aircraft
- Advances in national air system technology that will "grow" the capacity of primary and general aviation facilities
- Greater pressure on summer recreational industries to help bear the costs of revenue guarantees and even-out the seasonal vagaries of air activity
- In the absence of greater marketing efforts, declines in out-of-state skiers, greater reliance on Front Range skiers
- With continued economic growth and aging Baby Boomer population, increased second-home development

As previously mentioned, compared with national data, enplanement projections for regional airports (such as ASE, EGE, GJT and HDN) are forecast to increase at an annual rate of 5.5% between 1998 and 2009. Enplanements are forecast to slow to 3.6% between 2010 and 2020.

Figure 6. Types of Aircraft Serving the Mountain Corridor Airports

Boeing 757

Dash 8

Dornier 328

Beechcraft 1900d

BAE 146

Boeing 737

Historical and projected enplanements for the mountain corridor airports are summarized again in Table 1.11.

Table 1.11 Enplanement Activity for the Four Primary Airports

Airport	Historical Enplanements		Historical Annual Growth Rate	Projected Enplanements		Projected Annual Growth Rate	Seasonal Variation	Residential To Transient Ratio
	1991	*1998*		*2010*	*2020*			
ASE	206,041	249,651	2.80%	DNS	DNS	DNS	Winter, 50%	DNS
EGE	30,308	171,272	58%	200,000*	260,000*	5%	Winter, 70%	27%
GJT	133,735	129,697	-0.38%	264,000	299,800	2.3%	May-Oct, Slight ↑	30-40%
HDN	59,129	106,092	10%	128,800	188,200	2.9%	Winter, 90%	N/a

Source: FAA DOT/TSC CY1998 ACAIS Database, Airport Managers
* Projections for EGE are 2001 and 2006; Projections for HDN are 2005 and 2020

Access to Hub Airport Connections

Denver International Airport (DEN)

DIA, which is owned and operated by the City and County of Denver, is located 23 miles northeast of downtown Denver and is host to 20 passenger airlines. The Elrey B. Jeppesen Terminal is 1.5 million square feet and has three concourses with 94 gates. There are five runways, each 12,000 feet in length. An average of 104,000 passengers passed through the airport on a daily basis in 1999, accessing the airport by an average of 1,371 daily flights. Passenger enplanements grew 5.3% over 1997 figures with 36,831,400 enplanements in 1998.

DIA's busiest months, in order, are August, July and March. July and August are typical vacation months. March is the busiest ski month and schools typically schedule spring breaks during that month.

One hundred (100) nonstop domestic destinations and 10 nonstop international destinations are available from the airport, including service to the four mountain corridor airports. These flights are offered on Air Wisconsin (United Express), Great Lakes Aviation (United Express), Mesa Airlines (America West), Delta, Northwest, American, Continental, and Trans World Airlines.

Numerous charter and scheduled shared-ride transportation is available from DIA to the mountain resorts. There is some seasonality to the ground services due to fluctuations in tourist activity throughout the year.

Colorado Springs Airport (COS)

Colorado Springs Airport (COS) is owned and operated by the City of Colorado Springs. A new airport with new landside and airside facilities opened in October 1994 and is located 20 minutes east of Downtown Colorado Springs. COS handles approximately 100 combined arrivals and departures each day. There are five runways, each 12,000 feet in length. Currently, eight commercial airlines operate from the airport which as 12 gates in its 270,000 SF terminal. The terminal has three restaurants, five car rental agencies, two gift shops and miscellaneous concessions and vending machines.

In 1999, COS had 2,481,098 passenger enplanements, 60% of which were business-related and 40% of which were leisure-related. Twelve nonstop destinations are available from the airport, however none of those include the four mountain corridor airports. COS passengers seeking access to the mountain resorts by air, must take connecting flights at DIA. Presently, there are no scheduled shared-ride ground transportation services available from COS to the mountain resorts. Charter services are available, however.

General Aviation

General aviation activity occurs at each of the four mountain corridor commercial airports. Based on daily averages, local and transient GA activity can be summarized as follows:

Table 1.12 Percentage of General Aviation Aircraft Operations at Mountain Commercial Aviation Facilities

	Transient GA	Local GA	Total Daily GA	Total Annual GA	Total Aircraft Operations/ GA % of Total
ASE	71	11	82	29,930	45,625/66%
EGE	42	13	55	20,075	32,120/63%
GJT	93	60	153	55,845	86,870/64%
HDN	10	3	13	4,745	8,395/57%

Source: AirNav websites for ASE, EGE, GJT, and HDN

GA activity includes everything from single-engine propeller-driven aircraft to sophisticated corporate jets. General aviation airports in the mountain corridor include Garfield County Regional Airport, Glenwood Springs Municipal Airport, Kremmling Airport (formerly McElroy Airfield), Lake County Airport, and Steamboat Springs/Bob Adams Field. These airports have critical significance to a region even when shared with a primary airport as they transport cargo and provide air ambulances services and charter and aircraft rental.

Garfield County Regional Airport (RIL)

Garfield County Regional Airport is owned by Garfield County and operated by the Garfield County Airport Authority. Located three miles east of Rifle, this facility has one runway that is 7,000 feet in length with an asphalt surface. Its weight limitations are single wheel, 52,000 pounds and double wheel, 68,000 pounds. Air taxi (36%) and general aviation (local, 20%; transient, 44%) make-up the bulk of its aircraft operations. RIL is planning for significant GA growth and has added two new hangars (totaling 30,000 SF) and an extended taxiway to accommodate greater cueing at takeoff and arrival. RIL saw a 44% increase in fuel sales from 1998 as it continues to handle a lot of Aspen GA traffic.

Glenwood Springs Municipal Airport (GWS)

GWS has one runway with a length of 3,300 feet. Nearly 80% of its aircraft operations is local general aviation and 14% is transient general aviation. The balance is air taxi (6%) and military (less than 1%). For five years, the airport's capital improvement plan has included plans for siting of a new GA facility because the existing site cannot expand to meet GA demand due to the river valley terrain. However, with the bulk of FAA funding dedicated to ASE, GWS must rely on lease arrangements to fund any improvements or new facilities. GWS currently contracts with Rifle Air Field (another GA facility about 30 miles west of GWS along I-70) for maintenance service which it cannot provide due to facility constraints.

Kremmling Airport (20V)

Kremmling Airport (formerly McElroy Field) is located 50 miles from the junction of I-70 and State Highway 9, on the north side of the corridor. It is approximately 70 miles south of Steamboat Springs, the resort community served by HDN. 20V has two runways, 5,500 (asphalt) and 1,100 (turf) feet in length. With only 73 combined arrivals and departures per week, the bulk of aircraft operations is transient general aviation (67%), local general aviation (29%) and air taxi (4%). Minor improvements have been made to the airport through the last decade, but major capital improvements include runway strengthening to increase weight limitations from 22,000 pounds single axle to 68,000 pounds double axle, which would be comparable to weight limitations for EGE and HDN.

Lake County Airport (LXV)
Located two miles southwest of Leadville, LXV is sited at an elevation of 9,927 feet, and claims to be the highest airport in North America. It has one runway that is 6,400 feet in length with an asphalt surface that accommodates single wheel, 20,000 pounds, and double wheel, 20,000 pounds. This airport also has a Helipad H1 that is 150 x 100 feet with a concrete surface. Nearly 80% of aircraft activity is transient (50%) and local (28%) general aviation with military operations being 20%.

Steamboat Springs/Bob Adams Field (SBS)
Three miles northwest of Steamboat Springs, this GA facility actually has more aircraft based on the field than HDN – 42 compared to six – including a helicopter. SBS has one runway that is 4,400 feet in length with an asphalt surface that can accommodate single wheel, 12,500 pounds and double wheel, 55,000 pounds. Transient (47%) and local (47%) general aviation make-up the bulk of its air activity with 4% being commercial cargo (Federal Express and Clark's Grocer Association). Airport officials in the area consider themselves fortunate to have a significant GA facility and primary airport in the same region with close proximity to the resort areas.

Air Cargo

Air cargo is typically transported in the baggage compartments of scheduled passenger aircraft and by all-cargo aircraft. With regard to its impact on the need for greater airport capacity, most all-cargo flights are scheduled during off-peak periods and to not substantially contribute to airport congestion and delay problems.

Historically, air cargo service has not substituted in any significant way for freight shipping by truck to the communities and airports in the mountain corridor. Ground transportation remains the most economical means of shipment and a regional cargo hub is not expected to significantly reduce surface traffic volumes on I-70. At best, an individual aircraft might reduce the highway impact by only a single truck.

However, with global supply chains, production flexibility and speed characterizing the economy, it is certain that air cargo will play an increasingly important role. For example, according to The International Air Cargo Association, shipments passing through Southern California, already totaling three million tons annually, are forecasted to reach nine million tons annually in less than two decades, with LAX accounting for just under half of this volume. Additionally, just-in-time logistics will require that producers receive and ship smaller quantities more frequently and quickly over long distances. Air freight was once considered a luxury and reserved for small, lightweight, compact products with high value-to-weight ratios or to items needed on an emergency basis at distant sites. In the future, essentially anything that can be loaded onto a large aircraft will routinely be shipped by air.

Other Mountain Corridor Airports

There are other commercial service airports in the mountain region of Colorado and they include Gunnison County Airport (GUC), Montrose Regional Airport (MTJ), and Telluride Regional Airport (TEX). All three of these airports are located within the general road network of the I-70 corridor, but are not as readily accessible to the highway. GUC is located 66 miles beyond Montrose to the east on U.S. 50. GUC enplaned 58,518 passengers in 1998. MTJ is located 60 miles south of Grand Junction on U.S. 50. MTJ enplaned 64,992 passengers in 1998. TEX is located 60 miles south of Montrose from I-70. In 1998, TEX enplaned 18,202 passengers. Enplanement activity at all three airports is driven by winter ski markets.

A study of the feasibility of developing a new commercial service airport six miles south of the town of Fairplay in Park County, was conducted in the late 1980s. Sited between U.S. 285 and S.H. 9, the proposal lacked public support because of cost, ground access reliability, and lengthy travel times to the winter recreational areas relative to the other existing commercial service airports.

BIBLIOGRAPHY

(April 1998). Yampa Valley Airport – Heartbeat of the Rockies. http://www.yampa.com/routt/yvra. (1 June 2000).

(October 1999) The International Air Cargo Association - Professor's Predictions Provide Glimpse into the 'Fast Century'. http://www/tiaca.org. 23 June 2000.

(November 1999) FAA Enplanement and All-Cargo Statistics. http://www/faa.gov/arp/A&D-stat.htm. 9 June 2000.

(April 2000). ASE – Aspen-Pitkin County/Sardy Field Airport, Aspen, Colorado. http://www.airnav.com/airport/ASE. (1 June 2000).

(April 2000). EGE – Eagle County Regional Airport, Eagle, Colorado. http://www.airnav.com/airport/EGE. (1 June 2000).

(April 2000). GWS – Glenwood Springs Muni Airport, Glenwood Springs, Colorado. http://www.airnav.com/airport/GWS. (1 June 2000).

(April 2000). 20V – Kremmling Airport (previously known as McElroy Airfield), Kremmling, Colorado. http://www.airnav.com/airport/20V. (1 June 2000).

(April 2000). GJT – Walker Field Airport, Grand Junction, Colorado. http://www.airnav.com/airport/GJT. (1 June 2000).

(April 2000). Walker Field Airport -- Strategically located in beautiful Western Colorado. http://www.airnav.com/airport/GJT. (1 June 2000).

(April 2000). HDN – Yampa Valley Airport, Hayden, Colorado. http://www.airnav.com/airport/HDN. (1 June 2000).

Mel Baker. Telephone interview. Interim Airport Manager, Steamboat Springs/Bob Adams Field. Steamboat Springs, Colorado. 22 June 2000.

Eugene Dilbeck. Telephone interview. President/CEO, Metro Denver Convention and Visitors Bureau. Denver, Colorado. 16 June 2000.

Lisa Huffmann. Telephone interview. Assistant to Airport Manager, Eagle County Regional Airport. Eagle, Colorado. 16 June 2000.

Kenneth Mampa. Telephone interview. Airport Manager, Garfield County Regional Airport. Rifle, Colorado. 26 June 2000.

Jessica McMillan. Telephone interview. Airport Manager, Glenwood Springs Municipal Airport. Glenwood Springs, Colorado. 16 June 2000.

Charlie Novinskie. Telephone interview. Airport Manager, Walker Field. Grand Junction, Colorado. 19 June 2000.

Jim Parker. Telephone interview. Airport Director, Yampa Valley Regional Airport. Hayden, Colorado. 12 June 2000.

Lurline Underbrink Curran. Telephone interview. Grand County Manager, Kremmling Airport. Kremmling, Colorado. 16 June 2000.

Travis Vallin. Telephone interview. Director, Colorado Department of Transportation Aeronautics Division. Denver, Colorado. 16 June 2000.

Federal Aviation Administration, ARP Consulting, and QED Consulting. *1999 Airport Capacity Enhancement Plan*. Federal Aviation Administration, Office of System Capacity. Washington, D.C. December 1999.

Colorado Department of Transportation. CH2MHill. *I-70 Mountain Corridor Major Investment Study, Mobility Evaluation Report*. September 1998.

Appendix H.

TranSystems. 2001. I-70 PEIS Aviation Alternatives—Estimates of Auto Trips Diverted (memorandum). March.

559 E. Pikes Peak Ave. Suite 300
Colorado Springs, CO 80903
(719) 634-5579
(719) 634-5547 FAX

Memorandum

TO: Tim Tetherow, JF Sato
FROM: Joanne Greek
Date: March 6, 2001
RE: I-70 PEIS Aviation Alternatives -- Estimates of Auto Trips Diverted
CC: Bill Stringfellow

☒ *For Your Information* ☐ *Urgent* ☐
☒ *As Requested* ☐ *For Review and Comment*

REMARKS:

Tim,

I've chosen this memo format to communicate my findings regarding the above. Don't hesitate to call if you have any questions, 719-634-5579.

PURPOSE: As CDOT has requested, I have researched the impact of technological modernization and capital improvement projects on enplanements in the three mountain corridor commercial service airports, Eagle County (EGE), Aspen/Pitkin County Sardy Field (ASE), and Yampa Valley Airport (HDN), and the general aviation facilities (Glenwood Springs, Kremmling, Rifle, Steamboat Springs and Lake County). CDOT also was interested in the impact of seat guarantees on air service demand.

METHODOLOGY: Airport managers for each of the airports were contacted and asked to supply numbers regarding typical diversions of flights to other airports (due to weather or the inability to accommodate flights due to inadequate technology or physical capacity). Managers also were asked to project additional enplanements that could be accommodated if their airports added capital construction projects or technology ***not already included in their five-year CIPs.*** (The intent of excluding items already in their CIPs, is to gauge the impact additional projects or technology could have, as their CIPs are based on expected growth projections already.) Phone calls also were placed to Travis Vallin, CDOT Aeronautics Division Director; Alan Wiechmann, FAA Denver Airports District Office Manager; and Charlie Mayfield, Marketing Director with Colorado Ski County USA.

RESULTS: Both Jim Elwood (EGE) and Jim Parker (HDN) supplied anecdotal information but said it was difficult to identify the number of diversions because the FAA only requires this information for large hub airports and they would have to contact each of their airlines directly for the information. If this information can be obtained, however, both have promised to forward it to me as soon as possible. Peter Van Pelt from ASE did not respond. Both Travis and Alan offered anecdotal information as well.

FINDINGS: There was general concurrence by those contacted, that the airport capacity issue was best framed by asking the question: By 2010, without improved radar equipment and runway extensions (by at least 1000'), can ASE and EGE (as well as Rifle's general aviation facility) grow beyond their current projections? (For these projections, see I-70 Mountain Corridor Air Service Characteristics & Operational Inventory, July 2000.) It was projected that without these improvements -- radar or ASR11 for EGE (which would address inadequacies at EGE, ASE and Rifle) and runway extensions for all three airports – 500 to 1,000 average daily person trips would be added to I-70 over a 100-day winter season period.

With regard to seat guarantees, Travis and Alan suggested that the impact is negligible because out-of-state skiiers already have chosen to fly directly into mountain airports to access the resorts. Presently, the airlines reportedly are meeting their respective load factors and the resorts have not had to "ante up" the difference to ensure air service continues. This situation requires further investigation as there appears to be a significant number of resort-bound fliers who fly into DIA and rent cars or use the various privately operated shuttles to access the resorts. Research will continue to determine how long this present situation is expected to last and whether profitable load-factors are expected to continue. Information regarding estimated auto-trips diverted due to seat guarantees will be forwarded when and if they become available.

CS-Joanne P. Greek

From:	Alan Wiechmann [Alan.Wiechmann@faa.gov]
Sent:	Monday, February 26, 2001 1:18 PM
To:	jpgreek@transystems.com
Cc:	Jim.Fels@faa.gov
Subject:	Follow-up to our 2/22 phone call

JoAnne,

During instrument weather conditions and busy days of the year, the number of arrivals and departures at the Eagle County Regional Airport, Aspen-Pitkin County Airport, and Garfield County Airports is limited by the radar coverage. Airport Surveillance Radar (ASR) would increase capacity. From our discussion, I believe you are trying to quantify the benefits to the I-70 corridor of increased arrival and departure capacity into these airports.

The three airports currently handle approximately 800,000 airline passenger and 200,000 general aviation passenger each year. If all of these people flew into other airports like Grand Junction or DIA and then drove to their destination, it would probably average at least 1000 trips per day. When people arrive at Eagle, Aspen, or Rifle they also take ground transportation to a destination, but the distance is a fraction of the miles.

During instrument weather some users currently do not get to those airport because of capacity constraints. Demand is significant at these airports and activity is expected to grow faster than the national average. Activity should double in 15 years. During instrument weather the number of days with delays will go up dramatically. The airlines may schedule more flights but many more will experience delays even of hours instead of minutes. This lack of reliability will decrease use by passengers and expansion by the airlines. Also more general aviation flights will end at other airports with the passengers taking rental cars to destinations. While pure demand may predict a doubling of airport use, the actual growth may only be half of less. The balance will be taking flights into DIA, Grand Junction, or other airports and then using ground transportation. I believe an educated guess of the positive effect of an ASR 15 years from now would be a reduction of 500 vehicle trips per day.

We don't know how many flights or passenger are currently avoiding the airports because of delays, but it is probably something less than an average of 50 per day. I would expect an ASR installed today would remove 50 trips per day from I-70. It should grow to at least a 500 trip per day savings in 15 years.

We also talked about a runway extension at Eagle for improved summer service. Eagle presently handles almost 350,000 passengers in the winter. Summer service estimates are usually around 250,000 additional passengers. I estimate this would remove 500 I-70 vehicle trips per day.

Improvements at the Garfield County Airport would encourage more use by general aviation pilots. Its affect on I -70 would be minimal and I would estimate an elimination of 50 I-70 trips/day.

I hope this helps.

Alan Wiechmann

Appendix I
Colorado Department of Transportation
I-70 Mountain Corridor PEIS Alternate Routes Technical Report
August 2010

This page intentionally left blank.

I-70 Mountain Corridor PEIS Screening of Alternate Routes Technical Report

August 2010

This page intentionally left blank.

Table of Contents

List of Appendices

List of Figures

List of Tables

Section 1. Purpose of the Report

This *I-70 Mountain Corridor PEIS Screening of Alternatives Routes Technical Report* supports the information contained in **Chapter2** of the I-70 Mountain Corridor Preliminary Environmental Impact Statement (PEIS). It identifies:

- The 17 alternative routes identified in the I-70 Mountain Corridor PEIS
- The results of the Level 1 and Level 2 screening of alternative routes
- The public involvement activities during the screening of alternative routes process

Section 2. Background and Methodology

This Technical Report provides an overview of the screening process applied to alternate routes identified in the I-70 Mountain Corridor PEIS, as well as a description of the alternate routes and results from Level 1 and Level 2 screening of alternate routes. This Technical Report is based on the *Descriptions of Alternate Highway Routes* report (Felsburg Holt & Ullevig, June 2000).

Alternate routes were explored as a potential strategy to achieve the goals of the I-70 Mountain Corridor PEIS. This concept of alternative routes was investigated previously as a part of the *I-70 Corridor Major Investment Study*. Alternate routes were analyzed to determine roadway improvements necessary to make these routes viable alternatives to the I-70 highway. The mountainous terrain encountered west of Fort Collins, Denver, Colorado Springs, and Pueblo severely limits the range of alternate routes. Many of the concepts involved improving existing state highways and building new connections (often tunnels) to shorten distances and travel times. In identifying potential new connections, special care was taken to avoid wilderness areas where disturbance (and road construction) is prohibited.

For purposes of comparison with current travel patterns along the I-70 highway, existing and new roadway segments were combined in various ways to develop alternate routes between cities along the Front Range and destinations currently served by the I-70 highway. Alternate routes have been defined both north and south of the I-70 highway. Fort Collins (including Greeley, Loveland, and Longmont), the Denver metropolitan area, Colorado Springs, and Pueblo were specifically considered because of their populations and their proximity to the I-70 Mountain Corridor via I-25.

2.1 Existing Travel Shed Characteristics

Figure 1 depicts the greater travel shed extending westerly along the I-70 highway from Denver to Glenwood Springs and along I-25 between Fort Collins and Pueblo. Within this travel shed, numerous state highways and state highway segments potentially serve as alternate routes for certain trips now using the I-70 highway. Detailed physical and operational data collected for each existing state highway segments is shown in **Figure 1** and summarized in **Appendix A.**

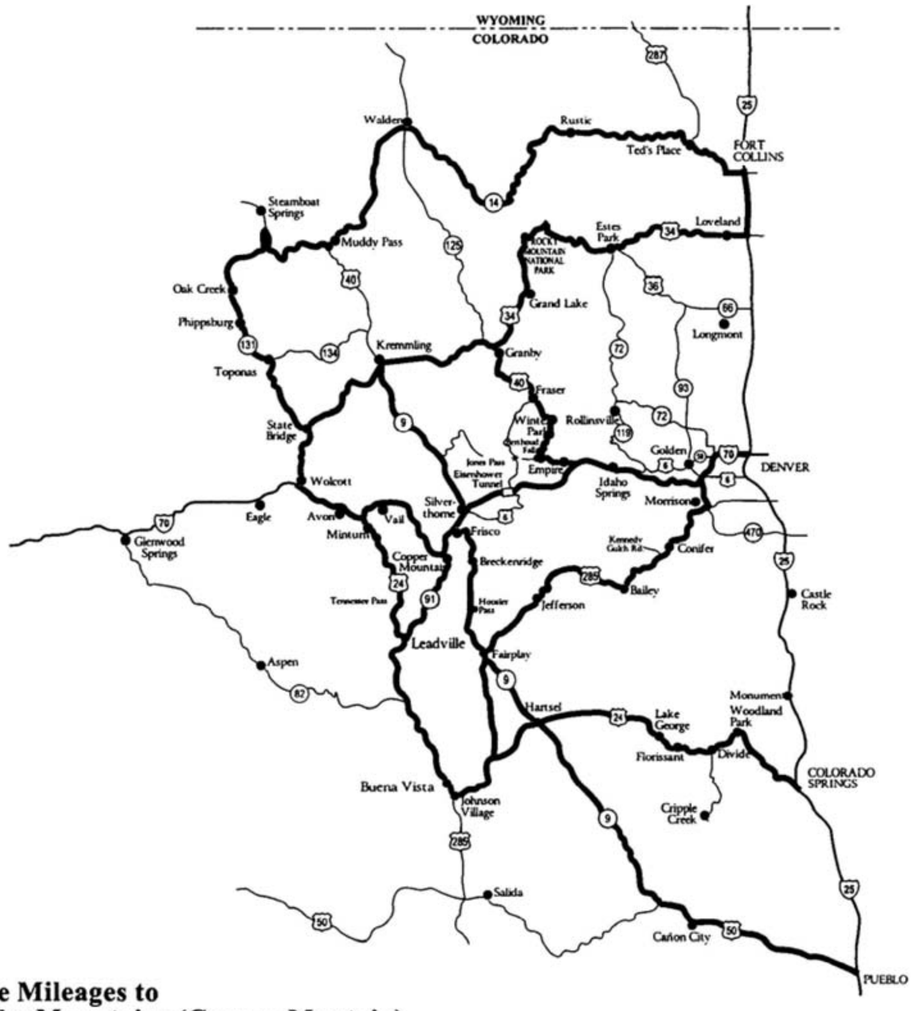
The travel shed is characterized by topographically constrained two-lane highways with four-lane and six-lane segments emanating from the edges of the major metropolitan areas. Traffic volumes are generally less than 10,000 vehicles per day in the rural areas, and travel speeds are typically at the posted speed limits.

To provide a general frame of reference, travel distances from the four major Front Range cities to the central Rocky Mountains (Copper Mountain) were calculated and are included in **Figure 1**. Note that trips between Fort Collins and the I-70 Mountain Corridor area are constrained to use I-25 to Denver and west on the I-70 highway. Alternate routes for these trips are essentially non-existent due to the presence of

Rocky Mountain National Park and the severe topography that characterizes areas west of I-25 and north of the I-70 highway.

To the south of the Corridor, more direct connections are possible between the central Rocky Mountains and Colorado Springs or Pueblo. These include State Highway (SH) 9 south from Breckenridge, which intersects with United States Highway (US) 24 (to Colorado Springs) and with US 50 (to Pueblo). As a consequence, very few trips from Colorado Springs or Pueblo use the I-70 highway to reach the central Rocky Mountains.

Figure 1. Comparative Mileages to Central Rocky Mountains



Comparative Mileages to Central Rocky Mountains (Copper Moutain)

FROM	VIA SHORTEST ROUTE	VIA I-70
Ft. Collins	135 mi.	135 mi.
Denver	79 mi.	79 mi.
Colorado Springs	118 mi.	144 mi.
Pueblo	147 mi.	186 mi.

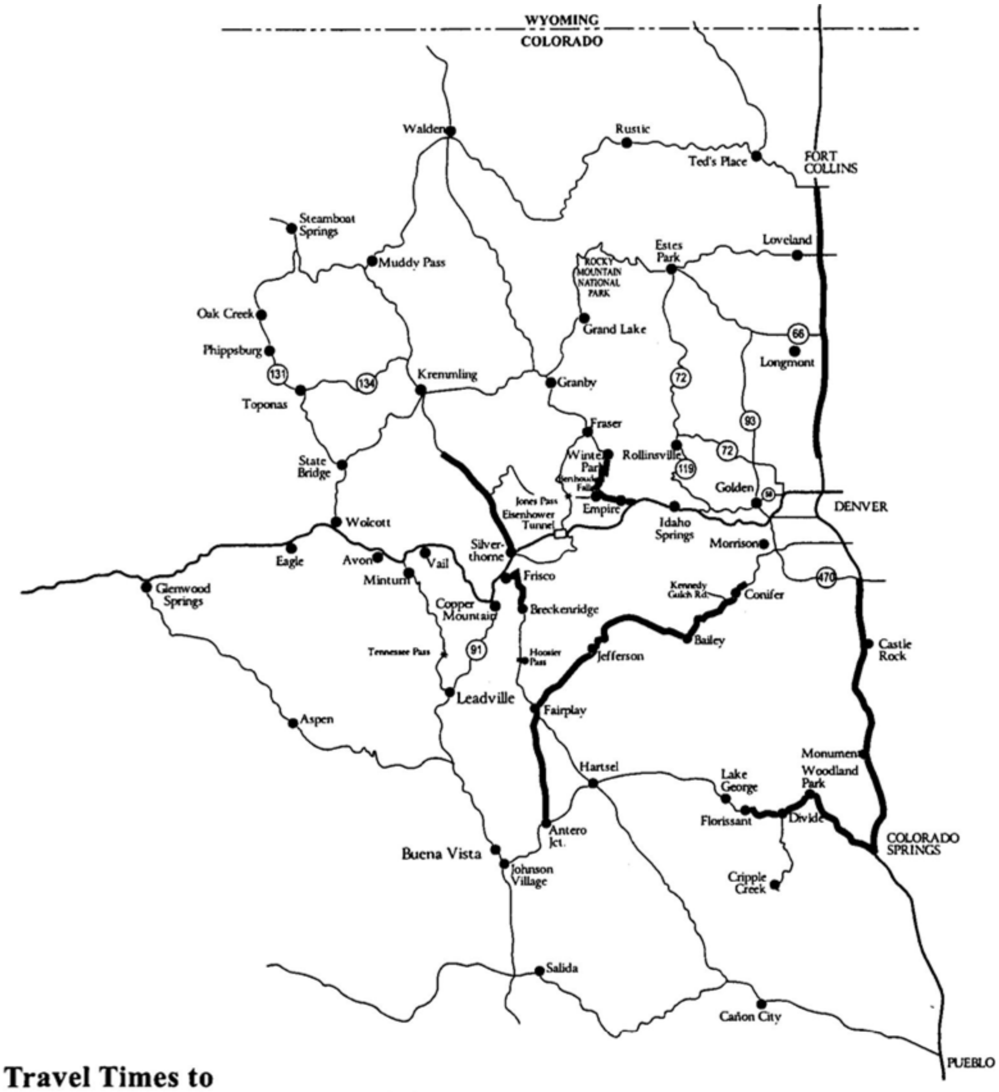
2.2 Planned Travel Shed Improvements

The Colorado Department of Transportation continuously monitors the state highway network to determine where future improvements should be made. Within the greater I-70 Mountain Corridor travel shed, more than 25 planning studies and improvement projects are programmed to occur over the next six years. These activities include various safety improvements, minor widenings, and major capacity increases. The proposed improvements within the I-70 Mountain Corridor travel shed are depicted in **Figure 2**.

All of these improvements, to some extent, improve the travel time along any given highway segment and, therefore, any combination of segments comprising an alternate route to the I-70 highway. **Figure 2** shows comparative travel times between the four major Front Range cities and the central Rocky Mountain area (Copper Mountain). Note that only trips from the Colorado Springs area (i.e., US 34 corridor) are susceptible to diversion from the I-70 highway due to travel time improvements. If travel time savings of more than six minutes could be achieved, it is probable that trips to the central Rocky Mountains from Colorado Springs could be diverted off the I-70 highway.

By contrast, trips between Pueblo and the central Rocky Mountain area are probably already using US 50 and SH 9 to a large degree since this route is not only 12 minutes faster but also 39 miles shorter.

Figure 2. Comparative Travel Times to Central Rocky Mountains After Completion of CDOT’s 6-year Improvement Program



Comparative Travel Times to Central Rocky Mountains (Copper Moutain)

(After Completion of CDOT's 6 Year Improvement Program)

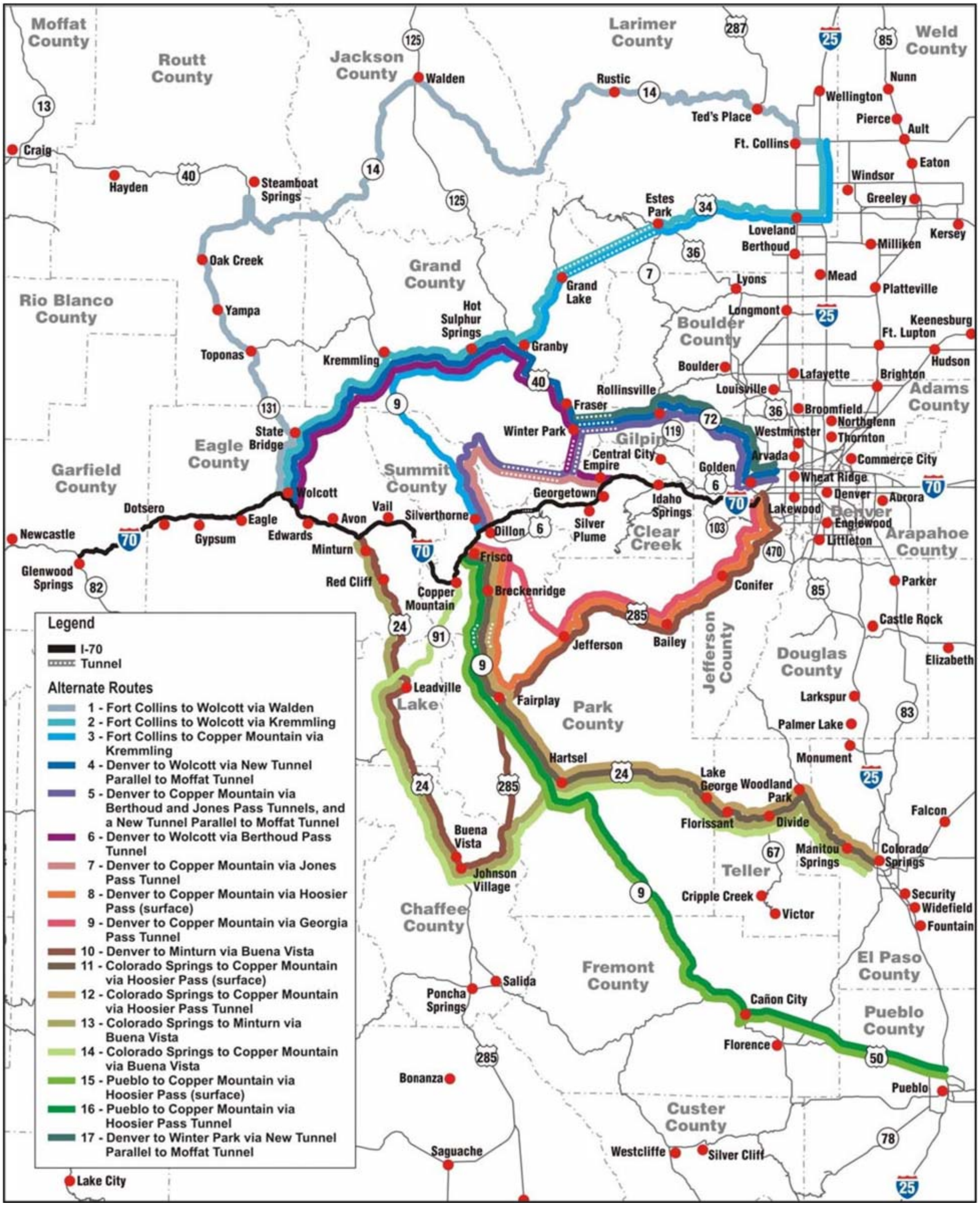
FROM	VIA SHORTEST ROUTE	VIA I-70
Ft. Collins	119 min.	119 min.
Denver	74 min.	74 min.
Colorado Springs	137 min.	131 min.
Pueblo	158 min.	170 min.

Section 3. Description of Alternate Routes

Seventeen alternate routes were identified with eastern termini ranging from Fort Collins to Pueblo and western termini at various points along the I-70 highway west of the Continental Divide as far west as Wolcott in Eagle County. These 17 alternate routes would connect the central Rocky Mountains with the four principal cities along the Front Range. Three alternate routes would connect with Fort Collins, eight with Denver and Denver International Airport, four with Colorado Springs, and two with Pueblo. These routes are shown on **Figure 3**.

- Alternate Route 1 – Fort Collins to Wolcott via Walden (SH 14/SH 131)
- Alternate Route 2 – Fort Collins to Wolcott via Kremmling (US 34)
- Alternate Route 3 – Fort Collins to Copper Mountain via Kremmling (US 34/SH 9)
- Alternate Route 4 – Denver to Wolcott via Moffat Tunnel (SH 72/US 40/US 34)
- Alternate Route 5 – Denver to Copper Mountain via Moffat, Berthoud, and Jones Pass Tunnels (SH 72/SH 9)
- Alternate Route 6 – Denver to Wolcott via Berthoud Pass Tunnel (SH 40/US 34)
- Alternate Route 7 – Denver to Copper Mountain via Jones Pass Tunnel (SH 9)
- Alternate Route 8 – Denver to Copper Mountain via Hoosier Pass - Surface (US 285/SH 9)
- Alternate Route 9 – Denver to Copper Mountain via Georgia Pass Tunnel (US 285)
- Alternate Route 10 – Denver to Minturn via Buena Vista (US 285/US 24)
- Alternate Route 11 – Colorado Springs to Copper Mountain via Hoosier Pass - Surface (US 24/SH 9)
- Alternate Route 12 – Colorado Springs to Copper Mountain via Hoosier Pass Tunnel (US 24/SH 9)
- Alternate Route 13 – Colorado Springs to Minturn via Buena Vista (US 24)
- Alternate Route 14 – Colorado Springs to Copper Mountain via Buena Vista (US 24/SH 91)
- Alternate Route 15 – Pueblo to Copper Mountain via Hoosier Pass - Surface (US 50/SH 9)
- Alternate Route 16 – Pueblo to Copper Mountain via Hoosier Pass - Tunnel (US 50/SH 9)
- Alternate Route 17 – Denver to Winter Park via New Tunnel Parallel to Moffat Tunnel (SH 58, SH 93, and SH 72) to Wolcott

Figure 3. Alternate Routes Considered in Screening Process



The eastern termini range approximately 160 miles north and south of the Denver metropolitan area extending between Fort Collins to Pueblo. The western termini occur at various points along the I-70 highway west of the Continental Divide extending as far as Wolcott in Eagle County.

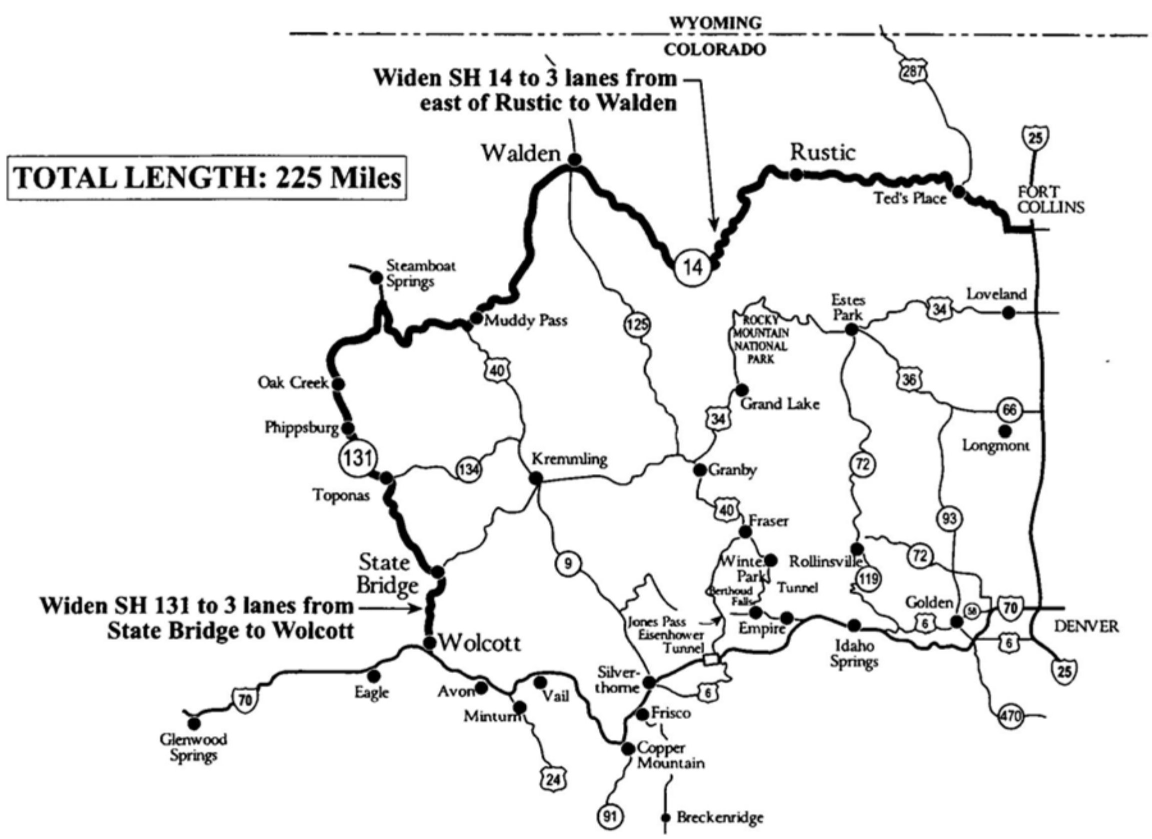
The descriptions on the following pages provide an overview of the basic route characteristics, the key features, and provide an illustration of each alternate route developed for screening Level 1 and Level 2.

3.1 Alternate Route 1 – Fort Collins to Wolcott via Walden (SH 14/SH 131)

Alternate Route 1 (AR-1) would use existing state highways along its entire length. SH 14 would provide the connection between Fort Collins and the junction of SH 14 and US 40 at Muddy Pass (**Figure 4**). Topographic constraints through the lower reach of the Cache la Poudre Canyon would prohibit any upgrades to SH 14 from Ted's Place to a point just east of Rustic. At this point, SH 14 would be widened to three lanes providing an uphill passing lane to Walden. West of Walden to Muddy Pass, SH 14 remains two lanes. The route would then continue on US 40 over Rabbit Ears Pass until it connects to SH 131 just south of Steamboat Springs. Most of US 40 on Rabbit Ears Pass already has three lanes for uphill climbing.

The route would turn south on SH 131 to State Bridge and pass through Oak Creek, Phippsburg, and Toponas enroute. These segments of SH 131 remain two-lane highways. Finally, the section of SH 131 between State Bridge and the I-70 highway at Wolcott would be upgraded to three lanes for uphill climbing.

Figure 4. Alternate Route 1 – Fort Collins to Wolcott via Walden (SH 14/SH 131)

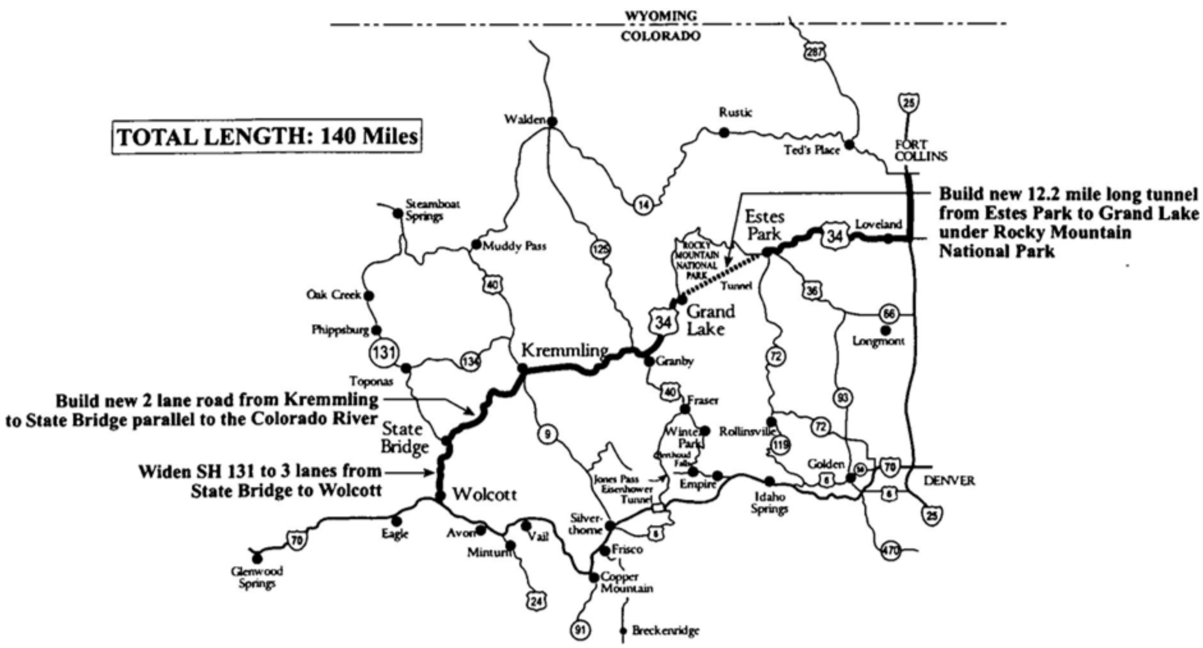


3.2 Alternate Route 2 – Fort Collins to Wolcott via Kremmling (US 34)

Alternate Route 2 (AR-2) would use two new road segments to connect existing state highways. From Fort Collins to Estes Park, the route would use existing I-25 and US 34. US 34 between Loveland and Estes Park would not be widened because of the topographic constraints through the Big Thompson Canyon. A long tunnel (approximately 12.2 miles) would be built under Rocky Mountain National Park from Estes Park to Grand Lake, generally paralleling the Alva B. Adams water tunnel (**Figure 5**).

Existing US 34 with no widening would be used between Grand Lake and Granby. Existing US 40, also with no widening, would be used between Granby and Kremmling. A new two-lane roadway would be built between Kremmling and State Bridge, which would follow the Colorado River. At State Bridge, the route would use SH 131 to travel south to Wolcott. As was the case with AR-1, SH 131 would be widened to three lanes through this section to provide an uphill passing lane.

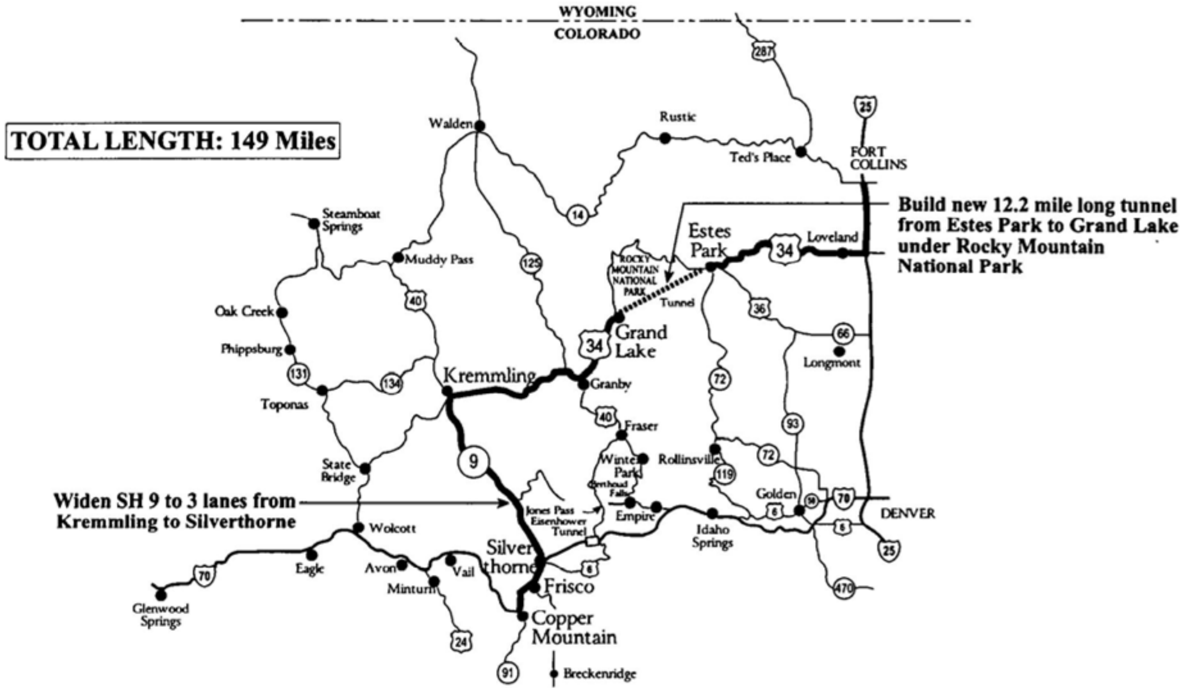
Figure 5. Alternate Route 2 – Fort Collins to Wolcott via Kremmling (US 34)



3.3 Alternate Route 3 – Fort Collins to Copper Mountain via Kremmling (US 34/SH 9)

Alternate Route 3 (AR-3) would be identical to AR-2 between Fort Collins and Kremmling and would include the new tunnel under Rocky Mountain National Park (**Figure 6**). To get to Copper Mountain, SH 9 from Kremmling to Silverthorne (junction of the I-70 highway and SH 9) and the I-70 highway would be used. SH 9 south of Kremmling to Silverthorne would be upgraded from two to three lanes for an uphill passing lane. At Silverthorne, the I-70 highway west would be used to complete the route to Copper Mountain.

Figure 6. Alternate Route 3 – Fort Collins to Copper Mountain via Kremmling (US 34/SH 9)



3.4 Alternate Route 4 – Denver to Wolcott via the Moffat Tunnel (SH 72/US 40/US 34)

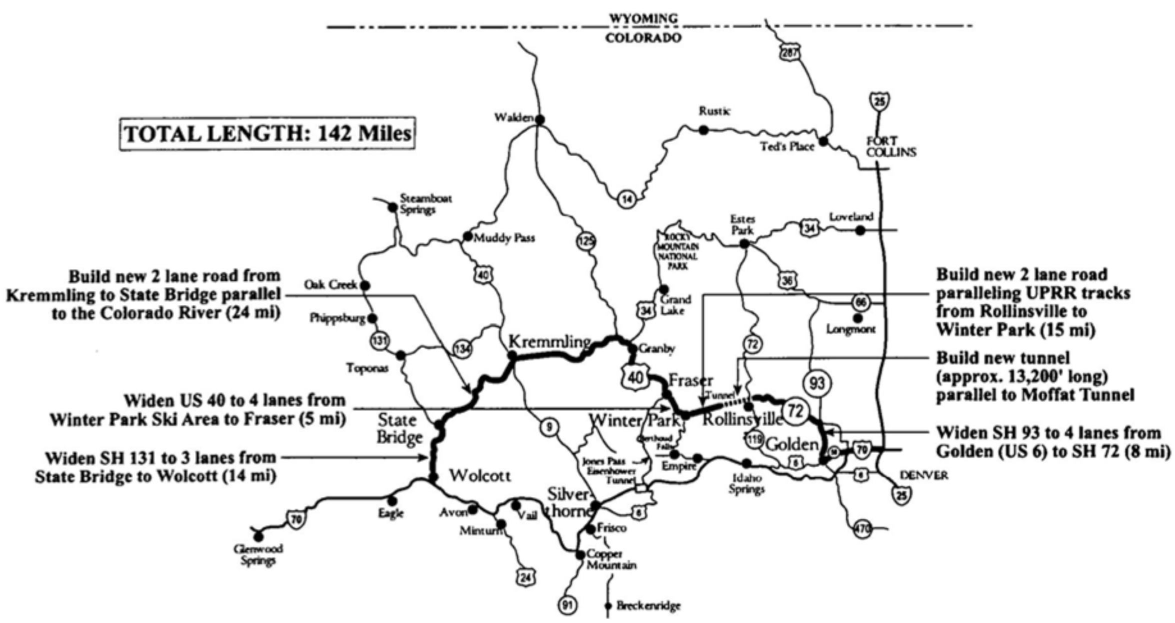
Alternate Route 4 (AR-4) would use eight state highways, a new tunnel, and a new route between Kremmling and State Bridge (**Figure 7**).

From the Mousetrap (I-25 and the I-70 highway interchange), the I-70 highway and SH 58 would be used as a route to Golden. Traveling north, SH 93 from Golden to its junction with SH 72 would be upgraded to a four-lane highway. From this junction, the route would use SH 72 and SH 119 to Rollinsville. There would be no widening on this section, although a number of sharp curves would need to be flattened as much as possible.

A new two-lane highway would be built west from Rollinsville that would generally follow the existing gravel road paralleling the Union Pacific Railroad tracks. A new two-lane tunnel (approximately 13,200 feet long) would be constructed along the alignment of the Moffat Tunnel, which would end at US 40 near the Winter Park Ski Area. US 40 would be used north to Granby and then west to Kremmling. The short stretch of US 40 from the ski area to Fraser would be widened to provide four through lanes. The remainder of US 40 would remain a two-lane highway.

To complete the route to Wolcott, the route would use a new two-lane highway from Kremmling to State Bridge (as previously described in AR-2) and an improved SH 131 (as previously described in AR-1) to Wolcott.

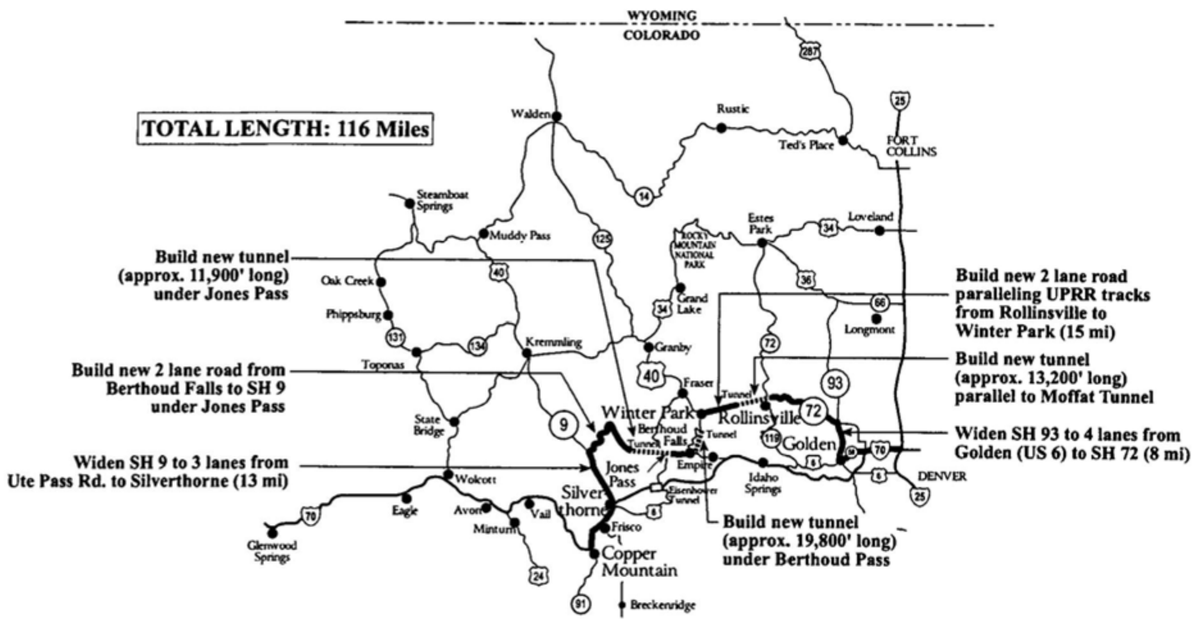
Figure 7. Alternate Route 4 – Denver to Wolcott via the Moffat Tunnel (SH 72/US 40/US 34)



3.5 Alternate Route 5 – Denver to Copper Mountain via Moffat, Berthoud Pass, and Jones Pass Tunnels (SH 72/SH 9)

Alternate Route 5 (AR-5) would require the construction of three new tunnels. From Denver to Winter Park, the route would be identical to AR-4 and use SH 93, SH 72, and the new tunnel parallel to the Moffat Tunnel (**Figure 8**). At the Winter Park Ski Area, this route would turn south on US 40 and use the Berthoud Pass Tunnel. At the south end of the Berthoud Pass Tunnel, the route would turn west on US 40 to Berthoud Falls. At this point, the route would use the new Jones Pass Tunnel and the new two-lane highway to connect to SH 9. To get to Copper Mountain, SH 9 would be used to travel to Silverthorne and then the I-70 highway to connect to Copper Mountain. SH 9 from Ute Pass Road to Silverthorne would be widened to three lanes providing an uphill passing lane.

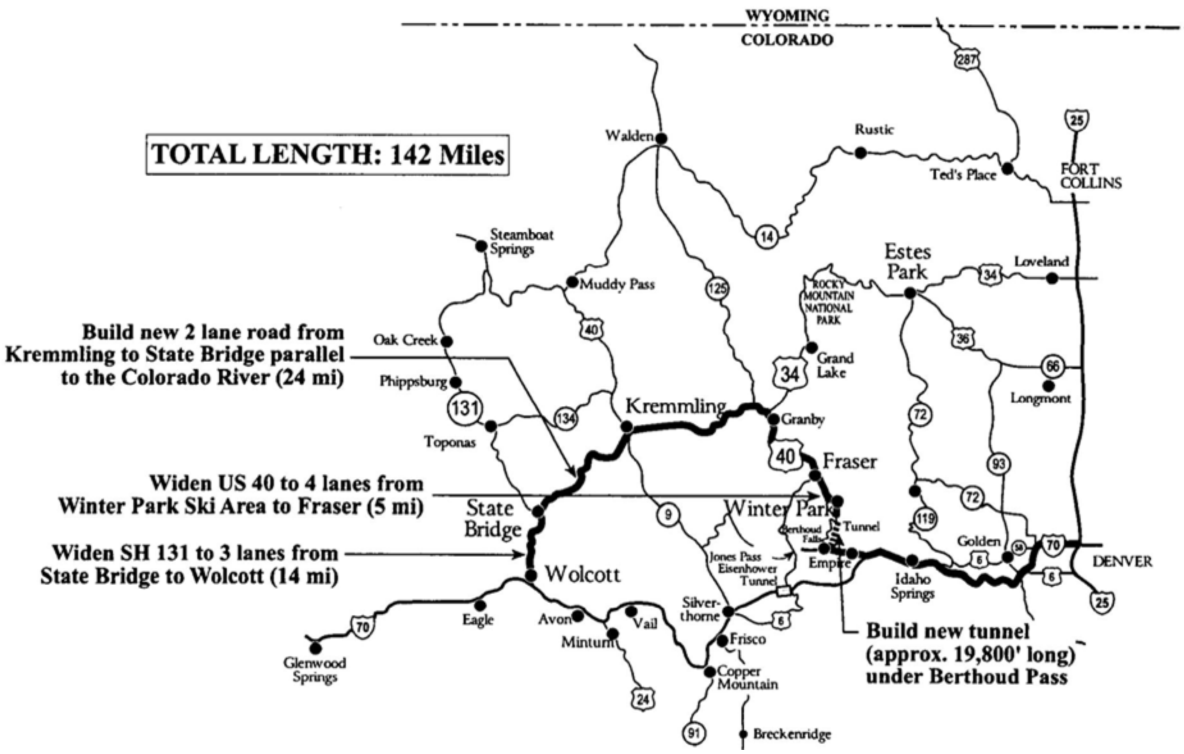
Figure 8. Alternate Route 5 – Denver to Copper Mountain via Moffat, Berthoud Pass, and Jones Pass Tunnels (SH 72/SH 9)



3.6 Alternate Route 6 – Denver to Wolcott via Berthoud Pass Tunnel (SH 40/US 34)

Alternate Route 6 (AR-6) would use the I-70 highway from Denver to the junction of the I-70 highway with US 40 near Empire and a new tunnel under Berthoud Pass (**Figure 9**). The new two-lane tunnel (approximately 19,800 feet long) would leave US 40 approximately halfway between Empire and Berthoud Falls in the vicinity of Blue Creek and would provide a by-pass to the steep grades and switchbacks of Berthoud Pass. The north end of the tunnel would be located at the last switchback on US 40. Investigations for a potential toll tunnel on this alignment were conducted several years ago. US 40 between Empire and the new tunnel would remain a two-lane highway. The remainder of this route from Winter Park to Wolcott would be identical to the previously described AR-4.

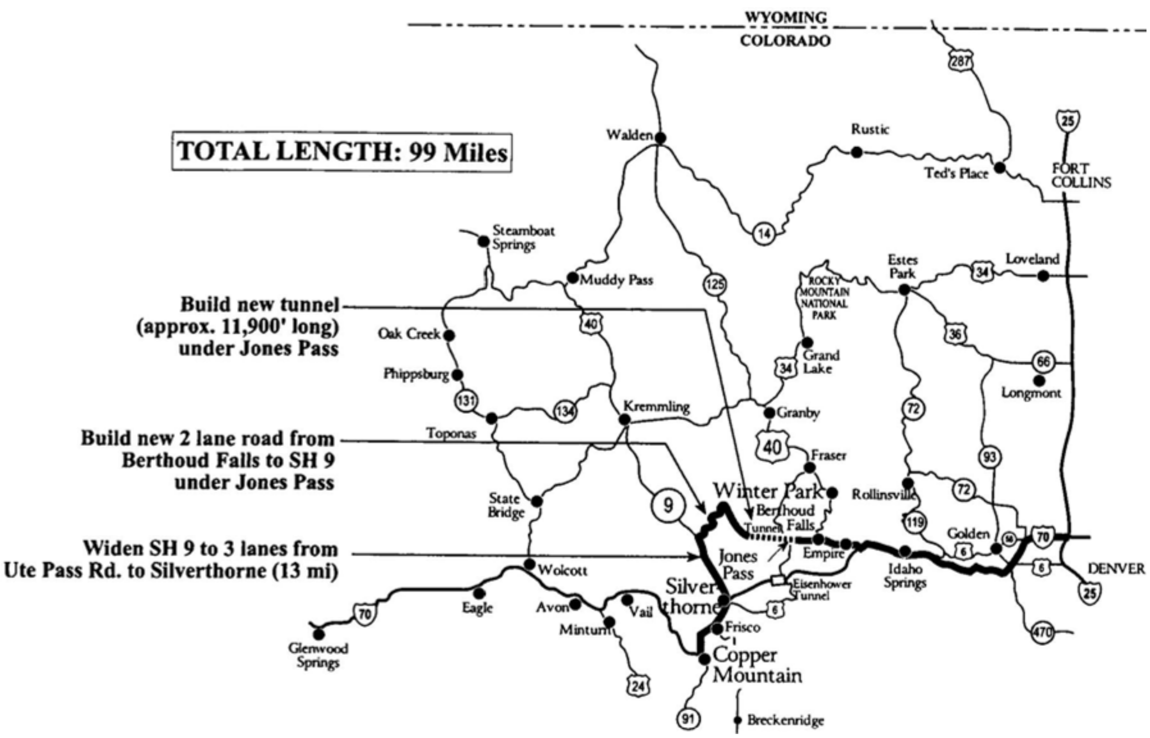
Figure 9. Alternate Route 6 – Denver to Wolcott via Berthoud Pass Tunnel (SH 40/US 34)



3.7 Alternate Route 7 – Denver to Copper Mountain via Jones Pass Tunnel (SH 9)

Alternate Route 7 (AR-7) would use the I-70 highway from Denver to Empire and then US 40 from Empire to Berthoud Falls (**Figure 10**). At Berthoud Falls, a new two-lane highway would be built to the west to provide a more direct connection between US 40 and SH 9. The new highway would leave US 40 and travel west to Jones Pass. At Jones Pass a new two-lane tunnel (approximately 11,900 feet long) would be constructed. West of Jones Pass the new highway would turn to the northwest and follow the Williams Fork. It would intersect FR 132 (Ute Pass Road) and then follow it southwest over Ute Pass to intersect SH 9. The route would continue south on SH 9 to Silverthorne and then turn west on the I-70 highway to Copper Mountain. The section of SH 9 south from Ute Pass Road to Silverthorne would be widened to three lanes to provide an uphill passing lane.

Figure 10. Alternate Route 7 – Denver to Copper Mountain via Jones Pass Tunnel (SH 9)

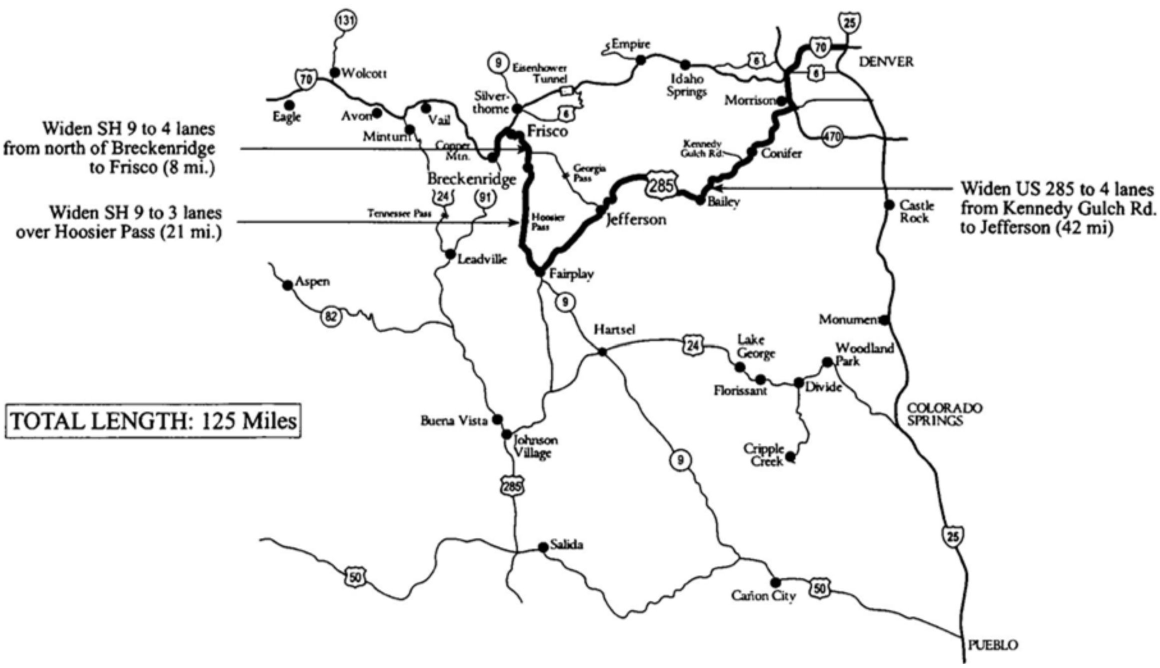


3.8 Alternate Route 8 – Denver to Copper Mountain via Hoosier Pass - Surface (US 285/SH 9)

Alternate Route 8 (AR-8) would follow the I-70 highway and C-470 from Denver to Morrison and then US 285 to the town of Jefferson. US 285 would be widened to four lanes for this entire segment consistent with the widening done through Turkey Creek Canyon to Kennedy Gulch Road (**Figure 11**).

AR-8 would continue along US 285 to Fairplay and then follow SH 9 northerly across Hoosier Pass into Breckenridge. Widening of SH 9 to four lanes would be completed between Breckenridge and Frisco. At Frisco, the I-70 highway would complete the alternate route to Copper Mountain.

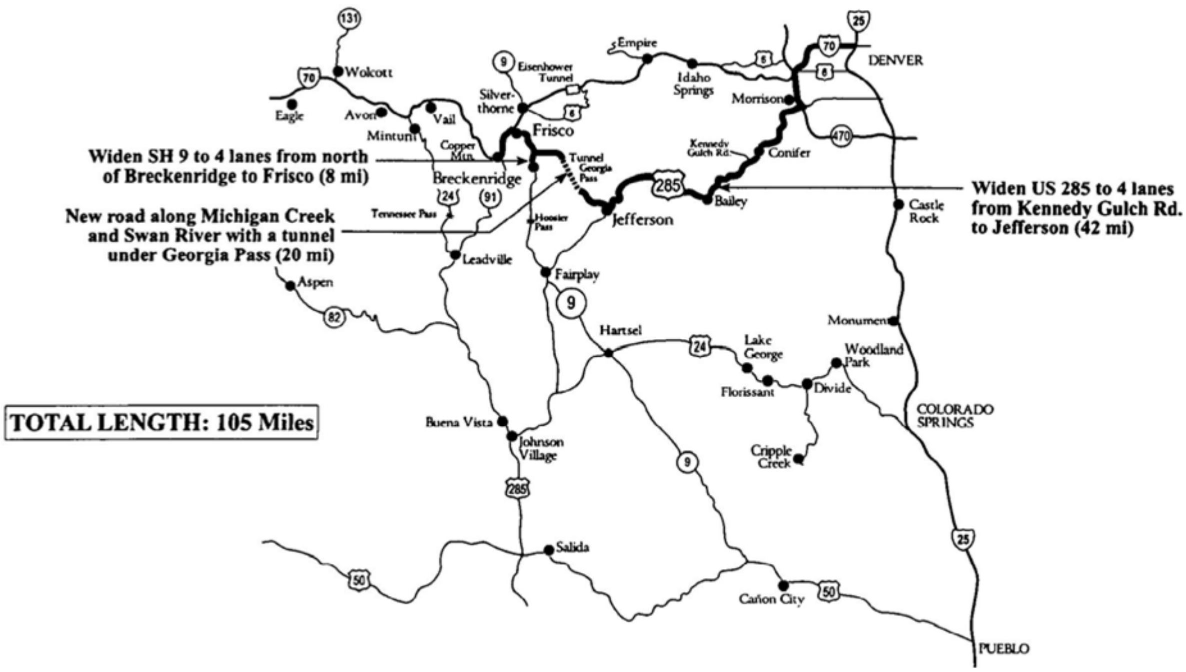
Figure 11. Alternate Route 8 – Denver to Copper Mountain via Hoosier Pass-Surface (US 285/SH 9)



3.9 Alternate Route 9 – Denver to Copper Mountain via Georgia Pass Tunnel (US 285)

Alternate Route 9 (AR- 9) would use the I-70 highway and C-470 from Denver to Morrison, then use US 285 between the Denver metropolitan area and the town of Jefferson (**Figure 12**). At this point, a new roadway would be built to provide a shorter connection to Breckenridge and Summit County. US 285 would be widened to four lanes through Turkey Creek Canyon to Kennedy Gulch Road. For this alternate, the widening of US 285 would be continued all the way to Jefferson. The short section of four lanes through Bailey would remain as it currently is. The new segment of road would leave US 285 at Jefferson and travel northwest up Michigan Creek. A two-lane tunnel (approximately 10,600 feet long) would be constructed under Georgia Pass. The road would continue down Tiger Road to an intersection with SH 9, north of Breckenridge. SH 9 from north of downtown Breckenridge to Frisco would be widened to four lanes and at Frisco, the I-70 highway would be used to complete the route to Copper Mountain.

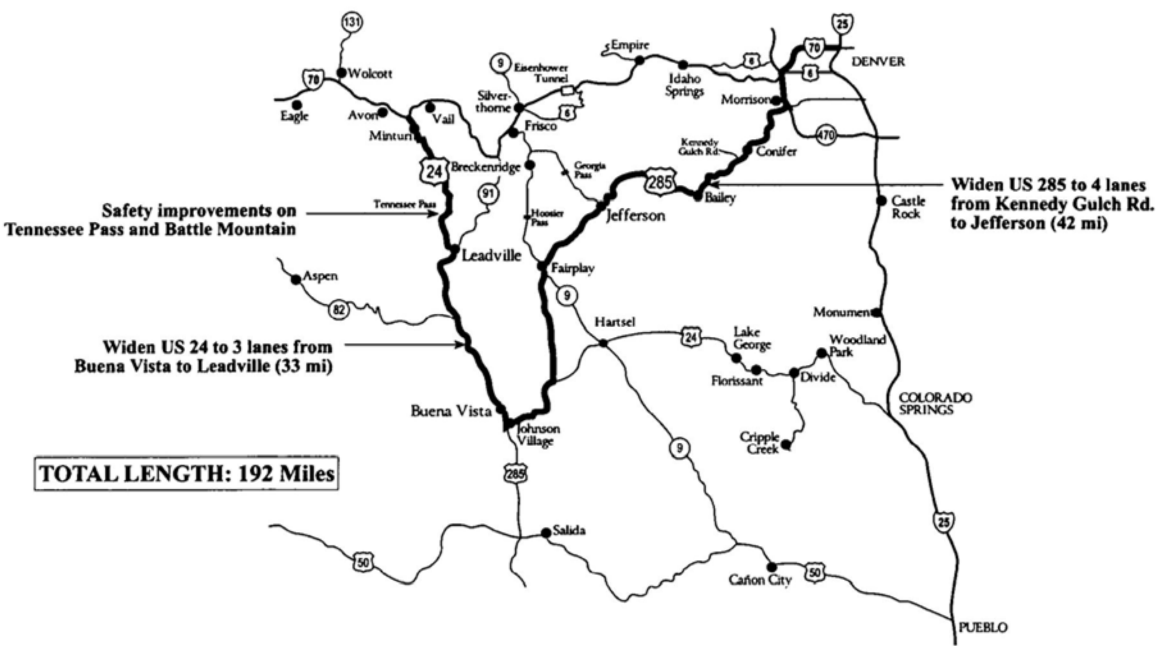
Figure 12. Alternate Route 9 – Denver to Copper Mountain via Georgia Pass (US 285)



3.10 Alternate Route 10 – Denver to Minturn via Buena Vista (US 285/US 24)

Alternate Route 10 (AR-10) would use existing highways to connect Denver with Minturn (**Figure 13**). It would include the previously described widening of US 285 between Kennedy Gulch Road and Jefferson (AR-8). The route would continue along US 285 to Johnson Village with no major improvements. At this point, the route would continue on US 24 through Buena Vista and Leadville and end at Minturn where US 24 meets the I-70 highway at Dowd Canyon. The section between Buena Vista and Leadville would be widened to three lanes to provide an uphill passing lane. There would be no major widening between Leadville and Minturn because topographic constraints would restrict widening to short segments of climbing lanes and safety improvements.

Figure 13. Alternate Route 10 – Denver to Minturn via Buena Vista (US 285/US 24)

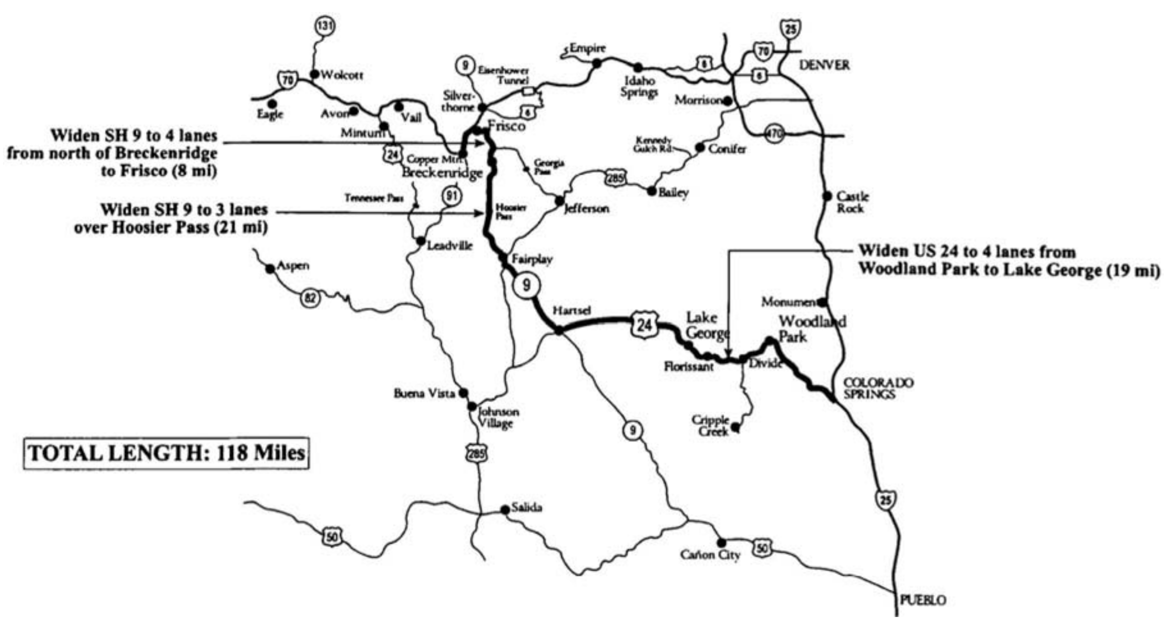


3.11 Alternate Route 11 – Colorado Springs to Copper Mountain via Hoosier Pass - Surface (US 24/SH 9)

Alternate Route 11 (AR-11) would upgrade two existing state highways to connect Colorado Springs with Summit County and its ski areas (**Figure 14**). US 24 between Colorado Springs and Woodland Park is currently a four-lane highway with a wide median. West of Woodland Park, US 24 would be widened to four lanes to the vicinity of Lake George. This would provide additional capacity through Divide (and the SH 67 connection to the gambling casinos in Cripple Creek) and Florissant. The segment of US 24 between Lake George and Hartsel would remain as a two-lane highway.

The route would use existing SH 9 between Hartsel and Breckenridge. The segment of SH 9 over Hoosier Pass would he upgraded to three lanes for an uphill passing lane, and existing switchbacks on the north side of the pass would be straightened to the extent possible. Mainstreet through Breckenridge would remain as it is today _a two-lane road through the middle of a historic town. From north of downtown Breckenridge to Frisco, SH 9 would be widened to four lanes. At Frisco, two interchanges with the I-70 highway would then be used to travel to Copper Mountain (at the junction of the I-70 highway and SH 91).

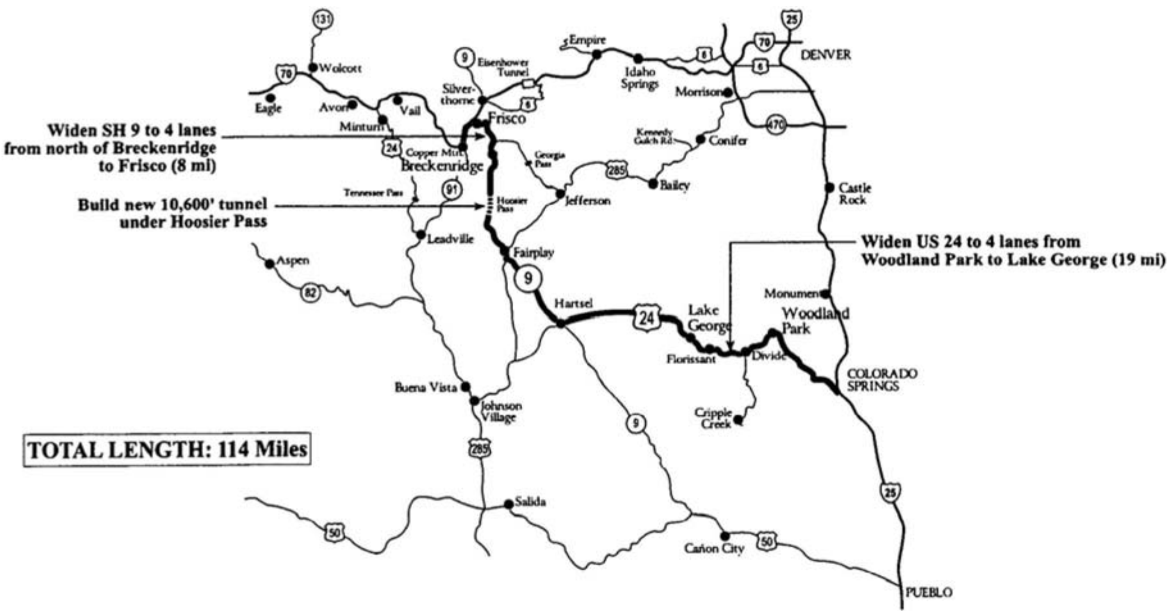
Figure 14. Alternate Route 11 – Colorado Springs to Copper Mountain via Hoosier Pass - Surface (US 24/SH 9)



3.12 Alternate Route 12 – Colorado Springs to Copper Mountain via Hoosier Pass Tunnel (US 24/SH 9)

Alternate Route 12 (AR-12) would differ from AR-11 only in that a tunnel under Hoosier Pass would be included. Unlike potential tunnels discussed relative to other alternate routes, preliminary field observations indicated that a tunnel under Hoosier Pass would encounter unique soil problems and major cost increases (**Figure 15**). A tunnel under Hoosier Pass has been identified for this alternate route. Potential construction constraints have been reflected in a higher cost estimate.

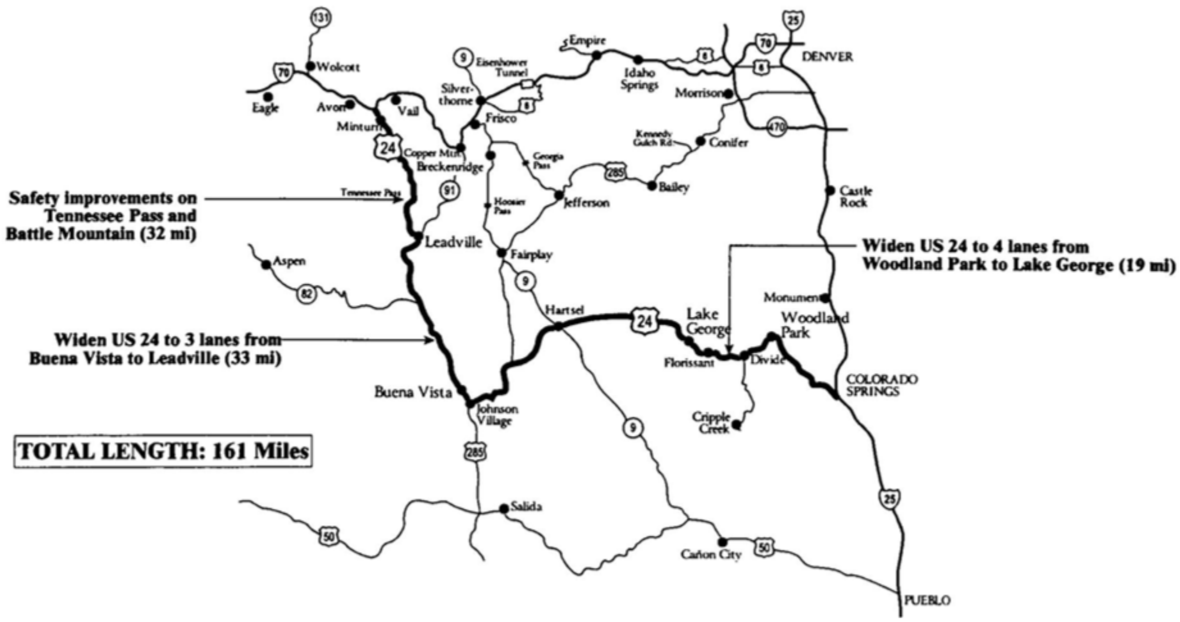
Figure 15. Alternate Route 12 – Colorado Springs to Copper Mountain via Hoosier Pass Tunnel (US 24/SH 9)



3.13 Alternate Route 13 – Colorado Springs to Minturn via Buena Vista (US 24)

Alternate Route 13 (AR-13) would use the entire length of US 24 between Colorado Springs and Minturn where it meets the I-70 highway at Dowd Canyon (**Figure 16**). This route would include improvements west of Woodland Park and north of Buena Vista. Topographic constraints over Tennessee Pass and Battle Mountain would restrict any widening to short segments of climbing lanes and safety improvements.

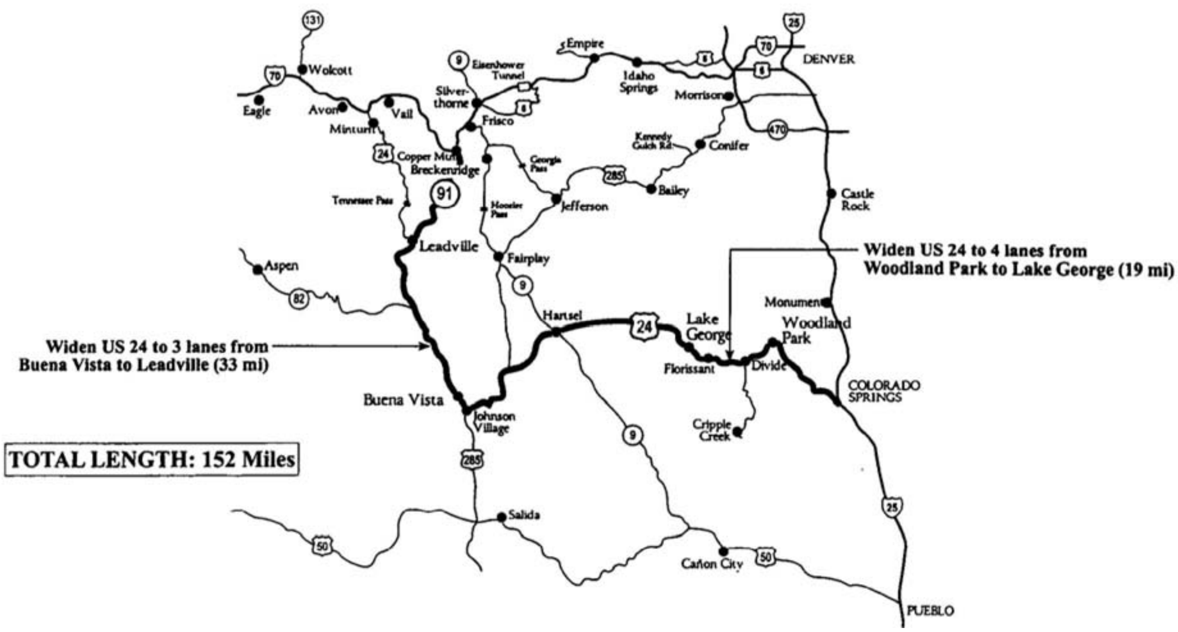
Figure 16. Alternate Route 13 – Colorado Springs to Minturn via Buena Vista (US 24)



3.14 Alternate Route 14 – Colorado Springs to Copper Mountain via Buena Vista (US 24/SH 91)

Alternate Route 14 (AR-14) would use a longer stretch of existing US 24 to make a different connection to Summit County (**Figure 17**). The same upgrade of US 24 to a four-lane roadway as previously described (AR-13) would be made between Woodland Park and Lake George. At Hartsel, the route would continue on US 24 through Buena Vista with no widenings being made. North of Buena Vista, US 24 would be widened to three lanes to provide an uphill passing lane to Leadville. Between Leadville and Copper Mountain, SH 91 traverses Fremont Pass. The road currently has a climbing lane on the steep sections of the pass, and no widening would be done on the remainder of SH 91, which is more level.

Figure 17. Alternate Route 14 – Colorado Springs to Copper Mountain via Buena Vista (US 24/SH 91)

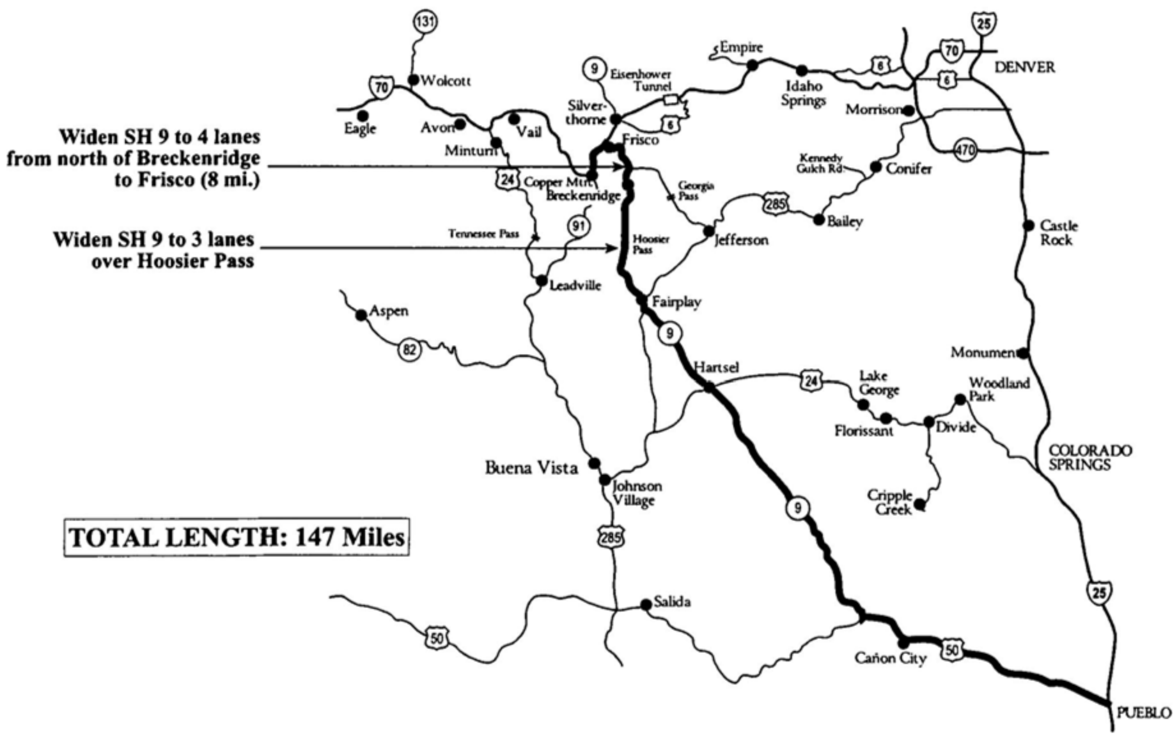


3.15 Alternate Route 15 – Pueblo to Copper Mountain via Hoosier Pass – Surface (US 50/SH 9)

Alternate Route 15 (AR-15) would follow US 50 west from Pueblo to its junction with SH 9 in the vicinity of Royal Gorge west of Canyon City (**Figure 18**). At this point, the route would follow SH 9 through Hartsel, Fairplay, Breckenridge, and Frisco to reach the I-70 highway. The I-70 highway would provide the final connection to Copper Mountain.

The segment of SH 9 over Hoosier Pass would be upgraded to three lanes to provide an uphill passing lane. Existing switchbacks on the north side of the pass are assumed to be straightened as much as possible with this alternate route.

Figure 18. Alternate Route 15 – Pueblo to Copper Mountain via Hoosier Pass – Surface (US 50/SH 9)

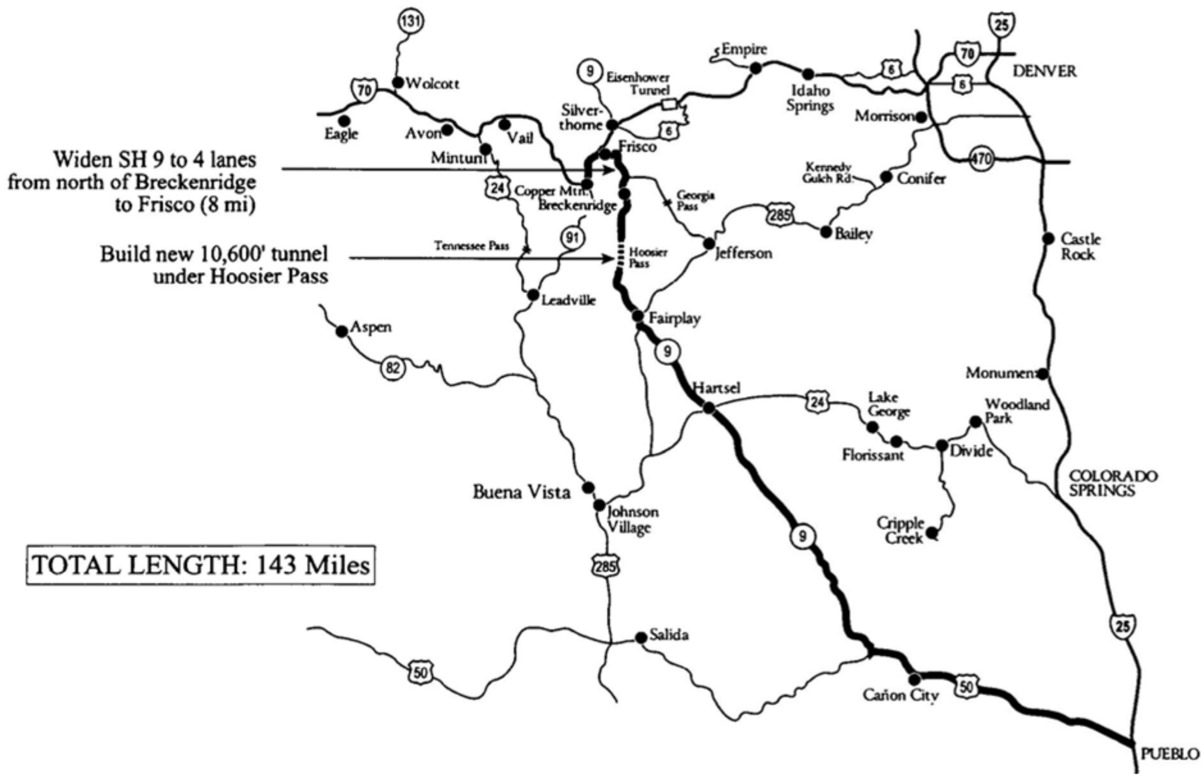


3.16 Alternate Route 16 – Pueblo to Copper Mountain via Hoosier Pass – Tunnel (US 50/SH 9)

Alternate Route 16 (AR-16) would follow US 50 west from Pueblo to its junction with SH 9 in the vicinity of Royal Gorge west of Canyon City (**Figure 19**). At this point, the route would follow SH 9 through Hartsel, Fairplay, Breckenridge, and Frisco to reach the I-70 highway. The I-70 highway would provide the final connection to Copper Mountain.

The segment of SH 9 between Breckenridge and Fairplay is assumed to include a tunnel under Hoosier Pass.

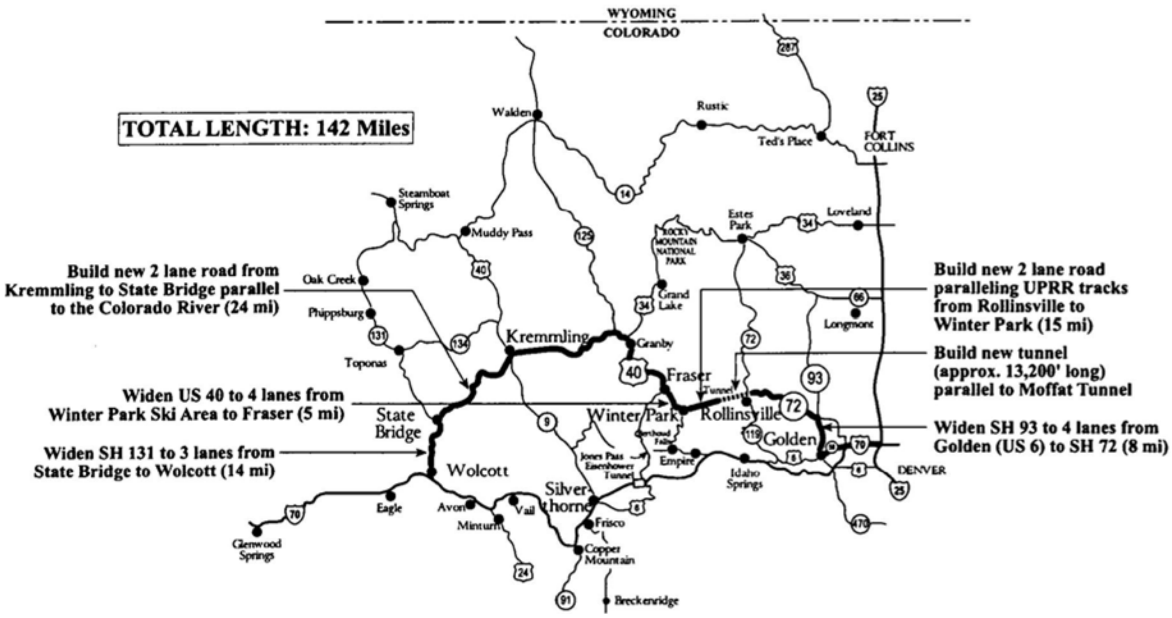
Figure 19. Alternate Route 16 – Pueblo to Copper Mountain via Hoosier Pass – Tunnel (US 50/SH 9)



3.17 Alternate Route 17 – Denver to Winter Park via New Tunnel Parallel to Moffat Tunnel (SH 58, SH 93, and SH 72) to Wolcott

Alternate Route 17 (AR-17) is the same route as Alternate Route 4. The route was re-considered during Level 2 screening under this new name.

Figure 20. Alternate Route 17 – Denver to Winter Park via New Tunnel Parallel to Moffat Tunnel (SH 58, SH 93, and SH 72) to Wolcott



Section 4. The Alternative Routes Screening Process

4.1 Level 1 Screening

Evaluation of the seventeen Alternate Routes at Level 1 screening focused on criteria related to project purpose and need, including:

- Mobility (ability to provide a competitive travel time advantage compared to the I-70 highway travelers);
- Accessibility (proximity to current origins and destinations along the I-70 highway Corridor); and
- Travel market served (proximity to Denver Front Range communities, where the majority of the I-70 highway travel originates).

All of these criteria were used to determine the potential of these seventeen Alternate Routes to alleviate traffic on the I-70 highway such that no mobility improvements are needed to the I-70 highway. These criteria, by the nature of the Level 1 screening process, were qualitative, with sufficient quantitative support to justify the basic conclusions.

The Colorado Department of Transportation conducted a user survey on the I-70 highway to understand where vehicles were coming from that were using the highway. The results are documented in the report titled *The I-70 User Study, Denver to Vail, Colorado, Summer 1999 and Winter 2000 Surveys* (HNTB, July 2000) and are summarized below.

The information was collected at three locations – Idaho Springs, Frisco, and Vail. The project team reported the county of origin of the vehicles using the I-70 highway at each of these location. The information is reported by the counties of residence in Colorado, and out-of-state travelers. **Table 1** provides details for counties within four areas—Denver Front Range, Corridor Counties, South Front Range, and North Front Range—and out-of-state travelers. **Table 1** presents the average of the summer and winter percentages of vehicles at Idaho Springs, Frisco, and Vail from the four areas of residence. Data from the I-70 highway User Study shown on **Table 1** demonstrate that the majority of travelers on the I-70 highway either reside in the Denver Front Range area, within the corridor communities, or are from out of state.

Level 1 screening resulted in the following findings:

- Alternate Routes 1, 4, 5, 6, 7, 8, and 10 between the Denver metropolitan area and the central Rocky Mountains would involve travel distances more than a comparable vehicle trip along the I-70 highway. In addition, travel times via all seven alternate routes would be greater than via the I-70 highway during uncongested travel periods. These routes were eliminated from further consideration because they would not provide suitable accessibility to the Corridor communities or the ability to constitute a viable alternative to the I-70 highway. Therefore, these alternatives were not considered attractive enough to divert traffic from the I-70 highway and they were therefore eliminated.
- Alternate Routes 2, 3, 11, 12, 13, 14, 15, and 16 would have a low percentage of travelers originating from the Front Range area and all were eliminated because they do not have the potential to divert any more than 3 to 4 percent of the traffic volume off the I-70 Mountain Corridor.
- Alternate Route 9 was carried forward for Level 2 screening because it was found that during peak travel periods, it may be able to provide competitive travel times with the I-70 Mountain Corridor.

Table 1. Percentage Vehicles by County of Residences

	Summer 1999 Survey			Winter 2000 Survey		
	Denver Front Range Counties					
Counties	Idaho Springs	Frisco	Vail	Idaho Springs	Frisco	Vail
Adams	4.7	3.3	2.1	3.6	2.3	1
Arapahoe	10.8	7.9	5.4	9.6	7.9	3.6
Boulder	6	5.3	3.1	6.8	5.4	2.4
Denver	19.8	15.8	12.2	20.7	20.6	10.9
Douglas	4.7	3	1.7	4	3.1	1.2
Jefferson	13.8	9.4	5.4	13.6	8.5	2.6
Total	59.8	44.7	29.9	58.3	47.8	21.7
Average of Summer and Winter Surveys	59.1	46.3	25.8			
	Corridor Counties					
Counties	Idaho Springs	Frisco	Vail	Idaho Springs	Frisco	Vail
Clear Creek	1.9	0.6	0.2	3.5	0.4	0.1
Eagle	5.5	11	37.9	2.5	7.8	42.8
Garfield	1.2	3.2	2.7	1.1	2.5	2.2
Summit	4.9	3.5	1.4	2.8	3.9	1.1
Park	0.3	0.2	0.2	0.3	0.2	0.1
Lake	0.6	2.7	0.4	0.5	2.6	0.7
Grand	1.6	0.2	0.1	1.5	0.2	0.1
Gilpin	0.1	0.1	0	0.4	0.1	0.1
Pitkin	0.4	0.9	0.4	0.4	0.8	0.7
Total	16.5	22.4	43.3	13	18.5	47.9
Average of Summer and Winter Surveys	14.8	20.5	45.6			
	South Front Range Counties					
Counties	Idaho Springs	Frisco	Vail	Idaho Springs	Frisco	Vail
Pueblo	0.3	0.3	0.3	0.1	0.3	0.2
El Paso	2.8	3.1	2.6	2.5	3	2
Teller	0.1	0.1	0.1	0	0.1	0.1
Fremont	0.1	0.1	0	0.1	0.1	0
Total	3.3	3.6	3	2.7	3.5	2.3
Average of Summer and Winter Surveys	3.0	3.6	2.7			
	North Front Range Counties					
Counties	Idaho Springs	Frisco	Vail	Idaho Springs	Frisco	Vail
Larimer	2.3	2.2	1.3	2.5	1.9	1
Weld	1.1	1.4	0.7	1	0.9	0.5
Total	3.4	3.6	2	3.5	2.8	1.5
Average of Summer and Winter Surveys	3.5	3.2	1.8			
	North Front Range Counties					
Origin	Idaho Springs	Frisco	Vail	Idaho Springs	Frisco	Vail
Out of State	10	16	16	19	21	22
Total	10	16	16	19	21	22
Average of Summer and Winter Surveys	14.5	18.5	19			

4.1.1 Analysis of Alternate Routes

In analyzing these alternate routes, they were divided into relatively homogenous segments (between existing towns or major road junctions) to better reflect existing conditions and determine needed improvements. This information for route segments is documented in the **Appendix A**. The technical information includes traffic volumes, total miles, average speeds, travel times, congested speeds, congested travel times, and information on existing and proposed laneage for each segment of the routes.

Certain segments have been recommended for upgrading to four lanes (which would include either a depressed median approximately 30 feet wide or a narrow, barrier separated median in difficult terrain) or to three lanes (to provide an uphill passing lane). Along segments of existing highways where no widening is recommended, spot improvements would be made to improve safety or flatten out particularly tight curves.

Travel Time Comparisons

Table 2 summarizes the distance and travel time for each alternate route for comparison with the I-70 highway. Two travel time estimates were prepared; one for uncongested conditions and one for peak period congested travel conditions. An examination of **Table 3** indicates:

- Five of the 16 alternate routes provide a shorter travel distance when compared to the I-70 highway. These alternate routes are:
  - AR-2 Fort Collins to Wolcott via Kremmling
  - AR-11 Colorado Springs to Copper Mountain via Hoosier Pass (surface)
  - AR-12 Colorado Springs to Copper Mountain via Hoosier Pass Tunnel
  - AR-15 Pueblo to Copper Mountain via Hoosier Pass (surface)
  - AR-16 Pueblo to Copper Mountain via Hoosier Pass Tunnel
- Three of the 16 alternate routes result in travel time savings, relative to the I-70 highway, during uncongested travel periods. These routes are:
  - AR-12 Colorado Springs to Copper Mountain via Hoosier Pass Tunnel
  - AR-15 Pueblo to Copper Mountain via Hoosier Pass (surface)
  - AR-16 Pueblo to Copper Mountain via Hoosier Pass Tunnel

  The most noteworthy travel time difference occurs with AR-16. For this route, a trip will take approximately 21 minutes less than if the same trip was taken on the 1-70 highway. This is a 12.4 percent difference in travel time.

- Five of the 16 alternate routes result in equal or reduced travel times relative to the I-70 highway, during congested travel periods. These routes are:
  - AR-9 Denver to Copper Mountain via Georgia Pass Tunnel
  - AR-11 Colorado Springs to Copper Mountain via Hoosier Pass (surface)
  - AR-12 Colorado Springs to Copper Mountain via Hoosier Pass Tunnel
  - AR-15 Pueblo to Copper Mountain via Hoosier Pass (surface)
  - AR-16 Pueblo to Copper Mountain via Hoosier Pass Tunnel

The most noteworthy travel time difference occurs with AR-16. For this route, a trip will take 43 minutes less than the same if the same trip was taken on the I-70 highway. This is a 19.3 percent difference in travel time. Note that AR-17 Denver to Winter Park via New Tunnel Parallel to Moffat Tunnel (SH58, SH93, SH 72) to Wolcott was originally ARNF-4 and was reconsidered under this new name during Screening Level 2, which is discussed in **Section 4.2**.

Table 2. Comparative Distances and Travel Times

Origin	Destination	Route	Distance (miles)	Travel Time (Minutes)	Congested Travel Time (Minutes)
Fort Collins	Wolcott	**The I-70 Highway**	**173**	**154**	**206**
		AR-1—SH 14 via Walden	225	267	323
		AR-2—US 34 via Kremmling	140	172	211
Fort Collins	Copper Mountain	**The I-70 Highway**	**135**	**119**	**171**
AR-3—US 34 via Kremmling			149	178	218
Denver	Wolcott	**The I-70 Highway**	**117**	**109**	**165**
		AR-4—SH 72 via Moffat Tunnel	142	197	244
		AR-6—the I-70 highway to US 40 via Berthoud Pass Tunnel	142	162	211
Denver	Copper Mountain	**The I-70 Highway**	**79**	**74**	**130**
		AR-5—SH 72 via Moffat, Berthoud Pass and Jones Pass Tunnels	116	169	230
		AR-7—SH 9? via Jones Pass Tunnel	99	113	154
		AR-8—US 285 via Hoosier Pass	125	147	185
		AR-9—US 285 via Georgia Pass Tunnel	105	118	130
Denver	Minturn	**The I-70 Highway**	**103**	**97**	**152**
AR-10—US 285 via Buena Vista			192	231	268
Colorado Springs	Copper Mountain	**The I-70 Highway**	**144**	**131**	**184**
		AR-11—US 24 via Hoosier Pass	118	138	182
		AR-12—US 24 via Hoosier Pass Tunnel	114	129	166
		AR-13—US 24 via Buena Vista	152	171	215
Colorado Springs	Minturn	**The I-70 Highway**	**168**	**153**	**206**
AR-14—US 24 via Buena Vista			161	194	244
Pueblo	Copper Mountain	**The I-70 Highway**	**186**	**170**	**223**
		AR-15—US 50 via Hoosier Pass	147	158	196
		AR-16—US 50 via Hoosier Pass Tunnel	143	149	180

Key to Abbreviations/Acronyms: AR = Alternate Route

Table 3. Level 1 Alternatives Analysis Screening Results

Alternate Route		Level 2 Screening Results
1	Fort Collins to Wolcott via Walden (SH 14 and SH 131)	Eliminated since travel time is not competitive with the congested I-70 highway. Low percentage (1.9 percent) of travelers originating from the area does not meaningfully reduce the I-70 highway congestion.
2	Fort Collins to Wolcott via Kremmling (US 34)	Eliminated due to the low percentage (1.9 percent) of travelers originating from the area.
3	Fort Collins to Copper Mountain via Kremmling (US 34 and SH 9)	Eliminated due to the low percentage (1.9 percent) of travelers originating from the area.
4	Denver to Wolcott via Moffat Tunnel (SH 72, US 40, and US 34)	Eliminated since travel time is not competitive with the congested I-70 highway.
5	Denver to Copper Mountain via Moffat, Berthoud, and Jones Pass Tunnels (SH 72 and SH 9)	Eliminated since travel time is not competitive with the congested I-70 highway.
6	Denver to Wolcott via Berthoud Pass Tunnel (US 40 and US 34)	Eliminated since travel time is not competitive with the congested I-70 highway.
7	Denver to Copper Mountain via Jones Pass Tunnel (SH 9)	Eliminated since travel time is not competitive with the congested I-70 highway.
8	Denver to Copper Mountain via Hoosier Pass (surface) (US 285 and SH 9)	Eliminated since travel time is not competitive with the congested I-70 highway.
9	Denver to Copper Mountain via Georgia Pass Tunnel (US 285)	Advanced to Level 2 screening.
10	– Denver to Minturn via Buena Vista (US 285 and US 24)	Eliminated since travel time is not competitive with the congested I-70 highway.
11	Colorado Springs to Copper Mountain via Hoosier Pass (surface) (US 24 and SH 9)	Eliminated due to the low percentage (2.7 percent) of travelers originating from the area.
12	Colorado Springs to Copper Mountain via Hoosier Pass Tunnel (US 24 and SH 9)	Eliminated due to the low percentage (2.7 percent) of travelers originating from the area.
13	Colorado Springs to Minturn via Buena Vista (US 24)	Eliminated due to the low percentage (2.7 percent) of travelers originating from the area.
14	Colorado Springs to Copper Mountain via Buena Vista (US 24 and SH 91)	Eliminated due to the low percentage (2.7 percent) of travelers originating from the area. Travel time not competitive with the congested I-70 highway.
15	Pueblo to Copper Mountain via Hoosier Pass (surface) (US 50 and SH 9)	Eliminated due to the low percentage (0.3 percent) of travelers originating from the area.
16	Pueblo to Copper Mountain via Hoosier Pass Tunnel (US 50 and SH 9)	Eliminated due to the low percentage (0.3 percent) of travelers originating from the area.

4.2 Level 2 Screening

Before initiating Level 2 screening, the project team reconsidered AR-4 under a new name, Alternative Route 17 (AR-17) – Denver to Winter Park via New Tunnel Parallel to Moffat Tunnel (SH58, SH93, and SH72) to Wolcott. This route was reconsidered because the newly-developed travel demand model provided additional information for evaluation.

The two alternate routes (AR-9 and AR-17) were analyzed for Level 2 Screening. The criteria used to evaluate these alternatives are: travel time, alternate routes costs, and potential impacts to environmental resources. The results of the screening analyses are presented below.

4.2.1 Alternate Route 9 –Screening Analysis

Alternative Route 9 was eliminated from further consideration due to the environmental conflicts of developing a new route to Breckenridge and an improved US 285 in Jefferson and Park Counties, with a lack of travel time advantage. The new alignment portion of Alternate Route 9 through Park County would traverse the area near Jefferson and Georgia Pass, which contains the highest concentration of natural and cultural resources in southern Park County located within a portion of the South Park National Heritage Area (13.3 miles of the alternate are in the South Park Heritage area). Of the 13.3 miles, 4.3 miles are improvements to US 285 and 9.0 miles are new construction. Natural resources in the area include an extensive fen that would be unavoidable in creating a new Georgia Pass tunnel alignment. This alternate route was also eliminated because of the extraordinary costs associated with building a new 10,600 foot 2-lane tunnel through Georgia Pass ($520 million in year 2001 dollars).

Alternate Route 9 would provide an alternative to the I-70 highway for access to Summit County; however, the travel time comparisons to using the I-70 highway do not show an advantage to using this alternate route. Travel time comparisons provided in **Table 2** show that the 105-mile trip using Alternate Route 9 would take 118 minutes (1 hour and 58 minutes) during uncongested periods, and 130 minutes (2 hours and 10 minutes) during congested periods. By comparison, the 79-mile trip via the I-70 highway to Copper Mountain would take 74 minutes (1 hour and 14 minutes) during uncongested periods, and 130 minutes (2 hours and 10 minutes) during congested periods.

Sixteen acres of important wetland/fen complexes in the Jefferson area are affected by widening US 285. The wetlands at Jefferson and Guernsey Creeks contain extremely rich fens with a biodiversity rank of B2 (very highly significant) (Sanderson, et al, 1996). The 16 acres of fens are shown in **Figure 5**.

Widening through this US 285 area has the potential to affect Kenosha Pass Summit, a property listed on the State Register of Historic Properties. Four Historic ranches in the Jefferson area have the potential to be affected by widening US 285, including the Wahl Ranch which is listed on the National Register of Historic Places. Widening also has the potential to affect the nationally listed Jefferson Denver South Park and Pacific Railroad Depot located at the junction of US 285 and City Road 35. See **Figure 6**, Proposed Alternate Route 9, Potential Wildlife Habitat Impacts in **Appendix B**.

Twenty-two miles of new 2-lane road northwest from Jefferson through Georgia Pass to north of Breckenridge would affect 28 acres of lynx habitat (on the White River National Forest); 91 acres of elk key habitat; and 133 acres of deer key habitat. See **Figure 5**, Proposed Alternate Route 9, Potential Wildlife Habitat Impacts in **Appendix B**.

The new 2-lane road affects 3,500 feet of streams; 60 acres of United States Forest Service Land, 3 acres of which are forest service designated roadless areas; and almost 6 acres of State Wildlife Areas. Other environmental resources affected include 8 acres of State land, and 172 acres of private land. See **Figure** 6, Proposed Alternate Route 9: Potential Stream and Land Impacts in **Appendix B**.

4.2.2 Alternate Route 17 –Screening Analysis

Alternative Route 17 was eliminated from further consideration due to the cost of developing a new tunnel ($650 million in year 2001 dollars) with a lack of travel time effectiveness. Alternate Route 17 would provide an alternative to the I-70 highway for access to Eagle County; however, the travel time comparisons to using the I-70 highway do not show an advantage to using this alternate route. Travel time comparisons indicate that the 142-mile trip using Alternate Route 17 would take 197 minutes (3 hours and 17 minutes) during uncongested periods, and 244minutes (4 hours and 9 minutes) during congested periods. By comparison, the 117-mile trip via the I-70 highway to Wolcott would take 109 minutes (1 hour and 49 minutes) during uncongested periods, and 165 minutes (2 hours and 45 minutes) during congested periods.

4.3 Summary of Level 2 Screening and Public Coordination

The analysis showed that neither alternate route would remove enough traffic from the I-70 highway to improve travel conditions and avoid the need to pursue mobility enhancements to the I-70 highway. In addition, the improvements to the existing roadways and the new roads and tunnels required for alternative routes would result in large social and environmental impacts, as well as high costs due to tunneling.

At the beginning of Level 2 screening, the information on alternate routes was presented at public workshops in January 2001 and at Advisory Committee meetings in February 2001, with the recommendation that alternate routes be eliminated. Attendees at each forum endorsed this recommendation. Results of Level 2 screening were announced in the June 2001 newsletter.

No alternate routes were advanced for further consideration in the PEIS.

Section 5. References

Felsberg Holt & Ullevig. 2000. *Description of Alternate Highway Routes Report*. June.

HNTB. 2000. *The I-70 User Study, Denver to Vail, Colorado, Summer 1999 and Winter 2000 Surveys*. July.

John Sanderson and Margaret March (Colorado Natural Heritage Program). 1996. *Extreme Rich Fens of South Park, Colorado: Their Distribution, Identification, and Natural Heritage Significance. Prepared for Park County, the Colorado Department of Natural Resources and the US Environmental Protection Agency*.

Two appendices support the Alternate Routes Technical Report:

- Appendix A provides operational details about the segments of the alternate routes contained in this technical report. The data were developed in 2000 as part of the initial study of alternate routes and were used to support the screening of these alternatives based on operational characteristics. They are timely to the screening decisions that occurred during this timeframe.
- Appendix B contains details about the environmental impacts associated with Alternate Route 9. Analysis of impacts from this alternate route was conducted in the second level of screening, which was also conducted in 2000 concurrent with the data collection.

1

Appendix A. Alternate Route Segment Data

This page intentionally left blank.

Alternative Route Segment Data													
Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Fort Collins to Wolcott via Walden													
AR-1	SH 14	I-25	US 287	12-27	4	35	7	30	8	2	2	0	4
	US 287	US 287	Ted's Place	5-20	9	45	12	35	15	2	2	0	9
	SH 14	Ted's Place	East Of Rustic	1-2	25	40	38	24	60	2	2	0	25
	SH 14	East of Rustic	Walden	1	63	55	69	45	84	2	3	63	0
	SH 14	Walden	US 40	1	34	55	37	50	41	2	2	0	34
	US 40	US 40	SH 131	2-3	21	55	23	50	25	2	2	0	21
	SH 131	SH 131	State Bridge	1-3	55	50	66	45	73	2	2	0	55
	SH 131	State Bridge	I-70/Wolcott	12-28	14	55	15	50	17	2	3	14	0
Total					225		267		323				
Via I-70					173		154		206				
Fort Collins to Wolcott via Kremmling													
AR-2	I-25	SH 14	US 34	27-43	12	75	10	65	11	2	2	0	0
	US 34	US 34	Estes Park	1-20	34	40	51	30	68	2	2	0	34
	US 34	Estes Park	Grand Lake	new	14	50	17	40	21	0	2	0	0
	US 34	Grand Lake	Granby	3-4	15	50	18	40	23	2	2	0	15
	US 34	Granby	Kremmling	2-4	27	55	29	45	36	2	2	0	27
	new	Kremmling	State Bridge	new	24	45	32	40	36	0	2	24	0
	SH 131	State Bridge	I-70/Wolcott	12-28	14	55	15	50	17	2	3	14	0
Total					140		172		212				
Via I-70					173		154		206				
Fort Collins to Copper Mountain via Kremmling													
AR-3	I-25	SH 14	US 34	27-43	12	75	10	65	11	2	2	0	0
	US 34	US 34	Estes Park	1-20	34	40	51	30	68	2	2	0	34
	US 34	Estes Park	Grand Lake	new	14	50	17	40	21	0	2	0	0
	US 34	Grand Lake	Granby	3-4	15	50	18	40	23	2	2	0	15
	US 34	Granby	Kremmling	2-4	27	55	29	45	36	2	2	0	27
	SH 9	Kremmling	Silverthorne	3-21	37	50	44	45	49	2	3	37	0
	I-70	Silverthorne	Copper Mountain	21-28	10	65	9	60	10	4	4	0	0
Total					149		178		218				
Via I-70					135		119		171				

Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Denver to Wolcott via Moffat Tunnel													
AR-4	I-70	I-25	SH 58	77-128	8	60	8	55	9	6	6	0	0
	SH 58	I-70	Golden	11-19	5	55	5	50	6	2	2	0	0
	SH 93	Golden	SH 72	15-20	8	45	11	40	12	2	4	19	0
	SH 72	SH 93	SH 119	1-4	19	25	46	15	76	2	2	0	19
	SH 119	SH 72	Rollinsville	3	2	35	3	25	5	2	2	0	2
	new	Rollinsville	Winter Park	new	15	45	20	40	23	0	2	12	0
	US 40	Winter Park	Fraser	6-7	5	55	5	50	6	2	4	5	0
	US 40	Fraser	Granby	5-8	15	55	16	50	18	2	2	0	15
	US 34	Granby	Kremmling	2-4	27	45	36	45	36	2	2	0	27
	new	Kremmling	State Bridge	new	24	45	32	40	36	0	2	24	0
	SH 131	State Bridge	I-70/Wolcott	12-28	14	55	15	50	17	2	3	14	0
Total					142		197		244				
Via I-70					117		109		165				

Total	116	169	230
Via I-70	79	74	130

Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Denver to Wolcott via Berthoud Pass Tunnel													
AR-6	I-70	I-25	C-470	60-139	14	60	14	55	15	4-8	4-8	0	0
	I-70	C-470	US 6	30-59	15	65	14	60	15	6	6	0	0
	I-70	US 6	US 40/Empire	30-34	12	65	11	20	36	4	4	0	0
	US 40	US 40/Empire	Winter Park	4-7	16	50	19	30	32	2	2	0	16
	US 40	Winter Park	Fraser	6-7	5	55	5	50	6	2	4	5	0
	US 40	Fraser	Granby	5-8	15	55	16	50	18	2	2	0	15
	US 34	Granby	Kremmling	2-4	27	45	36	45	36	2	2	0	27
	new	Kremmling	State Bridge	new	24	45	32	40	36	0	2	24	0
	SH 131	State Bridge	I-70/Wolcott	12-28	14	55	15	50	17	2	3	14	0
Total					142		162		211				
Via I-70					117		109		165				
Denver to Copper Mountain via Jones Pass Tunnel													
AR-7	I-70	I-25	C-470	60-139	14	60	14	55	15	4-8	4-8	0	0
	I-70	C-470	US 6	30-59	15	65	14	60	15	6	6	0	0
	I-70	US 6	US 40/Empire	30-34	12	65	11	20	36	4	4	0	0
	US 40	US 40/Empire	Berthoud Falls	5-7	9	50	11	30	18	2	2	0	1-2
	new	Berthoud Falls	Ute Pass Road	new	18	45	24	40	27	0	2	16	8-10
	new	Ute Pass Road	SH 9	new	8	35	14	30	16	0	2	8	8-10
	SH 9	New Road	Silverthorne	3-22	13	50	16	45	17	2	3	13	4-6
	I-70	Silverthorne	Copper Mountain	21-28	10	65	9	60	10	4	4	0	0
Total					99		113		154				
Via I-70					79		74		130				

Alternative Route Segment Data													
Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Denver to Copper Mountain via Hoosier Pass													
AR-8	I-70	Jct. I-25/I-70	Jct. I-70/C-470	60-139	14	60	14	55	15	4-8	4-8	0	0
	C-470	Jct. I-70/C-470	Jct. C-470/US 285	45-54	6	65	6	60	6	4	4	0	0
	US 285	Jct. C-470/US 285	Kennedy Gulch Rd.	18-25	9	50	11	45	12	4	4	0	9
	US 285	Kennedy Gulch Rd.	Bailey	5-16	19	55	21	50	23	2	4	19	0
	US 285	Bailey	Jefferson	3-5	23	55	25	50	28	2	4	23	0
	US 285	Jefferson	Fairplay	2.5-3	16	55	17	50	19	2	2	0	16
	SH 9	Fairplay	Breckenridge	3-7	21	40	32	30	42	2	3	21	0
	SH 9	Breckenridge	Breckenridge	7-12	2	25	5	5	24	2	2	0	2
	SH 9	Breckenridge	Frisco	12-19	8	50	10	50	10	2	4	8	0
	I-70	Frisco	Copper Mountain	20	7	65	6	65	6	4	4	0	0
Total					125		147		185				
Via I-70					79		85		130				
Denver to Copper Mountain via Georgia Pass Tunnel													
AR-9	I-70	I-25	C-470	60-139	14	60	14	55	15	4-8	4-8	0	0
	C-470	I-70	US 285	45-54	6	65	6	60	6	4	4	0	0
	US 285	C-470	Kennedy Gulch Rd.	18-28	9	50	11	45	12	4	4	0	9
	US 285	Kennedy Gulch Rd.	Bailey	5-16	19	55	21	50	23	2	4	19	0
	US 285	Bailey	Jefferson	3-5	23	55	25	50	28	2	4	23	0
	new	Jefferson	Tiger Road	new	20	45	27	40	30	0	2	18	0
	SH 9	Tiger Road	Frisco	14-19	7	55	8	50	8	2	4	0	7
	I-70	Frisco	Copper Mountain	20	7	65	6	55	8	4	4	0	0
Total					105		118		130				
Via I-70					79		74		130				

Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Denver to Minturn via Buena Vista													
AR-10	I-70	I-25	C-470	60-139	14	60	14	55	15	4-8	4-8	0	0
	C-470	I-70	US 285	45-54	6	65	6	60	6	4	4	0	0
	US 285	C-470	Kennedy Gulch Rd.	18-25	9	50	11	45	12	4	4	0	0
	US 285	Kennedy Gulch Rd.	Bailey	5-16	19	55	21	50	23	2	4	19	0
	US 285	Bailey	Jefferson	3-5	23	55	25	50	28	2	4	23	0
	US 285	Jefferson	Fairplay	2.5-3	16	55	17	50	19	2	2	0	16
	US 285	Fairplay	Johnson Village	2-3.5	35	55	38	50	42	2	2	0	35
	US 24	Johnson Village	Buena Vista	8-11	3	35	5	25	7	2	2	0	3
	US 24	Buena Vista	Leadville	3-6	33	50	40	50	40	2	3	33	0
	US 24	Leadville	SH 91	5-12	2	20	6	10	12	2	2	0	2
	US 24	SH 91	I-70/Minturn	2-8	32	40	48	30	64	2	2	0	32
Total					192		231		268				
Via I-70					103		97		152				
Colorado Springs to Copper Mountain via Hoosier Pass													
AR-11	US 24	I-25	Woodland Park	23-35	19	45	25	40	29	4	4	0	19
	US 24	Woodland Park	Lake George	3-6	19	55	21	55	21	2	4	19	0
	US 24	Lake George	Hartsel	2-3	26	65	24	45	35	2	2	0	26
	SH 9	Hartsel	Fairplay	1-2	16	65	15	65	15	2	2	0	16
	SH 9	Fairplay	Breckenridge (s)	3-7	21	40	32	30	42	2	3	21	0
	SH 9	Breckenridge (s)	Breckenridge (n)	7-12	2	25	5	5	24	2	2	0	2
	SH 9	Breckenridge (n)	Frisco	12-19	8	50	10	50	10	2	4	8	0
	I-70	Frisco	Copper Mountain	20	7	65	6	65	6	4	4	0	0
Total					118		138		182				
Via I-70					144		131		184				

Alternative Route Segment Data													
Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Colorado Springs to Copper Mtn via Hoosier Pass Tunnel													
AR-12	US 24	I-25	Woodland Park	23-35	19	45	25	40	29	4	4	0	19
	US 24	Woodland Park	Lake George	3-6	19	55	21	55	21	2	4	19	0
	US 24	Lake George	Hartsel	2-3	26	65	24	45	35	2	2	0	26
	SH 9	Hartsel	Fairplay	1-2	16	65	15	65	15	2	2	0	16
	SH 9	Fairplay	Breckenridge (s)	3-7	17	45	23	40	26	2	2	0	0
	SH 9	Breckenridge (s)	Breckenridge (n)	7-12	2	25	5	5	24	2	2	0	2
	SH 9	Breckenridge (n)	Frisco	12-19	8	50	10	50	10	2	4	8	0
	I-70	Frisco	Copper Mountain	20	7	65	6	65	6	4	4	0	0
Total					114		129		166				
Via I-70					144		131		184				

Colorado Springs to Minturn via Buena Vista													
AR-13	US 24	I-25	Woodland Park	20-35	19	45	25	40	29	4	4	0	19
	US 24	Woodland Park	Lake George	3-6	19	55	21	55	21	2	4	19	0
	US 24	Lake George	Hartsel	2-3	26	65	24	45	35	2	2	0	26
	US 24	Hartsel	Johnson Village	2-5	27	65	25	45	36	2	2	0	27
	US 24	Johnson Village	Buena Vista	8-11	3	35	5	25	7	2	2	0	3
	US 24	Buena Vista	Leadville	3-6	33	50	40	50	40	2	3	33	0
	US 24	Leadville	SH 91	5-12	2	20	6	10	12	2	2	0	2
	US 24	SH 91	I-70/Minturn	2-8	32	40	48	30	64	2	2	0	32
Total					161		194		244				
Via I-70					168		153		206				

Alternative Route Segment Data													
Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Colorado Springs to Copper Mountain via Buena Vista													
AR-14	US 24	I-25	Woodland Park	20-35	19	45	25	40	29	4	4	0	19
	US 24	Woodland Park	Lake George	3-6	19	55	21	55	21	2	4	19	0
	US 24	Lake George	Hartsel	2-3	26	65	24	45	35	2	2	0	26
	US 24	Hartsel	Johnson Village	2-5	27	65	25	45	36	2	2	0	27
	US 24	Johnson Village	Buena Vista	8-11	3	35	5	25	7	2	2	0	3
	US 24	Buena Vista	Leadville	3-6	33	50	40	50	40	2	3	33	0
	US 24	Leadville	SH 91	5-12	2	20	6	10	12	2	2	0	2
	SH 91	US 24	Copper Mountain	5-6	23	55	25	40	35	2	2	0	23
Total					152		171		215				
Via I-70					144		131		184				

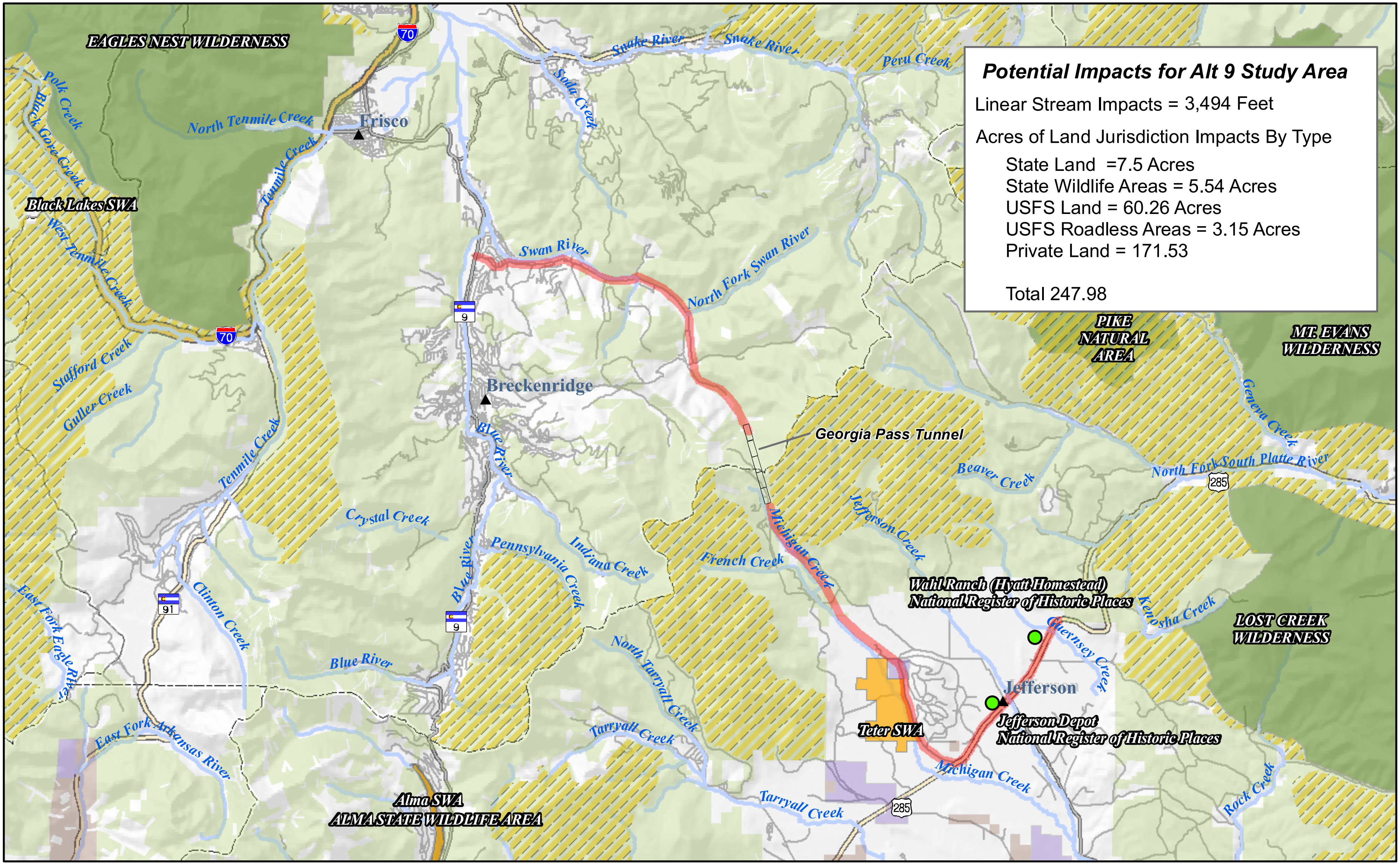
Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Pueblo to Copper Mountain via Hoosier Pass													
AR-15	US 50	I-25	SH 45	30-35	3	45	4	40	5	4	4	0	0
	US 50	SH 45	SH 115 (n)	10-25	22	55	24	45	29	4	4	0	0
	US 50	SH 115 (n)	Canon City	20-25	11	65	10	50	13	4	4	0	0
	US 50	Canon City	US 50	10-12	10	65	9	65	9	2	2	0	0
	SH 9	US 50	Hartsel	1-2	47	65	43	65	43	2	2	0	0
	SH 9	Hartsel	Fairplay	1-2	16	65	15	65	15	2	2	0	16
	SH 9	Fairplay	Breckenridge	3-7	21	40	32	30	42	2	3	21	0
	SH 9	Breckenridge	Breckenridge	7-12	2	25	5	5	24	2	2	0	2
	SH 9	Breckenridge	Frisco	15-20	8	50	10	5	10	2	4	8	0
	I-70	Frisco	Copper Mountain	20	7	65	6	65	6	4	4	0	0
Total					147		158		196				
Via I-70					186		170		223				

Alternative Route Segment Data

Route	Highway	From	To	ADT Range (1000s)	Total Miles	Avg Speed (mph)	Travel Time (min)	Cong. Speed (mph)	Cong. Travel Time (min)	Exist Laneage	Prop. Laneage	Miles of New Highway/ Upgrades	Miles of Highway Safety Upgrades
Pueblo to Copper Mountain via Hoosier Pass Tunnel													
AR-16	US 50	I-25	SH 45	30-35	3	45	4	40	5	4	4	0	0
	US 50	SH 45	SH 115 (n)	10-25	22	55	24	45	29	4	4	0	0
	US 50	SH 115 (n)	Canon City	20-25	11	65	10	50	13	4	4	0	0
	US 50	Canon City	US 50	10-12	10	65	9	65	9	2	2	0	0
	SH 9	US 50	Hartsel	1-2	47	65	43	65	43	2	2	0	0
	SH 9	Hartsel	Fairplay	1-2	16	65	15	65	15	2	2	0	16
	SH 9	Fairplay	Breckenridge (s)	3-7	17	45	23	40	26	2	0	0	0
	SH 9	Breckenridge (s)	Breckenridge (n)	7-12	2	25	5	5	24	2	2	0	2
	SH 9	Breckenridge (n)	Frisco	15-20	8	50	10	5	10	2	4	8	0
	I-70	Frisco	Copper Mountain	20	7	65	6	65	6	4	4	0	0
Total					143		149		180				
Via I-70					186		170		223				

Appendix B. Alternate Route 9 Resource Impact Maps

This Page intentional left blank



Potential Impacts for Alt 9 Study Area

Linear Stream Impacts = 3,494 Feet

Acres of Land Jurisdiction Impacts By Type

- State Land =7.5 Acres
- State Wildlife Areas = 5.54 Acres
- USFS Land = 60.26 Acres
- USFS Roadless Areas = 3.15 Acres
- Private Land = 171.53

Total 247.98

Legend

- Mileposts
- Limited Access Highways
- Major Highways
- State Boundary
- Lakes
- County Boundary
- Urban Areas
- Alternative 9 Impact Study Area

General Land Use

- USFS Land
- BLM Land
- Wilderness Areas
- State Land
- State Wildlife Areas
- Roadless Areas

0 1.5 3 Miles

SCALE - 1:207,388
or 1" = 3.27 Miles

I-70 Mountain Corridor PEIS

Figure 6
Proposed Alternative Route 9
Land Jurisdiction

Legend

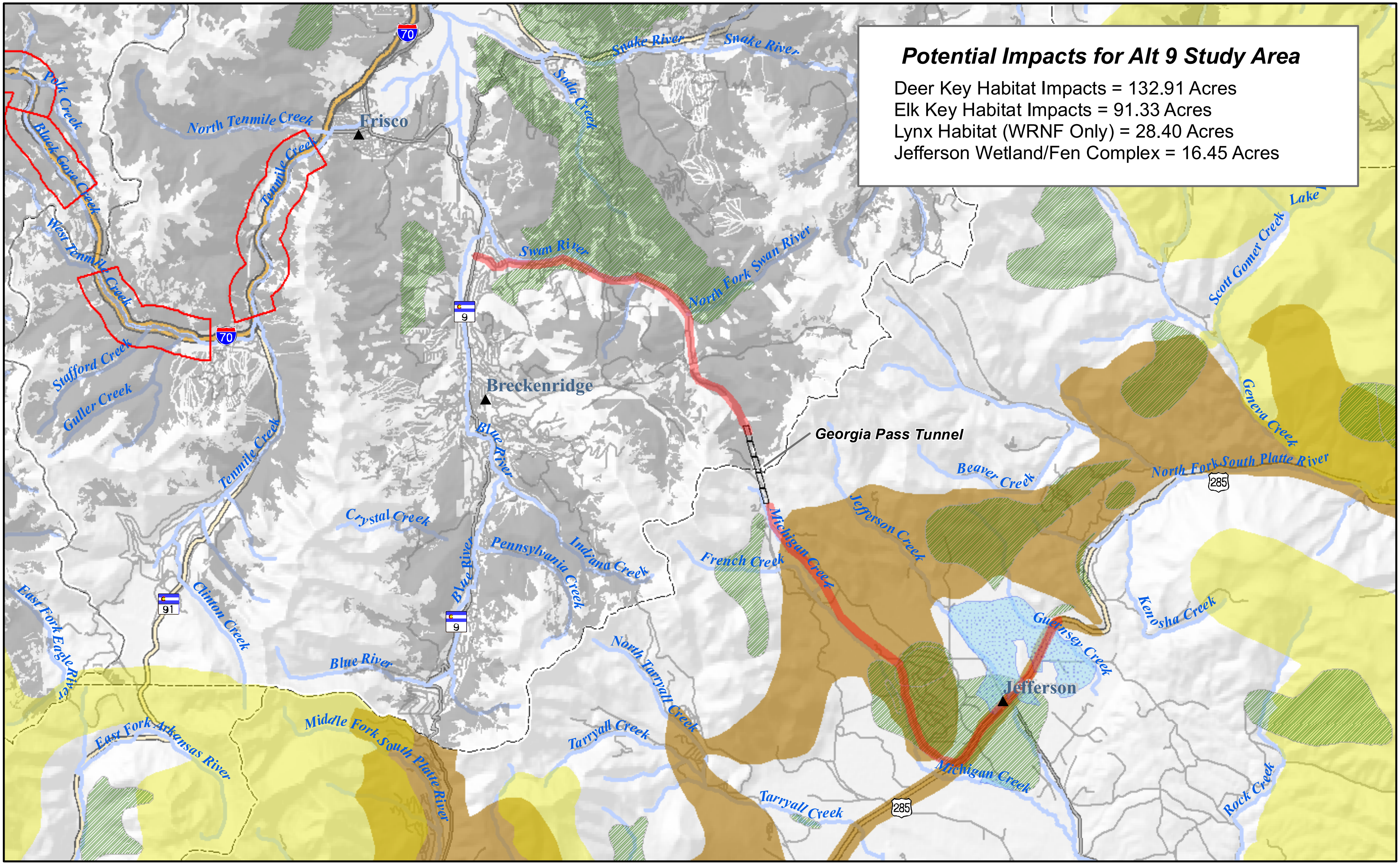
- Mileposts
- Limited Access Highways
- Major Highways
- State Boundary
- Lakes
- County Boundary
- Urban Areas
- US 285 Impact Area

0 75 150 Feet

SCALE - 1:1,800
or 1" = 150 Feet

I-70 Mountain Corridor PEIS

Figure 5
Proposed Alternative Route 9 Through Jefferson



Legend

- Mileposts
- Limited Access Highways
- Major Highways
- State Boundary
- Lakes
- County Boundary
- Urban Areas
- Lynx Habitat
- Wildlife Linkage Interference Zones
- Key Elk Habitat
- Key Bighorn Sheep Habitat
- Key Mule Deer Habitat
- Wetland/Fen Locations

0 1.635 3.27 Miles

SCALE - 1:207,388
or 1" = 3.27 Miles

I-70 Mountain Corridor PEIS

U.S. Department of Transportation Federal Highway Administration

Figure 7
Route 9 Potential Wildlife Habitat Impacts

Appendix J
TranSystems
I-70 Mountain Corridor Programmatic Environmental Impact Statement Level One Screening Process
October 2000

This page intentionally left blank.

I-70 MOUNTAIN CORRIDOR PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

LEVEL ONE SCREENING PROCESS

October 2000

Table of Contents

INTRODUCTION

The Colorado Department of Transportation (CDOT), in consultation with the Federal Highway Administration (FHWA), has decided to prepare a Programmatic Environmental Impact Statement (PEIS) for the I-70 Mountain Corridor in order to take a broad view of transportation-related issues and alternatives solutions for I-70 between C-470 and Glenwood Springs.

The I-70 Mountain Corridor Major Investment Study commissioned by CDOT projected increases in congestion and other mobility problems over a 20-year period. The PEIS approach enables these transportation problems to be addressed as a system. The transportation elements being addressed in the I-70 Mountain Corridor PEIS include transportation management, fixed guideway transit, rubber tire transit, highway and interchange improvements, alternate routes, and aviation.

The overall I-70 PEIS process involves a progression of steps: Scoping, Alternatives Analysis, Environmental Analysis, and PEIS Preparation. The Scoping process identifies issues and public and agency comments on alternatives. Through two levels of the Alternative Analysis, alternatives will procedurally be selected from within families for environmental impact assessment and comparison of the alternatives. Alternative(s) from the families will progress to the Environmental Analysis stage of the study where further refinement and packaging of single modes into multi-modal combinations will occur for an investigation of environmental impacts. Some alternatives may be evaluated as stand alone options. PEIS preparation provides documentation and disclosure of direct, indirect and cumulative environmental impacts and mitigation for the selected action and other alternatives.

Screening and Evaluation Process

The alternatives analysis component of the PEIS includes two levels of screening to be conducted based on an analysis of issues and alternatives identified through scoping. This document focuses on the initial level of analysis (Level One Screening). Level One Screening focused on criteria related to the purpose and need for the project. Related screening criteria include: 1) Meaningful reduction in congestion (increase mobility) and 2) improved safety in the I-70 Mountain Corridor. The screening process for each alternative employed these criteria in general, however, the criteria were modified as appropriate to reflect alternative-specific issues. This stage of the analysis developed alternatives within individual modes of transportation (i.e., transportation management, fixed guideway transit, rubber tire transit, highway and interchange elements, alternate routes, and aviation).

The results of the Level 1 Screening are summarized in Appendix B. This table provides a complete list of the alternatives within each family, Level 1 screening criteria and results. All of the alternatives within the highway and interchange element family and the transportation management family passed through the Level 1 screening process. The following sections summarize results for the transit alternatives, alternate routes, and aviation families.

It is important to remember that in both the first and second level screening processes, options are to be evaluated only within a family and not among or against options in other families. Once options within the families are selected during second level screening and move to the PEIS analysis, intermodal evaluation will take place utilizing cross-modal measures to ensure the most effective and efficient combination of recommended options is selected.

TRANSIT ALTERNATIVES

A number of transit alternatives exist which can be evaluated regarding their ability to contribute to improved mobility in the I-70 Mountain Corridor between C-470 and Dotsero. These transit alternatives consist of various forms of rubber-tired, rail based, and other promising technologies for ground transportation. These alternatives each have a number of implementation options that represent a variety of vehicle sizes and types, guideway technologies, line configurations, propulsion types, and resulting system performance capabilities. These differences greatly affect the initial capital costs to construct the various systems, the unit cost of the vehicles, the number of vehicles required to move a given number of people or volume of goods, the safety of the passengers and the public, and the costs to operate and maintain the systems. These differences, in turn, affect the ultimate capacity of any proposed system, the overall running time between end points, the energy consumption per passenger, and the environmental impacts of the system, and ultimately their suitability to operated effectively in a given environment.

The purpose of examining transit alternatives is to determine whether any ground transportation technologies that either currently exist or show significant promise of being developed in the near future, could become a meaningful component to address the overall I-70 Mountain Corridor capacity and mobility needs identified in the programmatic Environmental Impact Statement.

Description of Transit Options

Potential reasonably available (defined as either existing and in service or promising as characterized by the existence of a prototype or substantive research) public transit applications were culled from various sources within the Transportation Research Board (TRB) of the National Academy of Sciences, Jane's World Railways, Jane's Urban Transport Systems, The American Public Transportation Association (APTA), the Association of American Railroads (AAR), the Federal Transit Administration (FTA), and the Federal Railroad Administration (FRA). Additional promising technologies were identified by the technology proponents and in most cases have not been tested or verified under real-world operating conditions.

Once the universe of potential applications had been identified, an assessment was conducted to assure that they were capable of operation safely in the corridor considering the unique physical and environmental demands present. Given the nature and length of the I-70 Mountain Corridor, only fixed guideway and/or rubber tired system that utilize enclosed, lighted, and climate controlled passenger compartments are included in the description of reasonable alternatives presented for consideration. Additionally, potential systems must be capable of traversing the 127 mile corridor from C-470 to Dotsero in less than 3.5 hours (an average speed of about 35 miles per hour) in order to be considered a reasonable alternative.

This initial prescreening eliminated a number of short haul or specialty systems that would clearly be inappropriate in the corridor, including escalators, moving sidewalks, funiculars, aerial tramways, and gondolas. As a result, 31 reasonable technology options have been identified that meet the minimum requirements for operation in the corridor. These 31 options can be consolidated into five general groups having similar characteristics and attributes. These five transit groups are:

- Rubber tired transit (bus based systems)
- Automated guideway transit
- Rail transit
- Passenger railroads
- Advanced guideway systems

These five groups, and the 31 options within these groups, will be identified and generally described in the following section. Presentation of these options against the defined screening criteria will also be discussed later in this report.

The types of transit applications that could be utilized in the I-70 Mountain Corridor can be generally categorized into two major technology systems, rubber tired transit (buses) and fixed guideway transit. Each application has a number of options involving the type of propulsion, operational characteristics, and physical attributes. Within the rubber tired transit category, four major groups with fifteen options have been identified. Within the fixed guideway category, four major groups with sixteen options have been identified. Descriptions of these groups and options follow:

<u>Rubber Tire Transit (Bus based)</u>

Options to utilize buses in the I-70 Mountain corridor consist of a number of separate configurations of infrastructure and vehicles. In this report the term “bus” is defined to mean any self-powered vehicle designed for commercial use and capable of operating on state roads carrying in excess of six passengers. Fuel may be diesel, gasoline, compressed natural gas (CNG), propane, or other available alternate fuels. Buses using electric propulsion are referred to as Electric Trolley Buses (ETB) and buses able to use either electric propulsion or self-generated power are referred to as Dual Mode Buses (DMB). All buses are assumed to be traditional over-the-road coach designs suitable for long distance travel. Smaller buses and vans could also be utilized to supplement proposed services, especially as part of the feeder and distribution systems that will be required to serve any fixed station locations that may be constructed in the corridor. Various implementation versions of this application are discussed below.

Bus in Mixed Traffic

Operation in mixed traffic means that buses are commingled with regular traffic on I-70. Under this option, buses operate in the same general purpose travel lanes as trucks and automobiles throughout the I-70 Mountain Corridor. Buses would operate from pick-up/drop-off points in Denver or from park and ride lots near the I-70 corridor. Capacity of this option is essentially tied to the capacity of the general-purpose I-70 travel lanes. Buses would have no special operating advantages and general traffic conditions along with mountain grades would limit speeds.

Bus in HOV

Operation in High Occupancy Vehicle (HOV) lanes refers to buses operating in special traffic lanes that are intended for buses, car pools, and any vehicle carrying a minimum number of passengers set by the HOV operator (usually 2 or 3). HOV lanes may be either a regular highway lane distinguished with specially painted lines, symbols, and signage; or a segregated roadway separated by barriers and utilizing special access ramps; or some combination of both marked and segregated roadways. A single HOV lane may be managed in such a way as to provide travel in the peak direction only, with buses returning in mixed traffic. Multiple HOV lanes may be constructed in order to provide expedited travel simultaneously in both directions. Buses in segregated HOV lanes can be expected to operate at or near posted speed limits, restricted only by grades, HOV traffic congestion, and/or unusual circumstances. Buses in marked HOV lanes are more prone to traffic disruptions as drivers caught in stalled traffic in the regular lanes will often illegally enter marked HOV lines by crossing over the painted lines. This severely limits the speed at which the bus operator can safely pass stalled traffic in the adjacent travel lanes.

Options for implementation under this general category are:

- Bus in marked HOV lane – peak direction only
- Bus in marked HOV lane - both directions
- Bus in segregated HOV lane - peak direction only
- Bus in segregated HOV lane - both directions

Bus in Separated Transitway

A transitway is a completely separate roadway limited to transit vehicles only. A transitway could be constructed either in the median of I-70 or as a separate parallel roadway. As with the HOV alternatives, a single lane transitway could be constructed and managed in such a way as to provide travel in the peak direction only, with buses returning in mixed traffic. Multiple lane facilities could also be constructed in order to accommodate travel in both directions at the same time. Buses can be expected to operate at or above the posted limits for I-70 (since transitways are only utilized by professional drivers, speed limits can be set higher than for general traffic lanes). Mountain grades will still limit traditional bus performance, but travel speeds for DMBs or ETBs operating in a transitway would not be impacted by the grades due to their ability to draw whatever power is needed from their electric feeders. A relatively new variant of the "bus in transitway" approach to ground transportation is Bus Rapid Transit (BRT). This concept, in which buses only operate between fixed stations in the transitway (similar to a rail system), is gaining popularity and will be examined as well. Options for implementation under this general category are:

- Bus in transitway - peak direction only
- DMB in transitway - peak direction only
- Bus in transitway - both directions (includes BRT examination)
- DMB in transitway - both directions (includes BRT examination)
- ETB in transitway - both directions (includes BRT examination)

Bus in Guideway

In this option, a separate roadway limited only to transit vehicles with special guideway attachments would be constructed in the median of I-70 or as a separate parallel roadway. These special guideway attachments reduce lane width requirements and allow for a higher speed operation. These buses operate normally outside the guideway. As with the HOV and general transitway alternatives, a single lane guideway could be managed in such a way as to provide travel in the peak direction only, with buses returning in mixed traffic. Multiple lane facilities could also be constructed in order to accommodate travel in both directions. Buses can be expected to operate at or above the posted limits for I-70 (since guideways are only utilized by professional drivers and have built-in steering control, speed limits can be set significantly higher than for general traffic lanes). Mountain grades will still limit traditional bus performance, but travel speeds for DMBs or ETBs operating in a guideway would not be impacted by the grades due to their ability to draw whatever power is needed from their electric feeders. Guideways have the additional advantage that electric buses can be powered from an unobtrusive 3rd rail arrangement rather than the traditional overhead wire design. BRT variations will also be examined for guideways. Options for implementation under this general category are:

- Bus in guideway - peak direction only
- DMB in guideway - peak direction only
- Bus in guideway - both directions (includes BRT examination)
- DMB in guideway - both directions (includes BRT examination)
- ETB in guideway - both directions (includes BRT examination)

<u>Fixed Guideway Transit</u>

Like rubber tire transit alternatives, fixed guideway transit (FGT) alternatives consist of a variety of separate configurations of infrastructure and vehicle type. These systems can be exclusively divided into four distinct categories. Within those categories are a number of implementation options for various track configurations, propulsion types, and operating characteristics. Due to the nature of fixed guideway operations, a collector/distributor system will be needed to shuttle between FGT stations and key origins/destinations along an I-70 corridor line. It is anticipated that this system would take the form of a rubber tired bus feeder network in both the Denver area and in numerous mountain destinations. Various implementation versions of this application are discussed below.

Automated Guideway Transit

These systems have the common characteristic that they provide service without a human operator. Their guideway therefore must be completely protected to ensure that the automated vehicles cannot contact people, automobiles, or other obstacles in the guideway. For this reason they generally operate only short distances and are considered urban systems. The Federal Railroad Administration (FRA) does not regulate them. They can be operated using conventional rail transit steel wheel vehicles, over rubber tires with a guide mechanism, or on a monorail.

Automated Guideway Transit systems in airports are often referred to as APM (Airport People Mover) systems. Automated Guideway Transit systems used for downtown circulation are often referred to as DPM (Downtown People Mover) systems. DPM systems are currently operating in Detroit, Miami, and Jacksonville. Automated Guideway Transit used in universities (Morgantown), hospital campuses (Duke), casinos (Las Vegas & Reno), amusement parks, and other institutions are usually referred to as either a people mover or by the technology used (i.e.: the monorail, the tram, the shuttle). Automated Guideway Transit technology has also been used for general urban circulation, operating like a subway or metro system. Only one example of this technology exists in North America as an automated system operating outside a downtown area and that is in Vancouver, BC.

Some Automated Guideway Transit systems have the ability to operate on multiple routes on either a preprogrammed schedule or on a demand basis determined by the rider. These systems are referred to as Personal Rapid Transit (PRT) or Group Rapid Transit (GRT). Only one true PRT system is in operation at this time. It is an experimental system built in 1974 in Morgantown, WV. It provides service to a large university campus. Riders select their destination like floors on an elevator. Each small car carries the rider and accompanying parties directly to the station desired, bypassing any other stations along the way. A complex GRT system was also built about the same time at DFW airport. It has numerous car destination groupings, but no rider control.

Automated Guideway Transit can be cable hauled, powered by electric traction, or utilize linear induction motors. The complexity of Automated Guideway Transit increases substantially when more than one vehicle can operate on the same guideway. Simple cable hauled systems handling only one vehicle per guideway are operated using common elevator technology. When more than one vehicle is on the guideway, a sophisticated signal system is necessary to provide safe separation between the vehicles and to control braking and acceleration. Since cable hauled systems cannot be used for long distances or with multiple vehicles on the same guideway, the propulsion choice for the I-70 Mountain Corridor is limited to electric traction and linear induction motors. The choice of guideways can be conventional rail, concrete deck, or monorail. Only certain combinations of the above are available. Either double guideways or single guideways with passing zones can be utilized.

Options for implementation under this general category are:

- AGT using conventional rail with electric traction on single track or double track
- AGT using conventional rail with linear induction motor on single track or double track
- AGT using concrete guideway with electric traction on single guideway or double guideway
- AGT using monorail with electric traction on single beam or double beam

Rail Transit

Options to utilize rail transit in the I-70 Mountain corridor consist of either light rail or heavy rail transit systems. Each type of system can be constructed as a double-track line or as a single-track line with passing sidings. Either electric or diesel propulsion systems are available. The tracks can be located in the median of I-70 or on a parallel alignment, diverging only for heavy grades or to serve off line stations. In this report the term "Rail Transit" is defined to mean any conventional rail vehicle designed to operate on tracks not connected to the national railroad network. These systems, when operated in an "urban" area, are exempt from Federal Railroad Administration (FRA) regulation.

Light Rail Transit (LRT) and Heavy Rail Transit (HRT) systems are typically operated with either overhead wire or third rail electric propulsion. Diesel propulsion is also available for either mode, which is referred to as a Diesel Multiple Unit (DMU) operation. LRT vehicles, unlike HRT vehicles, can if necessary operate on tracks in city streets along with motor vehicle traffic.

High capacity HRT systems must operate only on exclusive rights-of-way due to their large vehicle size, long train lengths, their inability to brake and accelerate within motor vehicle tolerances, and (often) the presence of a ground mounted electric third (power) rail. They do have many more options for power pick-up and automation than LRT systems but represent one of the highest costs per mile to construct. They are typically built solely with high level boarding platforms and the vehicles are usually custom built for each system. AGT systems that use operators, such as the Scarborough Line in Toronto, are really HRT systems and will be examined under this category

LRT vehicles meet all highway operating standards for braking, acceleration, directional turn signals, and sight distances from the operators position. Usually, though, these systems are operated on either a reserved roadway median or an exclusive right-of-way.

LRT systems have been expanding rapidly around the country due to their flexibility, relative low cost, and their widely available equipment and technology. LRT vehicles can utilize either low level or high level boarding platforms. Newer low-floor versions are also available to speed street level boarding. Vehicles are available from many suppliers and are often built to standard specifications.

Conventional rail transit systems are limited to a maximum gradient of about 6%. Rack systems have been used to supplement grade-climbing capability in many European systems and could be used to overcome some of the highest grades on the I-70 Mountain Corridor.

Options available for implementation under this general category are:

- Diesel LRT on single or double track
- Electric LRT on single or double track
- Diesel HRT on single or double track
- Electric HRT on single or double track

Passenger Railroads

Options to utilize Passenger Railroads in the I-70 Mountain corridor consist of six separate configurations of infrastructure and rolling stock. In this report the term "Passenger Railroads" is defined to mean any conventional rail vehicle operating on track connected to the national railroad network. These systems are regulated by the Federal Railroad Administration (FRA).

Passenger Railroads take on many forms but utilize common vehicles and operating practices, which allows for an evaluation among only those items that truly differentiate the group. Passenger railroads used in service between suburban areas and major cities are identified as Commuter Rail (CR) systems. Passenger Railroads used for intercity service utilize the same basic locomotives and cars (with slightly modified interiors). High speed rail systems are a variant of intercity service that uses higher performance equipment but still with the same basic characteristics as other passenger operations (with the exception of tilt-body trains which can round corners at higher speeds than would otherwise be acceptable for conventional services).

Passenger rail trains may be hauled by diesel locomotives or electric locomotives. The trains may also be made up of multiple unit cars, each with their own diesel or electric traction motors. When utilizing diesel propulsion these trains are often referred to as Diesel Multiple Unit (DMU) or their former name of Rail Diesel Car (RDC). Note the DMU term is also used for similar rail transit equipment, which frequently causes confusion. When utilizing electric propulsion these trains are often referred to as Electric Multiple Unit (EMU). Electric power for passenger rail trains can be delivered through overhead catenary wires or a third (power) rail.

Conventional railroad trains are limited to a maximum gradient of about 6%, although they are typically expected to operate with a maximum of 2% grade on most mainlines (although there are many exceptions). Rack systems have been used to supplement grade-climbing capability in Europe, but none have been tested nor approved for use in the United States for general passenger railroad use.

Passenger rail trains and multiple unit train cars can utilize either low level or high level boarding platforms. Stations are required for boarding and alighting. These systems are very flexible, as they are able to operate on both new alignments as well as large amount of existing trackage that can shared with freight trains. Locomotives and passenger rail cars are available from many suppliers.

Options available for implementation under this general category are:

- Diesel locomotive-hauled trains on single or double track
- Electric locomotive-hauled trains on single or double track
- DMU trains on single or double track
- EMU trains on single or double track

Advanced Guideway Systems

Unlike the time tested and easily available systems listed above, the Advanced Guideway Systems group represents those systems undergoing research and development and may not currently be available for testing and evaluation. In recent years, most ground transportation research has been focusing on two types of magnetic levitation (maglev) systems that can be used for a new generation of high-speed ground service. In addition, an older mode primarily used for transit applications, the monorail, has been proposed in various forms for higher speed intercity service.

The monorail concept utilizes a single elevated beam to carry a train over any ground-based obstructions. Vehicles can ride above the beam, hang from the beam, or run astride of the beam. The concept has been in operation since the 1950s in amusement parks, downtown circulators, and airport AGT systems. In Japan, some monorail systems are used between downtown areas and airports.

Monorails are operated essentially as Heavy Rail Transit since they are grade separated and cannot run in mixed traffic. They have many of the attributes and limitations of Heavy Rail Transit. Propulsion systems available for monorail trains use either conventional electric traction motors or a newly proposed linear induction motor system. Vehicles can be operated on the monorail using either rubber tires or steel wheels.

Maglev systems have been under development since the 1960s. Two types are being actively tested: (1) a German attraction based design where the magnets on the underside of the track are attracted to electromagnets on the car, which are used to levitate the car for high speed running and (2) a Japanese repulsion based design where the magnets on the trough-type guideway push the car away from the sides and bottom to levitate it for high speed running.

Options available for implementation under this general category are:

- Monorail using electric traction
- Monorail using linear induction
- Maglev using attraction based levitation
- Maglev using repulsion based levitation

Level 1 Screening Process and Criteria

The issues to be addressed in the first level screening are Safety, Capacity, and Mobility.

- Safety addresses the conformance of the proposed technology to industry safety standards, the probability of vehicle accidents, the passenger injury rate per mile traveled, and the impacts on bystanders or other users in the corridor. For the first level screening, this criteria has been defined as the ability of the transit option to respond to and adequately handle issues of passenger safety and security, including being able to identify and avoid potential problems. This is measured by whether or not there is an operator physically operating the vehicle in this remote corridor to deal with incidents or issues as they arise.

- Capacity addresses the impacts to the extent and duration of existing and future traffic congestion on the I-70 Mountain Corridor. For the first level screening the transit option must have sufficient capacity to have a meaningful impact on congestion, either in number of vehicles removed from the roadway or by measurably shortening the length of congested periods. This is measured by the theoretical maximum capacity of each transit option.

- Mobility addresses the potential and actual movement of people and goods within the corridor. This can be evaluated by considering the total volumes of people and tons of freight moving through the corridor, the length of time necessary to traverse the corridor, the level of service to and access of local corridor communities, and the availability of appropriate and adequate transportation options within the corridor. For purposes of the first level screening, this has been defined and the ability of a transit option to maintain an average vehicle operating speed and achieve a total travel time (which includes loading and dwell times) reasonably comparable with the automobile. In addition, a judgment as to the likely level of access to corridor communities that can be achieved by each option is included.

In summary, the first level screening process is focused on identifying those transit options that can operate safely in the corridor, have a meaningful impact on congestion, and provide improved mobility for people and goods traveling in the corridor.

Appendix A identifies the operational characteristics relevant to the above-described criteria for the 31 options identified earlier. The specific criteria that have been considered are:

- Maximum theoretical capacity in passengers per hour
- Percent of I-70 Mountain Corridor communities that could reasonably be served
- Average vehicle speed for the technology
- Corridor travel time including boarding and dwell times for ten intermediate stations
- Meets industry safety standards and utilizes an on-board vehicle operator

The maximum theoretical capacity of a transit option is determined by multiplying the average speed of the vehicle by the maximum capacity of vehicle and by the number of vehicles that can be operated within the travelway within a set time frame. The average speed is calculated by determining the maximum possible speed over any one travelway segment and then adjusting for grade limitations of the vehicle's powerplant, congestion from other vehicles, clear time for signal systems, station dwell, and off-line station access time. The segments are aggregated and the result is used for general comparison against other options. It should be noted that this method significantly overstates real-world capacity, but is valid for comparison among options. It should not be used to predict actual line capacity, as that modeling is a complex and time-consuming task that is not appropriate at the screening level of analysis.

Level 1 Screening Recommendations and Results

The I-70 Mountain Corridor presents a number of challenges to designers of transit alternatives. The grades limit vehicle performance. The curves limit speed. The right-of-way size limits the land available for infrastructure. The mountains limit the choice of power systems. The remoteness limits automation solutions.

In order to determine appropriate options for a more detailed evaluation of possible applications for the I-70 Mountain Corridor, it is necessary to screen the various options identified above in order to determine which have the greatest potential to address issues of concern in the corridor.

Many bus transit options include the possibility of operating along a special lane or guideway in the direction of peak traffic and having vehicles returning or operating in the non-peak direction use the regular travel lanes. The alternative is to build separate facilities for each direction of travel. Analysis of I-70 travel demand shows that during peak periods, 80% of the traffic is traveling in one direction, but only 20% in the opposite direction. This strongly supports consideration of building reversible flow transit facilities instead of dual-flow facilities. Accordingly, only peak direction facility options were recommended to be retained for further screening by the project team. However, at the request of the advisory committees, all RTT options will advance into the second level screening.

The issue of operation over a single track (or guideway) with passing sidings or a double track (guideway) structure is universal among the fixed guideway transit options. Single or double operation affects average vehicle speed and system capacity. The frequency and length of passing facilities significantly impacts the operational characteristics of the system. Since all of these systems have the same general impact from single or double operation, all systems will initially be compared using single track (guideway) scenarios with passing facilities assumed to be located at reasonable intervals consistent with the peak travel nature of this corridor. During later option refinement, the issue of single or double operating plans will be further evaluated.

The number of corridor communities served by a proposed system is a function of the proposed technology limitations on curve speed, acceleration/deceleration capabilities, and reasonable alignment assumptions. All of the transit options listed herein are able to operate over some portions of the existing I-70 Mountain Corridor alignment. Extreme grade limitations in some areas would force some options onto alternate alignments. Other systems, because of very high speed operation, are unable to follow the existing I-70 alignment due to the number and degree of curvature. These systems would most likely have to bypass some I-70 Mountain Corridor communities to operate at their designed speed. The number of communities that would have to be bypassed were expressed as a percentage of the total number of communities along the corridor and shown on Appendix B. High speed MagLev is one such system that would be unable to serve many of the communities along the corridor. The project team had initially recommended that this system be screened from further consideration. At the request of the advisory committees, a low speed version of the technology will be retained for further analysis.

Safety is paramount in all transportation operations. All of the transit options considered for the I-70 Mountain Corridor meet their industry requirements for safe operation. There are small differences in the passenger accident rate and the accident rate for right-of-way trespassers and for vehicles at grade crossings between these transit options, but not enough to warrant screening out any of these viable modes. One transit option, Automated Guideway Transit (AGT), by its very nature is designed to operate without an operator physically at the controls. These systems are intended for operation in restricted environments where emergency assistance is available on short notice. Typically this protection is provided in urban areas by fire, police, and medical personnel that can be quickly assembled at a service disruption and provide passenger evacuation and assistance. The remoteness and physical difficulty of accessing an AGT right-of-way in many parts of the I-70 Mountain Corridor makes this option unsuited to passenger safety needs. Due to this basic incompatibility, AGT systems are not recommended for further consideration, although the technology used for the longer distance versions of these systems will be evaluated as part of the Heavy Rail Transit and Monorail technologies. AGT with an operator (which is arguably an HRT system) is currently in operation in suburban Toronto.

ALTERNATE ROUTES

In order to determine if a particular alternate route will provide sufficient benefits to I-70 to warrant further analysis, the two basic criteria were applied at the first level of technical evaluation. These criteria, by the very nature of the first level screening process, are qualitative in nature with sufficient quantitative support to justify the basic conclusions. Subsequent levels of screening will incorporate increasingly more detailed quantification. The intent of the first level screening, therefore, is to eliminate alternatives which clearly do not meet the purpose and need of the I-70 PEIS.

Description of Alternate Routes

Many of the alternate routes may provide significant benefits to Colorado residents and the motoring public, not in terms of improvements to I-70, but rather in terms of other corridors or travel sheds. As a result it might be appropriate that they be considered further, perhaps for inclusion in the State-wide Transportation System Plan for example. However, if the potential benefits of an alternate route do not adequately address the problems along I-70, it is not a viable solution for the corridor.

Sixteen alternate routes have been defined which connect the central Rocky Mountains with the four principal cities along the front range. Three alternate routes connect to Fort Collins, seven with Denver and DIA, four with Colorado Springs, and two with Pueblo. All of these corridors are, in varying degrees, important elements of the Colorado state-wide transportation network. In fact, many of these corridors are planned to be upgraded while other corridors are increasing in statewide significance.

However, if the alternate route does not address the criteria of the “significant volume” and “motorist benefit” as used in the first level screening criteria, it is not responsive to the purpose and need of the I-70 PEIS and should not be considered as a feasible solution to the problems in the I-70 corridor.

Level 1 Screening Process and Criteria

The criteria used for the first level screening of the alternate routes are:

- First, the alternate route must have some reasonable potential to divert a significant volume of traffic off of the I-70 corridor.

- Second, the alternate route must provide a discernable benefit to the motorist to encourage them to divert from I-70. Such a benefit may be a shorter travel distance but, more typically, involves a reduced travel time, especially during peak demand periods.

The focus of those two criteria, when taken together, is to insure that the purpose and function of the alternate route is oriented toward resolving traffic problems on I-70. This is necessary to meet the objectives of the "Purpose and Need" statement for the I-70 PEIS.

Along the 170-mile extent of the front range between Fort Collins and Pueblo, it is estimated that the greater Denver metropolitan area (including DIA) is associated with approximately 90% of the traffic on I-70. This means that those alternate routes primarily associated with Fort Collins, Colorado Springs, and Pueblo will not attract sufficient traffic off of I-70 to meet the purpose of the I-70 PEIS or the needs of the I-70 corridor.

Level 1 Screening Recommendations and Conclusions

The seven alternative routes between the Denver metropolitan area and the central Rocky Mountains all involve longer travel distances than does a comparable trip along I-70. In addition, travel times via all seven alternate routes are greater than via I-70 during off peak travel periods.

However, during peak travel periods, two alternate routes may be able to provide competitive travel times with the I-70 corridor. These alternate routes are:

- A modified version of Alternate Route 5 which utilizes SH 58, SH 93, and SH 72 (to Rollinsville) in conjunction with a new tunnel (paralleling the Moffat Tunnel) eventually connecting to Winter Park.
- Alternate Route 8b which utilizes US 285 to Jefferson in conjunction with a new tunnel under Georgia Pass connecting to SH 9 north of Breckenridge and continuing onto Frisco and I-70.

Further, analyses are required to determine the feasibility of these two alternate routes. Such a feasibility analysis will include a more detailed analysis of travel times and traffic diversion along with consideration of costs and potential impacts.

Therefore the results of the first level screening of alternate routes are:

- Alternate Routes 1, 2, 3, 10a, 10b, 11, 12, 13a and 13b are not carried into the second level evaluation because they have virtually no potential to divert any significant traffic volume off of the I-70 corridor. Without such traffic diversion, the purpose and need of the I-70 PEIS is not served.
- Alternate Routes 4, 6, 7, 8a, and 9 are not carried into the second level evaluation because they do not provide any travel benefit to the motorist in terms of reduced travel distance or reduced travel time. Without such travel benefits, no trip diversion from I-70 will occur and the purpose and need of the I-70 PEIS is not served.

- More analysis is required to better understand the feasibility of a modified Alternate Route 5 and Alternate Route 8b.

Alternate Route 5 (modified) and 8b will be carried into the second level screening.

AVIATION

Potentially reasonable air transportation alternatives were culled from various sources including the Federal Aviation Administration's (FAA) Airport Capacity Branch, FAA's 1999 Airport Capacity Enhancement Plan, FAA enplanement data, aviation directors and airport managers of the mountain corridor airports, and AirNav data. Four promising alternatives were identified from the I-70 Mountain Corridor Major Investment Study Alternatives Analysis Report and carried forward. Two were added for consideration in this phase.

Description of Aviation Alternatives

The following alternatives are predominantly capital improvement oriented and it is important to consider the realm in which the more capital-intensive alternatives could occur. For example, many airports in Colorado are under the direction of local airport authorities, county commissioners and city elected officials. Compared with some other states, historically, the planning and implementation of Colorado's transportation systems have been heavily weighted toward its highway system rather than its air transportation system. The Colorado Department of Transportation (CDOT), who enjoys a good working relationship with the Federal Aviation Administration (FAA), conducts planning for alternative modes and aeronautics. However, its aviation role and determining the siting of new airports or improvements to existing airports, primarily has been one of a coordinating agency, as opposed to a lead agency.

It also is important to note, particularly with regard to the final alternative, which is more market-based, that the cost and implementation of travel demand management strategies such as "seat guarantees" and flight scheduling fall within the realm of private sector entities such as the airlines and resort operators. A strong partnership with the local community's chambers of commerce and public sector entities are critical, nonetheless. The policy needed to implement these strategies must evolve from a process that will result in buy-in and willingness on the part of the stakeholders to financially support the strategies.

The six alternatives are described below. Intentionally, the descriptions are designed to frame the issues and avoid conclusions about the viability of the alternatives until input can be sought from the citizen-based Mountain Corridor Advisory Committee and the staff-based Technical Advisory Committee.

<u>Alternative 1: Develop new airports in the mountain corridor</u>

This alternative provides the siting and construction of entirely new airports at appropriate locations in the corridor, with all new terminal, airfield and landside facilities. The airports would be designed to accommodate commercial service and allow access to the national air system and potential all-weather capability very similar to Aspen-Pitkin County/Sardy Field (ASE), Eagle County Regional Airport (EGE), Walker Field (GJT) and Yampa Valley Regional Airport (HDN).

With regard to the capacity criterion, obviously the new airport(s) would be designed given sufficient and appropriate land in the corridor where the terrain is relatively flat and reasonably unconstrained. It is also presumed that mobility/accessibility would be addressed as the airport would be sited in proximity to major activity centers. Airport safety could be presumed to be better as larger airports with greater runway capacity and air traffic control ability are safer compared to smaller airports. Extremes of weather and terrain are unchanged, but larger aviation facilities and enhanced technologies can accommodate larger aircraft that are better equipped to handle these challenges.

Nevertheless, aviation experts have indicated that commercial service capacity is not an issue in the mountain corridor. In fact, there is a shortage of general aviation facilities. This issue is expanded upon in the description of similar alternatives below.

<u>Alternative 2: Develop heliport and short take-off landing (STOL) facilities</u>

This alternative provides new or revamped aviation facilities that could accommodate vertical flight aircraft such as rotocrafts, tiltrotors and tilt-wing aircraft. These facilities could be constructed at existing commercial service and general aviation airports but would require exclusive heliport pads independent of the runways. Special hangars and tie-downs also would be necessary for storage of these types of aircraft.

It is likely that greater capacity and the ability to meet travel demand would not be realized, as vertical flight aircraft tend to be small and hold fewer passengers. Additionally, vertical flight aircraft operate at half the speed of conventional aircraft and are noisier during take-off and landing. Likewise, the impact on mobility, again intuitively, would be less as these types of aircraft hold fewer passengers, thus diverting an insignificant number of cars from the highway.

With regard to safety, vertical flight aircraft, as compared to conventional large aircraft, are less equipped to deal with the extremes of mountain weather conditions such as ice, snow and wind.

<u>Alternative 3: Improve existing commercial service aviation facilities</u>

This alternative includes a variety of improvements to the Aspen-Pitkin County/Sardy Field (ASE), Eagle County Regional Airport (EGE), and Yampa Valley Regional Airport (HDN) airports that would allow them to accommodate greater commercial airline service. These improvements include longer runways and the addition of crosswind runways that would allow more planes to land under acceptable wind conditions.

Greater capacity could indeed accommodate travel demand and be expected to alleviate corridor highway congestion. Mobility could be expected to be enhanced, and accessibility and proximity to activity centers has been proven. Safety could be expected to be improved as the existing commercial service airports are designed to accommodate large conventional aircraft of the type suitable for regional airports (e.g., BAE 146 and

737s) and thus are better equipped to deal with the challenges of mountain weather and terrain.

However, as mentioned previously, capacity at commercial service airports is sufficient, if not abundant.

Additionally, advances in aircraft technology and performance offer greater capacity as more aircraft can be accommodated during more types of weather. For example, higher output engines with greater climb capabilities allow aircraft to operate at higher altitudes where previously long runways were needed to obtain the lift necessary for flight.

The Federal Aviation Administration (FAA) has undertaken a long-term effort known as the National Airspace System Modernization to accommodate air traffic growth and to meet the increased safety and efficiency demands placed on the air traffic control system. These proposed improvements include:

- Increased ability of users to fly more direct routes
- Expanded surveillance coverage
- Clearer, less congested, air/ground communications
- Optimized flight profiles
- More efficient sequencing of air traffic
- Accurate and timely weather and traffic information in the cockpit

"Free flight" is the impetus for these changes. Free flight offers pilots greater flexibility and discretion in determining routes and speeds. As the move toward free flight continues, NAS users will face fewer restrictions in their flight operations, resulting in more choices, fewer delays, and lower operating costs.

Capacity – at both commercial service and general aviation airports (because GA will benefit greatly from NAS Modernization) -- may very well be "grown" through technological advances and therefore diminish the need for infrastructure improvements or new facilities. And, absorbing that "growing" capacity may have more to do with market-based strategies such as those outlined in Alternative Six below.

<u>Alternative 4: Improve existing general aviation facilities to accommodate commercial operations</u>

This alternative includes improvements to Lake County Airport in Leadville (LXV), Glenwood Springs Municipal Airport (GWS), or Kremmling Airport (formerly McElroy Field) (20V). Similar to improvements to existing commercial service airports, improvements to general aviation facilities include lengthening runways, strengthening runway pavement, adding cross-wind runways, adding IFR (instrument flight rules) or precision instrument landing capabilities, and staffing air traffic control towers.

Similar to improving commercial service airports, the increased capacity could be expected to accommodate travel demand in the corridor and mobility could improve as more cars are diverted from the highway to air transportation. Airports with better runway facilities and enhanced technologies can accommodate larger aircraft and thus better deal with the vagaries and hazards of mountain weather.

Nevertheless, capacity of commercial service airports is not the issue. Instead, commercial service airport capacity is underutilized eight months out of the year as most facilities are designed for the peak winter season. Second, there is a shortage of general aviation facilities, those facilities typically used by air taxi services (with four to six passengers), recreational flyers and private charters. At least one of the commercial service airports in the mountain corridor is considering development of its GA facilities, not to compete with nearby GA facilities, but to accommodate the growing demand for GA facilities.

The Federal Aviation Administration (FAA) has developed a strategic plan called the General Aviation Roadmap to stimulate the production of safe, affordable and fast GA aircraft over the next 25 years. This would greatly enable "doorstep-to destination" travel (at four times the speed of highway travel) to 25 percent of the nation's suburban, rural and remote communities in 10 years. Improvements such as those mentioned above are necessary to accommodate this growth; real-time graphical weather and traffic information and precision instrument (IFR) approaches, in particular.

Alternative 5: Develop Walker Field into a western slope regional hub airport

This alternative includes expansion of the Walker Field airport to provide access to the national air transportation system, similar to Colorado's two existing hub airports, Denver International Airport (DIA) and Colorado Springs (COS).

Similarly, Walker Field's runways would be lengthened to twice their existing lengths and larger hangar facilities and terminal amenities would be added to accommodate greatly increased air passenger activity. Capacity would be enhanced and the larger airport could offer a poor-weather alternative to the smaller regional airports (ASE, EGE and HDN). Traffic congestion between Glenwood Springs and Grand Junction is also greatly diminished in this section of I-70 and much of the traffic previously travelling from DIA, ASE, EGE or HDN would be coming east-bound through currently less congested stretches of the highway.

However, Walker Field once was a gateway or hub airport, and its function in that respect has changed greatly. Until the development of ASE, EGE and HDN as regional commercial service airports, Walker Field served as a gateway airport to these resort communities and a gateway airport alternative to DIA. It is likely that Walker Field will not resume its position as a hub or gateway airport in light of the capacities of ASE, EGE and HDN, as well as technological advances that make it increasingly safer to use the smaller, regional commercial service airports.

Additionally, shifting the transport of goods from truck to aircraft historically has been deemed to have too insignificant an impact on highway congestion given the small increase in capacity relative to the enormous cost (e.g., one plane carries about as much cargo as one truck). Nevertheless, state aviation officials have cited Walker Field as ideal for increased cargo distribution to alleviate cargo operations at HDN, EGE and ASE.

Alternative 6: Develop aviation systems management and subsidy programs

Includes scheduling techniques combining two or more destination markets on the same flight and the use of seat guarantees or subsidies to encourage air travel.

This alternative is very similar to what is known as travel demand management (TDM) where a variety of strategies are implemented to encourage or discourage single-occupant-vehicle driving. An example would be the subsidization of vanpool seats by an employer or municipality to maintain a vanpool route. Empty seats are paid for or passenger fares are "bought down." In the case of aviation, similar market-based solutions, such as fare subsidies to air passengers (or "buying down" the cost of the ticket) or guaranteed revenue to airlines, are offered to encourage people to fly and to encourage airlines to continue otherwise unprofitable flights. In some cases, both incentives may be offered.

For years, "guaranteed seats" (also known as guaranteed revenue to the airlines) have been offered and the cost borne by the ski resorts to ensure airline service and routes into the mountain corridor airports. Only Eagle County Regional Airport (EGE) has been successful in weaning itself off of these types of incentives due in large part to less seasonal fluctuation and considerable growth in enplanements over the past ten years. EGE's location in the corridor directly off of I-70, compared with the remote locations of the other primary airports, contributes to its success as well.

The other mountain corridor airports continue to rely on subsidy programs and have begun strategizing ways in which they can involve summer-oriented activities (e.g., golf packages, conferences and conventions, rafting and bicycling trips) to bear the costs of summer time "guaranteed seats." This also would result in better year-round use of their airports. Consideration also has been given to involving the real estate community because of the burgeoning growth in second homes.

In addition to determining who should bear the cost of aviation subsidy programs, such programs also require constant analysis of the travel demand market. Each year, community leaders (comprising the resorts, chambers and local municipalities) engage in contract negotiations with the airlines to set the number of seat guarantees based on the previous year's lift ticket sales. Each dip in lift ticket sales (as Colorado has seen for two consecutive years now) weakens a community's bargaining power with the airlines.

Considerable discussion has taken place regarding the market's ability to bear the cost of air travel. Anecdotally, it has been learned that a family planning a ski vacation to the Colorado mountains already is incurring a large expense, and airfare is only one proportional piece of that expense which the family (or market) is willing to bear. Many experts tie this ability to bear the cost of a Colorado ski vacation to the nation's increasing economic wealth. However, similar to any market product or service, this "ability to bear the cost" will always be subject to price elasticity, which ski communities and the airlines grapple with each year as they negotiate "seat guarantees."

Increasingly, consideration also is given to trends relevant to the aging Baby Boomer population. For two consecutive years, lift ticket sales have declined in Colorado as skier numbers decline and vacationers access the Internet for vacation ski packages around the world. Tourism authorities have urged greater marketing (the state's tourism tax to fund promotion ended in 1994 and the newly re-established office has a budget which is only a third of its previous years' campaigns), in particular, to younger outdoor enthusiasts, such as snowboarders.

Another market-based strategy is the combining of two destinations into one flight. For example, an airline could make stops at Aspen-Pitkin County/Sardy Field (ASE) and Yampa Valley Regional Airport (HDN) and serve two destination markets. Flights from U.S. cities to destinations in Mexico are often combined in such a fashion (e.g., Cancun and Cozumel on the Yucatan Peninsula).

The combining of two destinations is enabled by advances in aircraft fleet. Increasing use of regional jet aircraft, known as RJs (also dubbed mini-757s), has resulted in a shift from large propeller-driven aircraft, the type often used at mountain corridor airports. These RJs accommodate 50-80 passengers and allow airlines to offer nonstop flights from large, international airports with markets of 4-5 million. As airlines extend their route structures to cities previously beyond the range of propeller aircraft, they serve nonstop markets previously too small for direct service and reduce the travel time in markets they already serve. The changeover from propeller to regional jet aircraft is expected to continue and accelerate, as passenger acceptance of jet aircraft has proven higher than for propeller aircraft. RJs are projected to contribute to an 87 percent increase in regional/commuter enplanements by 2010.

NAS (National Airspace System) Modernization benefits market-based solutions as well. For example, the ability to combine two destinations on one flight is enhanced as NAS Modernization offers greater route flexibility and improved planning for fuel- and time-efficient flight plans. Moreover, as modernization contributes to more choices and lower operating costs for airlines, it can be expected to benefit the air transportation consumer with more choices and affordable fares.

Level One Screening Process and Criteria

The criteria, as they are applicable to evaluating the aviation alternatives, are further described below.

<u>Capacity</u>

To determine the potential of an alternative to offer additional capacity that would meet the demand for mountain corridor travel, one integral question was posed regarding the feasibility of airport expansion or creation. In other words, each alternative was screened (where applicable) relative to the question: Is there sufficient and appropriate land available for construction and expansion? Additionally, consideration was given to what type of improvements are needed.

<u>Mobility</u>

Alternatives also were measured relative to their contribution to enhanced mobility and accessibility in the corridor. At this first screening level (as previously mentioned), mobility was intuitively evaluated as compared with its more typical application in transportation planning where a mode is evaluated for its quantitative impact on traffic congestion (e.g., the number of people in cars removed from the road). More importantly, while it is intuitive that greater air passenger travel would remove cars from the highway, accessibility to and from mountain corridor airports is critical to the viability of an airport. Therefore, with regard to an alternative's impact on corridor mobility, in the case of construction of new airports or expansion of existing airports, the question also was posed regarding reasonable proximity and accessibility to major activity centers in the corridor.

<u>Safety</u>
Finally, the alternatives were evaluated relative to safety for air passengers as mountain corridor airports accommodate greater air service activity. Similar to mobility, safety – which is typically applied to an alternative's ability to alleviate congestion and reduce highway accidents – was considered relative to the safety of the new or expanded aviation facility. In this case, safety was defined as airport safety by posing the question: Is the existing airport location (or general region intended for a new airport) free of major topographical and meteorological conditions that would hamper air activity expansion?

It is important to note that in the first level of screening, the criteria are used in the strictest sense without any regard for political acceptability or community values that will be applied later in the environmental assessment stage. For purposes of this first level screening process, the alternatives are evaluated in light of technological feasibility or logistical application. Moreover, the first level screening process is intended to *frame the issues*. This "framing of the issues" will shape the second level screening criteria and further fine-tune the process by which alternatives are carried forward.

Level One Screening Recommendations and Results

As mentioned previously, the alternatives are very capital-intensive with the exception of Alternative Six, which is market-based. Remarkably, given the current situation and absence of demand for greater airport capacity in the mountain corridor, alternative 6 appears to offer a feasible solution to encouraging, or maintaining air passenger travel. Clearly, technological advances will drive airport capacity and market-based strategies. Although alternatives 3 and 4 would offer additional capacity, enhance mobility within and accessibility to the corridor, and presumably improve safety, these alternatives are anticipated to be implemented regardless of the demand places on the I-70 Mountain Corridor.

APPENDIX A

TRANSYSTEMS CORPORATION CONSULTANTS

Mode	Capacity Psgr/Hr.	Percent Access to Corridor Communities	Average vehicle running speed (MPH)	Corridor Travel Time including Boarding and Dwell Time (Hrs)	Passenger SAFETY Operator on board?	Description of General Service Characteristics and Special Requirements
Rubber Tire Transit						"Bus" is defined to mean any self-powered vehicle designed for commercial use capable of operating on state roads carrying in excess of six passengers. Fuel may be diesel, gasoline, natural gas, propane, electricity or other alternate fuels.
Bus in Mixed Traffic						Buses are commingled with regular traffic on I-70 in the same general purpose lanes as cars and trucks. Speed is dependent on general traffic conditions and is limited by grades.
Bus in mixed traffic, both directions	2,459	100	38.5	5.09	Y	
Bus in High Occupancy Vehicle Lane (HOV)						HOV lanes refer to buses operating in special traffic lanes intended for buses, carpools, and any other vehicles carrying a minimum number of passengers. Speed is limited by HOV traffic conditions and grades.
Bus in HOV Marked Lane, peak direction	41,687	100	42.2	4.84	Y	
Bus in HOV Marked Lane, both directions	42,439	100	45.7	4.59	Y	
Bus in HOV Segregated Lanes, peak direction	46,637	100	47.5	4.17	Y	
Bus in HOV Segregated Lanes, both directions	50,835	100	49.2	3.75	Y	
Bus in Separated Transitway						A Transitway is a completely separate roadway limited to transit vehicles only. These can be single or multiple lane facilities. Buses would operated at or near the posted speed restricted only by grades or special circumstances. Bus Rapid Transit (BRT) is an approach that allows buses to essentially operate with the same characteristics as Light Rail Transit. Electric buses require overhead wires.
Bus in Separate Transitway, peak direction	55,361	100	44.7	4.01	Y	
Bus in Guided Transitway, peak direction	55,809	100	46.4	3.9	Y	
Hybrid Electric Bus (HEB) in Separate Transitway, peak direction	76,636	100	64.8	3.12	Y	
HEB in Guided Transitway, peak direction	72,589	100	51.2	3.64	Y	
Bus in Separate Transitway, both directions	57,144	100	52.3	3.59	Y	
Bus in Guideway						This option is a separate roadway with guideway attachments to control the direction and alignment of the buses. These attachments reduce lane width requirements and help maintain vehicle operating speed. These could be single or multiple lanes. Electric buses require overhead wires.
Bus in Guided Transitway, both directions	58,108	100	57.5	3.38	Y	
HEB in Separate Transitway, both directions	77,802	100	69.8	2.98	Y	
HEB in Guided Transitway, both directions	78,841	100	74.7	2.86	Y	
Electric Bus (EB) in Separate Transitway, both directions	77,802	100	69.8	2.98	Y	
EB in Guided Transitway, both directions	78,841	100	74.7	2.86	Y	

TRANSYSTEMS CORPORATION CONSULTANTS

Mode	Capacity Psgr/Hr.	Percent Access to Corridor Communities	Average Vehicle Speed	Corridor Travel Time including boarding and dwell time	Passenger SAFETY Operator on board?	Description of General Service Characteristics and Special Requirements
Fixed Guideway Transit (FGT)						FGT alternatives may be characterized by their means of support, guidance, propulsion, and/or control mechanisms. Due to the line-haul nature of these alternatives and the need for stations to board and deboard passengers, extensive RTT feeder and distribution services will be required at all station locations.

Automated Guideway Transit						These systems provide service without an operator; therefore the guideway must be completely protected. For this reason, these systems operated only within defined "urban areas" and only for short distances. The absence of an operator on board presents major safety and security concerns for passengers in a corridor of the length and remoteness of the I-70 environment.
Automated Guideway Transit (AGT) using Conventional Rail with Electric Traction	16,035	90	74.7	1.91	N	Rural nature of the corridor will make rescue and emergency response very difficult.
AGT using Conventional Rail with Linear Induction Motors	16,035	90	74.7	1.91	N	
AGT Concrete Guideway with Electric Traction	16,035	90	74.7	1.91	N	
AGT using Concrete Guideway with Linear Induction Motors	16,035	90	74.7	1.91	N	
AGT using Monorail with Electric Traction	16,035	90	74.7	1.91	N	
AGT using Monorail with Linear Induction Motors	16,035	90	74.7	1.91	N	
Rail Transit						Options for rail transit in the corridor consist of either light rail (LRT) or heavy rail (HRT) systems. LRT and HRT generally utilize electric propulsion, although diesel multiple units (DMU) can be a part of this group. LRT can, if necessary, operate on tracks in city streets with motor vehicle traffic. HRT differs from LRT by its requirement for an exclusive right-of-way.
Diesel Multiple Unit (DMU) on single track with passing sidings	4,912	80	53.1	2.76	Y	Overhead wires are required for electric propulsion. Could use RTD LRT for distribution in Denver.
DMU on double track	6,163	80	63.8	2.37	Y	
Light Rail Transit (LRT) on single track with passing sidings	12,681	100	58.3	2.39	Y	
LRT on double track	15,988	100	69.8	2.03	Y	
Heavy Rail Transit (HRT) on single track with passing sidings	20,481	90	62.3	2.24	Y	Heavy rail would be required to divert around Eisenhower Tunnel.
HRT on double track	25,937	90	74.7	1.91	Y	
Passenger Railroads						Passenger railroads are defined as any conventional rail vehicle operating on track connected to the national railroad network. These systems are regulated by the Federal Railroad Administration (FRA). Conventional railroads are limited to a maximum gradient of 6%, although they are usually designed to operate with only a maximum grade of 2%. AMTRAK, which operates in the corridor, is an example of this system. Could connect with existing track at Golden and Dotsero.
Diesel Locomotive Hauled Train on Single Track	13,525	80	53.1	3.13	Y	
Diesel Locomotive Hauled Train on Double Track	17,078	80	63.8	2.74	Y	
Electric Locomotive Hauled Train on Single Track	13,713	80	58.3	2.60	Y	
Electric Locomotive Hauled Train on Double Track	17,301	80	70.2	2.23	Y	
Electric Multiple Units on Single Track with Passing Sidings	16,938	80	62.6	2.45	Y	
EMU on Double Track	21,402	80	74.7	2.11	Y	
Advanced Guideway Systems						The most appropriate types of systems that are reasonably available for implementation in the corridor are monorail (existing and in service) and magnetic levitation (maglev) on which there are prototypes and extensive research. Maglev has severe curve limitations and would require extensive tunneling.
Monorail Aerial Structures	29,955	80	100.0	1.69	Y	
Magnetic Levitation Trains (Attraction Based)	40,284	20	178.9	1.12	Y	
Magnetic Levitation Trains (Repulsion Based)	40,817	20	259.2	0.91	Y	

APPENDIX B

Highway and Interchange Elements Family

Alternatives	Screening Criteria: Safety	Screening Criteria: Mobility	Alternatives Retained for Level 2 Screening
Adding Standard Lanes	Will the alternative reduce the following safety problems: • Roadway Geometry – Horizontal curves – Vertical curves • Accident Prone Areas – High number of incidents – Rock fall zones – Ice build–up/snow pack areas – Inclement weather areas	Will the alternative reduce traffic congestion at problematic areas? Problematic areas are defined as: • A low Level of Service (LOS E or F for 2000). LOS F occurs when uniform traffic flow cannot be maintained. The flow conditions are such that the number of vehicles that can pass a point is less than the number of vehicles arriving at that point. • Where there is extensive traffic delay caused by roadway geometry constraints (i.e., steep grades or lane drop areas).	P
"Smart" Widening			P
"Flex" Lanes *			P
Reversible Lane with Fixed Barrier			P
Moveable Barrier			P
Idaho Springs Parallel Route			P
Curve Smoothing *			P
Climbing Lane *			P
Tunnel Capacity Improvement			P
New Tunnel from Downieville to Silverthorne			P
Interchange Reconfiguration/Access Consolidation *			P
Local Access Improvement *			P
Structured Lanes (alternative concept)			P
Covered Lanes (alternative concept)			P
Structured lanes specifically for trucks *			P

* These alternatives are also considered Transportation Systems Management, which is specified under the Transportation Management Family.

Alternate Routes Family

Alternatives	Screening Criteria: Safety	Screening Criteria: Mobility	Alternatives Retained for Level 2 Screening
1 - Fort Collins to Wolcott via Walden (includes SH 14 and SH 131)	Does the alternative meet highway standards?	• Does the alternative route provide a shorter or equal to travel distance than a trip via I-70? • Does the alternative route provide a shorter or equal to travel time than a trip via I-70? • Does the alternative route have the potential to significantly reduce the traffic flow on an extended segment of I-70?	Screened out since travel time is not competitive with congested I-70 and travel distance is 20 miles more than I-70. Low percentage (1.9%) of travelers originating from the area does not meaningfully reduce the I-70 congestion.
2 - Fort Collins to Wolcott via Kremmling (includes US 34)			Screened out due to the low percentage (1.9%) of travelers originating from the area.
3 - Fort Collins to Copper Mountain via Kremmling (includes US 34 and SH 9)			Screened out due to the low percentage (1.9%) of travelers originating from the area.
4 - Denver to Wolcott via Moffat Tunnel (includes SH 72, US 40, and US 34)			Screened out since travel time is not competitive with congested I-70 and travel distance is 20 miles more than I-70.
5 - Denver to Copper Mountain via Moffat, Berthoud and Jones Pass Tunnels (includes SH 72 and SH 9)			Screened out since travel time is not competitive with congested I-70 and travel distance is 20 miles more than I-70.
5a - Denver to Winter Park via Moffat Tunnel (includes SH 72)			P
6 - Denver to Wolcott via Berthoud Pass Tunnel (includes US 40 and US 34)			Screened out since travel time is not competitive with congested I-70 and travel distance is 20 miles more than I-70.
7 - Denver to Copper Mountain Jones Pass Tunnel (includes SH 9)			Screened out since travel time is not competitive with congested I-70 and travel distance is 20 miles more than I-70.
8a - Denver to Copper Mountain via Hoosier Pass (surface) (includes US 285 and SH 9)			Screened out since travel time is not competitive with congested I-70 and travel distance is 20 miles more than I-70.
8b - Denver to Copper Mountain via Georgia Pass Tunnel (includes US 285)			P
9 - Denver to Minturn via Buena Vista (includes US 285 and US24)			Screened out since travel time is not competitive with congested I-70 and travel distance is 20 miles more than I-70.
10a - Colorado Springs to Copper Mountain via Hoosier Pass (surface) (includes US 24 and SH 9)			Screened out due to the low percentage (2.7%) of travelers originating from the area.
10b - Colorado Springs to Copper Mountain via Hoosier Pass Tunnel (includes US 24 and SH 9)			Screened out due to the low percentage (2.7%) of travelers originating from the area.
11 - Colorado Springs to Minturn via Buena Vista (includes US 24)			Screened out due to the low percentage (2.7%) of travelers originating from the area.
12 - Colorado Springs to Copper Mountain via Buena Vista (includes US 24 and SH 91)			Screened out due to the low percentage (2.7%) of travelers originating from the area. Travel time not competitive with congested I-70 and travel distance is 20 miles more than I-70.
13a - Pueblo to Copper Mountain via Hoosier Pass (surface) (includes US 50 and SH 9)			Screened out due to the low percentage (0.3%) of travelers originating from the area.
13b - Pueblo to Copper Mountain via Hoosier Pass Tunnel (includes US 50 and SH 9)			Screened out due to the low percentage (0.3%) of travelers originating from the area.

Aviation Family

Alternatives	Screening Criteria: Safety	Screening Criteria: Mobility	Alternatives Retained for Level 2 Screening
Develop new airports in the mountain corridor	Is the location relatively free of major topographical and meteorological conditions that would hamper air traffic activity expansion?	• Is there sufficient and appropriate land available for construction and expansion? • How viable is the location of the airport? • Is the location in reasonable proximity to the major activity centers of the corridor? • Would this alternative have a significant, positive impact on I-70 Vehicle Miles Traveled (VMT) and/or Vehicle Hours Traveled (VHT)?	Screened out since there are no sponsors or air travel demand, and it is difficult to site.
Develop heliport and short take-off-and-landing (STOL) facilities			Screened out because the smaller aircraft that could use the facilities: carry too few passengers and are less equipped to deal with weather and mountain terrain.
Improve existing commercial service aviation facilities			P
Improve existing general aviation facilities to accommodate commercial operations			P
Develop Walker Field (the Grand Junction airport) into a West Slope regional hub airport			Screened out since Walker Field is already under utilized. It is not in the travel trend because Hayden, Rifle, and Glenwood Springs Airports are successful for general aviation purposes.
Develop aviation systems management and subsidy programs			P

Transportation Management Family

Alternatives	Screening Criteria: Safety	Screening Criteria: Mobility	Alternatives Retained for Level 2 Screening
Transportation System Management (TSM): • Highway improvements • Flex lanes • HOV lanes • Curve smoothing • Slow-moving vehicle lanes • Interchange improvements (longer acceleration and deceleration ramps) • Incident Management Program • Trucking Operations Plan • Improved maintenance • Access management • TSM for Transit • Skier express service • Private shuttle service • Local transit operations • Intermountain bus service • Amtrak Ski Train	Does the alternative meet safety standards as specified by FHWA/CDOT and the American Association of State Highway and Transportation Officials (AASHTO)/ Manual of Uniform Traffic Control Devices (MUTCD)?	Is the alternative compatible with CDOT's long term TSM/TDM/ITS plan?	P
Travel Demand Management (TDM): • Marketing of alternate modes • Intermodal transfer centers • Park-n-ride lots (places to meet and carpool) • Parking management programs • Time-of-use restrictions • Congestion pricing • Land use strategies			P
Intelligent Transportation Systems (ITS): • Traveler information • Traffic management • Vehicle control • Commercial vehicle systems • Public transport • Emergency management systems • Electronic transactions • Safety systems			P

Fixed Guideway Transit (FGT) Family

Alternatives	Screening Criteria: Safety	Screening Criteria: Mobility	Alternatives Retained for Level 2 Screening
Automated Guideway Transit (AGT) These systems (powered by either electric traction or linear induction motor) include: conventional rail, concrete guideway or monorail.	Does the alternative meet passenger safety and security standards?	Does the alternative meet the following criteria: • Meet the maximum theoretical capacity (passenger /hour). • Provide sufficient access to mountain corridor communities. • Average vehicle speed (mph), with and without stops, must be capable of transversing the 127-mile corridor from C-470 to Dotsero in less than 3.5 hours.	This group has been divided into 2 subgroups: long haul and short haul. Short haul systems were screened out because they are not suited for the Mountain Corridor environment. Long haul systems will be retained for Level 2 Screening; however, they will be included under the HRT alternatives.
Rail Transit Diesel Multiple Unit (DMU) on a single track with passing sidings or on a double track			P
Light Rail Transit (LRT) Either on a single track with passing siding or on a double track			P
Heavy Rail Transit (HRT) Either on a single track with passing sidings or on a double track			P
Passenger Railroad • Diesel locomotive train on a single track with passing sidings or on a double track • Electric locomotive train on a single track with passing sidings or on a double track • Electric Motor Unit (EMU) on a single track with passing sidings or on a double track			P
Advanced Guideway Systems • Monorail • Magnetic Levitation (Maglev) attraction based or repulsion based			Monorail systems are retained for Level 2; however, maglev systems were screened out due to curve/grade limitations. It would be difficult to serve all corridor communities.

Rubber Tire Transit (RTT) Family

Alternatives	Screening Criteria: Safety	Screening Criteria: Mobility	Alternatives Retained for Level 2 Screening
Bus in mixed traffic	Does the alternative meet passenger safety and security standards (measured by the presence of an operator)?	Does the alternative meet the following criteria: • Meet the maximum theoretical capacity (passenger /hour). • Provide sufficient access to mountain corridor communities. • Average vehicle speed (mph), with and without stops, must be capable of transversing the 127-mile corridor from C-470 to Dotsero in less than 3.5 hours.	P
Bus in High Occupancy Vehicle (HOV) Lanes Either in a marked lane (peak direction only or both directions) or a separated lane (peak direction only or both directions)			All options will be retained for Level 2 screening. The initial recommendation was to screen out the bus in separated HOV (both directions) because the excessive capacity is not needed in non-peak directions.
Bus in a separated transitway All options include peak direction only or both directions by: traditional bus, hybrid electric bus (HEB) or electric buses			P
Bus in guideway • Hybrid electric bus (HEB) (peak direction only or both directions) • Traditional or electric bus (both directions)			P
Bus Rapid Transit (BRT)			P
Improved Van Operation			P

I-70 MOUNTAIN CORRIDOR

PROGRAMMATIC EIS

TRANSIT ALTERNATIVES

DRAFT FINAL REPORT

Prepared For:

J. F. Sato & Associates

Prepared By:

TRANSYSTEMS CORPORATION

June 1, 2000

TABLE OF CONTENTS

INTRODUCTION

A number of transit alternatives to highway expansion are available to handle the growth in traffic along the I-70 Mountain Corridor. These alternatives consist of various forms of rubber tired, rail based, and promising new technologies for ground transportation. Each of these alternatives has a large number of type variations due to options in guideway technology, line configuration, propulsion source, and design capacity. These differences affect the initial capital costs to construct the proposed system, the unit cost of the vehicles, the number of vehicles required to meet proposed schedules, and the costs to operate and maintain the system. These option choices significantly affect the ultimate capacity of the proposed system, the overall running time between end points, the energy consumption per passenger, and the environmental impacts of the system.

PURPOSE AND SCOPE

The purpose of examining transit alternatives is to determine whether any ground transportation technologies that either currently exist or show significant promise in being developed in near future could be used to provide a meaningful component of the overall I-70 corridor capacity. All fixed guideway and rubber tired systems that provide an enclosed, lighted, and heated passenger cabins are open for consideration. The systems must also be capable of traversing the I-70 Mountain Corridor segment in less than 3 hours, which would be at a minimum average speed of approximately 35 mph.

METHODOLOGY

Attributes of existing technologies were culled from various sources within the Transportation Research Board (TRB) of the National Academy of Sciences, Jane's World Railways, Jane's Urban Transport Systems, the American Public Transportation Association (APTA), the Association of American Railroads (AAR), the Federal Transit Administration (FTA), and the Federal Railroad Administration (FRA) of the United States Department of Transportation. Attributes of promising technologies were provided by the technology proponents and in most cases have not been tested or verified under real-world operating conditions.

Technologies were divided into five exclusive groups based on general operating characteristics. These groups are:

- Busways
- Automated Guideway Transit
- Rail Transit
- Passenger Railroads
- Advanced Guideway Systems

Characteristics of each type technology are described along with various implementation options, photographs, and key points applicable to the I-70 Mountain Corridor. In a screening to be accomplished later in the PEIS, performance criteria for each system will be measured against other systems to develop a ranking of the technology among its peers for application to the I-70 Mountain Corridor. After a second screening the most viable existing technology and promising technology will be identified for further evaluation against other highway improvement options.

RESULTS AND FINDINGS

The difficult mountain terrain traversed by the I-70 Mountain Corridor limits the performance of many transit technologies. Vehicles must operate up and down 6% grades, follow tight highway curvature, operate unobtrusively in a spectacular mountain setting, fit within a narrow highway right-of-way, and not significantly degrade the environment while also providing a serious alternative to highway expansion. The route is long and mostly rural or wilderness in character, which limits typical urban solutions.

The overall operating requirements for a 35-mph average speed and an enclosed, lighted, heated cabin eliminate a number of short haul systems that would be inappropriate for a 100 mile corridor. These include escalators, moving sidewalks, funiculars, aerial tramways, bikeways, and hiking paths.

A total of 12 different technologies were found to meet the general requirements for operation in the corridor. Of them, only a few have real potential to truly provide a cost effective, environmentally friendly transit alternative. The most likely candidates will be examined further as part of the system screening process.

1.1 BUSWAYS

Options to utilize buses in the I-70 Mountain corridor consist of a number of separate configurations of infrastructure and rolling stock. In this report the term “Bus” is defined to mean any self-powered vehicle designed for commercial use and capable of operating on state roads carrying in excess of six passengers. Fuel may be diesel, gasoline, compressed natural gas (CNG), propane, or other available alternates. Buses using electric propulsion are referred to as “ETB” and hybrid buses using both electric propulsion and self-generated power are referred to as “HEB”.

Operation in Mixed Traffic means the bus is commingled with regular traffic on I-70. High Occupancy Vehicle (HOV) lanes refer to special traffic lanes that are intended for buses, car pools, and any vehicle carrying a minimum number of passengers set by the HOV operator (usually 2 or 3). HOV lanes may be either a regular highway lane distinguished with specially painted lines, symbols, and signage or a segregated roadway with its own access ramps. A Transitway is a completely separate roadway limited to transit vehicles only. It may contain special bus guide rails to reduce lane width requirements and help speed operations.

Each of the 5 scenarios that follow have significantly differing capital costs, operating costs, running times, and capacity limitations. Examples of each of these systems are currently available and in operation somewhere in the world.

1a - Bus in Mixed Traffic

This alternative would use buses operating within the general traffic lanes of I-70 to provide additional highway traffic capacity. The additional highway capacity is obtained by using the buses as a replacement for numerous automobiles, thus freeing up lane space.

Buses could operate from pick-up/drop-off points in Denver or from specially built Park & Ride lots near the entrances to I-70. The capacity of this alternative is essentially tied to the capacity of the I-70 highway lanes. The buses would have no lane priority therefore speeds would be limited by traffic conditions. The buses would also operate slowly on the numerous grades on I-70 as typical available engine output limits the horsepower available.

The types of bus vehicles that could be used include standard 40-foot coaches, tractor-pulled units, articulated sets, or double-deckers. Either diesel fueled or alternate fueled power plants can be utilized. Electric Trolley Buses (ETBs) can not be used due to the limited maneuverability of these types of buses alongside higher speed traffic running at the 65-MPH speed limit on I-70. Smaller buses and van operations could also be used as a supplement to the service.

This is a typical suburban or over-the-road bus operating scenario with examples available in any large metropolitan area. Some of the services described above are already being provided on a much smaller scale within the corridor.

[Insert small photos of over-the-road buses here with captions in Italics, prefer one picture each of standard, tractor-pulled, articulated, and double-deck]

[Substitute page with "Bus in Mixed Traffic" diagram here]

1b - Bus in HOV Marked Lane

This alternative would add a third lane to I-70 in each direction. The lane would be restricted to High Occupancy Vehicles (HOV) such as buses, vans, and automobiles carrying at least 3 persons. A simple paint stripe and signage would separate the HOV lane from adjacent traffic.

Bus service would operate similarly to the system described in Section 1a except that once the buses enter I-70 they would move to the inside HOV lane and travel to their destination with presumably less congestion than in the regular travel lanes. Congestion at interchanges would still be a factor, as would difficulties maintaining speed on grades. In addition, due to the existing high passenger occupancy levels per automobile on this corridor, so many vehicles would qualify for the HOV lanes that any travel advantage might be minimal. Continuous enforcement of the 3-person limit would be required and add to the operating costs of this alternative.

Body style and propulsion types described in Section 1a are also applicable to this alternative. ETBs cannot be used due to the multiple crossover movements required to access the inside HOV lane. The eastbound and westbound HOV lanes could be operated as restricted to HOV qualified traffic at all times or only in the peak direction, with the opposite direction HOV lane opened for general use.

[Insert photo of bus with automobiles operating in marked HOV lane – 3-lane configuration preferred]

[Substitute page with “Bus in Marked HOV Lane” diagram here]

1c - Bus in HOV Segregated Lanes

In this option, the HOV lanes would be built as a separate highway facility, either in the median of I-70 or as a parallel roadway. A median barrier would completely separate this facility from the general highway lanes. Bus body style and propulsion types described in Section 1a are applicable to this alternative. ETBs and HEBs could be used due to the separate interchanges, but high speed running in mixed traffic has not been tested for this option. The appearance of the overhead wires would be a problem.

The segregated lanes require less HOV enforcement effort and are less affected by adjacent lane traffic problems. Diesel buses would operate slowly on the grades as engine output limits the horsepower available

Bus service would operate similarly to the system described in Section 1a except that the buses would enter and leave the HOV lanes at special interchanges. They would travel to their destination with presumably less congestion than in the regular travel lanes. Congestion at regular interchanges would not be a factor, but difficulties maintaining speed on grades would still be a problem. As in Section 1b, due to the existing high passenger occupancy levels per automobile on this corridor, so many vehicles would qualify for the HOV lanes that any travel advantage might be minimal. Enforcement of the 3-person limit would still be required (but at a significantly less level due to the restricted entry points) and will add to the operating costs of this alternative.

A single pair of HOV lanes can be set to operate only in the peak direction as dictated by demand. This option requires considerable daily maintenance to clear and reverse the lanes, but keeps highway right-of-way use to a minimum. This scenario would require HEBs to return in mixed in traffic, without the electric power advantage on the grades. ETBs could not be used for the return in mixed traffic.

[Insert photo of bus with automobiles operating in segregated HOV lane – Shirley Highway (I-395) in Northern Virginia a good example]

[Substitute page with “Bus in Segregated HOV Lane” diagram here]

1d - Bus in Separate Transitway

In this option, a separate roadway dedicated just to buses would be constructed in the median of I-70 or as a parallel roadway. With only professionally operated buses traveling at the same speed, only one lane with a shoulder is required. Enforcement would be minimal as Automatic Vehicle Identification (AVI) technology could be used to raise a barrier at the transitway entrances.

Bus service would operate similarly to the system described in Section 1a except that the buses would enter and leave the transitway at special interchanges. They would travel to their destination with virtually no congestion. For diesel buses, difficulties maintaining speed on grades would still be a problem. Operation of ETBs and HEBs under electric power would be possible and their use would eliminate any slow operation on grades. The appearance of the overhead wires would be a problem.

A single direction transitway could be set to operate in the peak direction as dictated by demand. This option keeps highway right-of-way use to a minimum. This scenario would require HEBs to return in mixed in traffic, without the electric power advantage on the grades. ETBs could not be used for the return in mixed traffic.

A separate transitway can also be operated like a rail rapid transit system, using stations along the transitway for passenger boarding instead of leaving the transitway and circulating into the community. This scenario is known as Bus Rapid Transit (BRT) and will be an option to be reviewed under the screening.

[Insert photo of bus operating in separate transitway – Ottawa or Pittsburgh would be good examples, also BRT station photo would be useful]

[Substitute page with “Bus in Separate Transitway” diagram here]

1e - Bus in Guided Transitway

In this option, a separate roadway dedicated just to special buses with guideway attachments would be constructed in the median of I-70 or as a parallel roadway. With only professionally operated buses traveling at the same speed, only one narrow guideway lane is required for each direction. No enforcement costs would be required, as conventional vehicles could not use the guideway.

Bus service would operate similarly to the system described in Section 1a except that the buses would enter and leave the guided transitway at special interchanges. They would travel to their destination with virtually no congestion. For diesel buses, difficulties maintaining speed on grades would still be a problem. Operation of ETBs and HEBs under electric power would be possible and their use would eliminate any slow operation on grades. Due to the presence of the guideway, 3rd rail power pickup for ETBs and HEBs could be used in place of overhead wires.

A single direction guided transitway could be set to operate in the peak direction as dictated by demand. This option keeps highway right-of-way use to a minimum. This scenario would require HEBs to return in mixed in traffic, without the electric power advantage on the grades. ETBs could not be used for the return in mixed traffic.

A guided transitway can also be operated like a rail rapid transit system, using stations along the transitway for passenger boarding instead of having buses leave the transitway and circulating into the community. This scenario is known as Bus Rapid Transit (BRT) and will be an option to be reviewed under the screening phase.

[Insert photo of bus operating in guided transitway – sent previously, more can be found in Australia]

[Substitute page with “Bus in Guided Transitway” diagram here]

Summary of Busway Options

Buses operating in mixed traffic, as they do today, have little potential for relieving congestion on the I-70 Mountain Corridor.

In a corridor with already high passenger/vehicle averages, HOV lanes are bound to be congested shortly after their opening and will require continuous enforcement to keep them from reverting to general lane status.

Conventional buses operating on transitways are limited by the grades in this corridor and will produce unacceptable slow speeds, limiting ridership.

All electric buses cannot efficiently serve areas outside the corridor due to the lack of the overhead wire infrastructure in origin and destination areas.

Hybrid electric buses allow for fast mountain operations and flexible service areas outside the corridor. When operated on a conventional transitway, they would require unsightly overhead wires and that would be a significant visual obstacle to overcome.

Hybrid electric buses when operated on a guided transitway can draw power from an unobtrusive third rail in the guideway and operate normally outside of the corridor. The guideway would also be very narrow and presents the most effective use of the existing right-of-way.

2 - AUTOMATED GUIDEWAY TRANSIT

These systems have the common characteristic that they provide service without a human operator. Their guideway therefore must be completely protected to ensure that the automated vehicles cannot contact people, automobiles, or other obstacles in the guideway. For this reason they generally operate only short distances and stay within the definition of an "urban" system. The Federal Railroad Administration (FRA) does not regulate them. They can be operated using conventional rail transit steel wheel vehicles, rubber tires with a guide mechanism, or on a monorail. They are usually differentiated five ways: (1) Where they operate, (2) Whether they can operate outside, (3) Whether they operate with more than one independent vehicle per guideway, (4) Whether they can operate multiple routes, and (5) The propulsion mode of the vehicle.

Automated Guideway Transit systems in airports are often referred to as APM (Airport People Mover) Systems. Automated Guideway Transit systems used for downtown circulation are often referred to as DPM (Downtown People Mover) systems. DPM systems are currently operating in Detroit, MI and Jacksonville, FL. Automated Guideway Transit used in universities (Morgantown), hospital campuses (Duke), amusement parks, and other institutions are usually referred to as either a people mover or by the technology used (i.e.: the monorail, the tram, the shuttle). Automated Guideway Transit systems used for general circulation in an urban area are called ICTS for Intermediate Capacity Transit System. Only one example of this technology exists as an automated operation not exclusively in a downtown area and that is in Vancouver, BC.

Many Automated Guideway Transit systems are operated totally indoors through corridors in buildings. These systems, often found in airports, have far less difficulty providing a safe operating guideway than those operating outside. In two cases the vehicles used in these indoor systems don't even have ceilings, with lighting provided on the roof of the tunnel. They are located in Houston Intercontinental Airport and the basement of the United States Capitol.

The complexity of Automated Guideway Transit increases substantially when more than one vehicle can operate on the same guideway. Simple cable hauled systems handling only one vehicle per guideway can be operated using common elevator technology. When more than one vehicle is on the guideway, a sophisticated signal system is necessary to provide safe separation between the vehicles and to control braking and acceleration. Obviously, systems that can operate multiple vehicles on a single guideway are more efficient and have a much greater capacity.

Some Automated Guideway Transit systems have the ability to operate on multiple routes on either a preprogrammed schedule or on a demand basis determined by the rider. Preprogrammed systems are referred to as GRT (Group Rapid Transit). Rider demand systems as referred to as PRT (Personal Rapid Transit). Only one true PRT system is in operation at this time. It is an experimental system built in 1974 in Morgantown, West Virginia. It provides service to a large university campus and connects it to downtown Morgantown. Riders select their destination like floors on an elevator. Each small car carries the rider and accompanying parties directly to the station desired, bypassing any other station along the way.

Automated Guideway Transit can be powered by electric traction, cable hauled, or utilize linear induction motors. Sometimes Automated Guideway Systems are characterized by their vehicle capacity. Small systems can be referred to (inaccurately) as PRT systems, larger vehicles as GRT systems, and full size subway-like vehicles as ICTS.

When evaluating transportation options for a long corridor, only those systems that can operate outside, with multiple vehicles per guideway, need be considered. The ability to operate on multiple routes or the capacity of the vehicle is a variable that would depend on demand forecasts and the overall corridor development plan. The choice of propulsion is currently limited to electric traction and linear induction motors. The choice of guideway is either conventional rail, concrete guideway, or monorail.

No Automated Guideway Transit system in use operates over a corridor as long as the I-70 Mountain Corridor. Use of this technology would be controversial since no experience is available for operations in a long, remote corridor. The FRA does not currently regulate these systems since they are considered “urban” systems. Implementation on the I-70 Mountain Corridor would most likely trigger a review of the scope of current regulations, with unpredictable results. The lack of an operator to handle breakdowns or emergencies in remote areas would appear to eliminate this technology from consideration.

2a - AGT using Conventional Rail

This type of system is currently in operation in Vancouver, BC Canada. A manned version is also in operation in suburban Toronto, ON Canada. The linear induction motors in use allow quick acceleration, but can be noisy.

2b - AGT using Monorail

This type of system is currently in operation at Downtown Jacksonville, FL and the Newark, NJ Airport.

3 - RAIL TRANSIT

Options to utilize rail transit in the I-70 Mountain corridor consist of either light rail or heavy rail transit systems. Each type of system can be constructed as a double-track line or as a single-track line with passing sidings. Either electric or diesel propulsion systems are available. The tracks can be located in the median of I-70 or on a parallel alignment, diverging only for heavy grades and to serve off line stations. In this report the term “Rail Transit” is defined to mean any conventional rail vehicle designed to operate on tracks not connected to the national railroad network. These systems, when operated in an “urban” area, are exempt from Federal Railroad Administration (FRA) regulation.

Rail Transit vehicles may self-generate their own power or utilize electric propulsion. The term “DMU” refers to light rail Diesel Multiple Unit vehicles that can be operated on non-electrified lines that are not regulated by the FRA. Generally, Light Rail Transit (LRT) and Heavy Rail Transit (HRT) systems utilize electric propulsion. LRT vehicles can, if necessary, operate on tracks in city streets with motor vehicle traffic. Light rail trains could also operate in mixed traffic through the Eisenhower Tunnel to avoid separate transit tunnel costs.

High capacity HRT systems must operate only on exclusive rights-of-way due to their large vehicle size, long train lengths, their inability to brake and accelerate within motor vehicle tolerances, and (often) the presence of a ground mounted electric third (power) rail. They do have many more options for power pick-up and automation than LRT systems but represent one of the highest costs per mile to construct.

The use of Rail Transit vehicles on the I-70 Mountain corridor would be controversial since Rail Transit systems are designed for urban and metropolitan areas and are not currently operated in North America on lines as long and remote as this corridor. Although “Interurban” systems utilizing basic Rail Transit technology frequently operated for hundreds of miles in the first half of the 20th Century, there are no surviving examples in service today (the oft-cited South Shore line in Chicago was built as an Interurban but is currently operated as a FRA compliant railroad). Although examples of long distance rail transit systems can be found in Europe, none are compliant with FRA vehicle safety requirements. The use of this type of equipment would depend on whether the FRA considers the system “urban” or if a difficult-to-justify safety waiver could be obtained.

3a – Light Rail Transit

This type of rail transit system is designed for medium capacity urban and suburban transportation. It differs from Heavy Rail Transit by its ability to operate in mixed street traffic if desired. These vehicles meet all highway operating standards for braking, acceleration, directional turn signals, and sight distances from the operators position. Usually, though, these systems are operated on either a reserved roadway median or an exclusive right-of-way. Their flexibility to operate in many environments and lower initial costs than Heavy Rail Transit has made them the fastest growing rail transit mode in the nation, with over ten new systems being opened in the last twenty years.

Although typically operated using a 600V-700V DC overhead wire, diesel propulsion and 3rd rail versions are also available. Vehicles can utilize low level or high level boarding platforms and are ADA accessible. Newer low-floor versions are also available to speed street level boarding. Vehicles are available from many suppliers.

Light Rail Transit cars are usually 75 – 90 feet long and often operate in train lengths of one to five cars. Train length is typically limited by the street block size when operating in mixed traffic, to avoid blocking intersections. The vehicle width is smaller than Passenger Railroad systems (typically 8.5 feet) to be able to operate on roadways.

3b – Heavy Rail Transit

This type of rail transit system is designed for high capacity urban and suburban transportation. It differs from Light Rail Transit by its requirement for an exclusive right-of-way. These trains are too big and long to operate on highways and the operator cannot see nor brake sufficiently to deal with typical highway maneuvers. Heavy Rail Transit vehicles are capable of high acceleration and are one of the few modes in this report with sufficient power to operate over the I-70 grades at full speed. The PATCO system in Philadelphia currently operates over a 6% gradient on either side of the Ben Franklin Bridge. The BART system in San Francisco uses high performance motors that will out-accelerate an automobile with a ten-car train. .

Although typically operated using a 600V-700V DC 3rd rail, diesel propulsion and overhead catenary versions are also available. Vehicles utilize high level boarding platforms and are ADA accessible. Stations are required for boarding and alighting. Vehicles are available from many suppliers.

Heavy Rail Transit cars are usually 70 - 90 feet long and often operate in train lengths of two to twelve cars. The vehicle width is sometimes smaller than Passenger Railroad systems but cars can be built to their standards if desired

4 - PASSENGER RAILROADS

Options to utilize Passenger Railroads in the I-70 Mountain corridor consist of two separate configurations. In this report the term “Passenger Railroads” is defined to mean any conventional rail vehicle operating on track connected to the national railroad network. These systems are regulated by the Federal Railroad Administration (FRA).

Passenger Rail trains operate throughout the United States. All of these systems share many similarities since they must comply with various construction standards and operating regulations promulgated by the FRA. When operated between a major city and its suburbs the service is referred to as “Commuter Rail.” When operated between major cities the service is referred to “Intercity Rail.” Virtually all intercity trains in the United States are operated by Amtrak.

Intercity trains are further subdivided into Short Haul and Long Haul service. Short Haul trains are almost always day trains operating between cities less than 500 miles apart. Long Haul trains operate overnight and many travel across the entire country. Equipment configuration differs between Commuter Rail, Short Haul Intercity trains, and Long Haul Intercity trains. Commuter Rail trains have fairly constricted seating designed for short trips. Short Haul Intercity trains are more generous with seating space and usually provide food service. Long Haul Intercity trains provide seating with leg rests and deep reclines for overnight trips as well as full dining car service, lounge cars, and sleeping room cars.

A variant of Short Haul Intercity train service is High Speed Rail. These trains operate at very high speeds (over 125 mph) for premium fares. Only one system currently exists in the United States. It is currently in service in between Washington, New York, and (soon) Boston. Dozens of other states as also planning High Speed Rail systems, with California and the Midwest (centered on Chicago) in the most advanced state. High Speed Rail systems require a straight, flat trackbed to achieve their speed goals and attendant ride quality.

Passenger Rail trains may be hauled by diesel locomotives or electric locomotives. The trains may also be made up of multiple unit cars, each with their own diesel or electric traction motor(s). Electric power can be delivered through overhead catenary wires or a third (power) rail. Conventional railroad trains are limited to a maximum gradient of about 6%, although they are usually designed to operate with only a maximum of a 2% grade on most mainlines, with some exceptions. These systems are very flexible, as they are able to operate on both new alignments as well as existing trackage shared with freight trains.

4a - Locomotive Hauled Trains

This option would provide rail service using existing trackage from Denver Union Terminal to Golden and then over a new alignment to the I-70 corridor. The new tracks would run parallel to I-70 to Dotsero and then rejoin existing trackage that leads to Glenwood Springs and Grand Junction. The grades on this line would require use of a number of diesel locomotives to power each train in order to be able to traverse the grades in a reasonable period of time.

Electric locomotives could also be utilized to mitigate the grade problem and help maintain air quality standards. Overhead catenary would be necessary but could be designed to minimize visual impacts. 3rd rail systems could also be utilized but would require a completely separate, fenced right-of-way to avoid any dangers to trespassers and wildlife (although underrunning type 3rd rail is far less accessible than the exposed overrunning type. Due to the distance, 25,000V AC overhead wire systems are the most efficient. 600-700V DC 3rd rail systems could also be used with frequent substations necessary along with a continuous high voltage feeder system.

Passenger Rail trains can utilize either low level or high level boarding platforms and are ADA accessible. Stations are required for boarding and alighting. Locomotives and cars are available from many suppliers.

Passenger Rail train cars are 85 feet long, 10.5 feet wide and can be operated in trains as long as 20 cars. Cars can either be single deck (13.5 feet high) or double deck (16.2 feet high)

[Insert Amtrak train photos here – one single level, one double level]

4b – Multiple Unit Trains

This option would provide rail service using existing trackage from Denver Union Terminal to Golden and then over a new alignment to the I-70 corridor. The new tracks would run parallel to I-70 to Dotsero and then rejoin existing trackage that leads to Glenwood Springs and Grand Junction.

Diesel powered and electric powered multiple unit trains could be used to provide service along this line. Multiple unit trains have a power advantage in that every car has its own driving motors. Overhead catenary would be necessary but could be designed to minimize visual impacts. 3rd rail systems could also be utilized but would require a completely separate, fenced right-of-way to avoid any dangers to trespassers and wildlife (although underrunning type 3rd rail is far less accessible than the exposed overrunning type). Due to the distance, 25,000V AC overhead wire systems are the most efficient. 600-700V DC 3rd rail systems could also be used with frequent substations necessary along with a continuous high voltage feeder system.

Passenger Rail multiple unit trains can utilize either low level or high level boarding platforms and are ADA accessible. Stations are required for boarding and alighting. Multiple unit cars are available from many suppliers.

Passenger Rail multiple unit train cars are 85 feet long, 10.5 feet wide and can be operated in trains as long as 20 cars. Cars can either be single deck (13.5 feet high) or double deck (16.2 feet high)

5 – ADVANCED GUIDEWAY SYSTEMS

For the over hundred years there have been only two realistic modes in use for ground transportation: railway and highway. In the last twenty years research has been closing in on two types of magnetic levitation (maglev) systems that can be used for a new generation of high speed ground transportation. In addition, an older mode primarily used for transit applications, the monorail, has been proposed in various forms for higher speed intercity service.

These systems share a common attribute. None has been operated in revenue service over a line anywhere near this length. Implementation would require a significant construction cost risk, performance risk, and operating cost risk. Costly development and testing would be necessary to even prove the concept and develop the design to meet current safety requirements.

While a successful implementation of this technology would certainly be a major victory for these technology proponents, the costs and returns to the taxpayers would be questionable if other proven technology were able to meet the needs of the travelling public, most of whom don’t care how the vehicle is propelled.

The major advantage of both the maglev and monorail technologies is speed. Running times could be significantly shortened, but the infrastructure necessary to accomplish this time savings may mean significant new right-of-way acquisition. Curve limitations will limit the use of the I-70 corridor for most high speed conventional rail, monorail, or maglev systems

5a - Monorail Systems

The monorail concept utilizes a single elevated beam to carry a train over any ground based obstructions. Vehicles can ride above the beam, hang from the beam, or run astride of the beam. The concept has been in operation since the 1950s in amusement parks, downtown circulators, and airport AGT systems. In Japan, some monorail systems are used between downtown areas and airports.

Monorails are operated essentially as Heavy Rail Transit since they are grade separated and cannot run in mixed traffic. They have most of the attributes and limitations of Heavy Rail Transit, but have not been proven in a corridor as long or as remote as the I-70 Mountain Corridor.

A monorail system would need a circulation system at each end of the trip to provide reasonable access. Propulsion for the trains is electric using either conventional electric traction motors or a proposed linear induction motor system. Vehicles can be operated using rubber tires or steel wheels.

5b - Magnetic Levitation Systems

Maglev systems have been under development since the 1960s. Two types are being actively tested. A German attraction based design where the magnets on the track are attracted to electromagnets on the car, which are used to levitate the car for high speed running. Also a Japanese repulsion based design where the magnets on the track push the car away to levitate it in a trough for high speed running.

The German design, which was being planned for a new line from Berlin to Hamburg, was recently defunded. The Japanese design is still undergoing full scale testing in a section of the planned track built outside of Tokyo.

Although both systems would be capable of operating in the I-70 Mountain Corridor, neither is sufficiently advanced to generate reliable cost and performance data.

CONCLUSIONS AND RECOMMENDATIONS

The I-70 Mountain Corridor presents a number of challenges to designers of transit alternatives. The grades limit vehicle performance. The curves limit speed. The right-of-way limits the width available for infrastructure. The mountain vistas limit the choice of power systems. The remoteness limits automation solutions. A few choices do remain that show significant promise in helping alleviate congestion on the corridor.

Of the Busway options, the best appears to be use of a hybrid electric bus (similar to those currently operating in Seattle) operating over a guided transitway. A single peak lane would work, but would limit return speeds and performance. A double lane would be ideal and fit within the existing highway median in most locations along the corridor.

Of the Automated Guideway Transit options, none appears to be suitable for a long, remote corridor. The prospect of being stranded in a vehicle breakdown without even an operator on-board presents too many negative scenarios.

Of the Rail Transit options, an electric multiple unit train similar to those operated by BART in San Francisco and PATCO in New Jersey appears to have all of the necessary capabilities to operate successfully in the corridor. The looming question of FRA regulatory jurisdiction and its affect on equipment design is currently open and one of significant concern.

Of the Passenger Railroad options, the only equipment capable of operating in this corridor would be an Electric Multiple Unit train, which would have the horsepower, tractive effort, and adhesion necessary to operate at substantial speed on up to 6% grades. It also has the advantage of being able to use existing railroad connections at Dotsero and Golden to continue operations beyond the I-70 Mountain Corridor and into Denver Union Terminal.

Of the Advanced Guideway Systems, the two magnetic levitation systems require a much straighter right-of-way than is available in the I-70 Mountain Corridor without significant tunneling. The aerial monorail approaches appear feasible, but would require a significant amount of testing and certification before they could be ready for implementation. The uncertainty of the monorail's final design parameters could delay upgrade work in the I-70 corridor while waiting for the results of testing to determine such items as the location of support piers and ground based facilities.

Of the existing systems it is recommended that further analysis be undertaken on the Hybrid Electric Guided Busway using 3rd rail equipped buses, the Rail Transit alternative using 3rd rail equipped electric multiple unit vehicles, and the Passenger Railroad option using 3rd rail electric multiple unit vehicles. Of the promising systems, the monorail system should be investigated further.